Agricultural Trajectories in Yunnan, Southwest China: a comparative analysis of archaeobotanical remains from the Neolithic to the Bronze Age

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Declaration

I, Rita Dal Martello confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

Signature ______________________

Date __________________________

Abstract

This dissertation investigates the emergence and development of agricultural practices in the southwest Chinese province of Yunnan, between the 3rd and 1st millennia BC. Drawing from previously unstudied archaeobotanical remains from the sites of Baiyangcun, Haimenkou, and Dayingzhuang; this research analyses compositional and chronological changes in the crop assemblage from each site. These sites are located in the strategic region of *sanjiang,* at the crossroads of three main Asian rivers: Yangzi, Mekong, and Salween. Local and regional developments of agricultural systems are explored through the comparison of these new material with other published datasets from Yunnan, the surrounding provinces of Sichuan, Tibet, Chongqing, Guangxi, and mainland Southeast Asian countries.

The main research questions addressed in this dissertation are:

-What was the basis of early agriculture in Yunnan?

-Given that the first attested agricultural systems in Southwest China appear 3000 to 2000-years later than those associated with domestication centres in North China and along the Yangzi River, to what extent can agricultural practices in Yunnan be derived entirely from migrating farmers, or did adoption (acculturation) by local forager populations play a role?

-What role did native wild plants play in Yunnan Neolithic and Post-Neolithic subsistence, and were there any local processes of domestication underway?

-With regards to rice, what was the ecology of rice cultivation? Did this differ either from source regions along the Yangzi, or from the early systems in Southeast Asia, which have sometimes been suggested to have origins in Yunnan?

The results contained in this thesis provide archaeological evidence that was until now lacking to evaluate the validity of the language/farming dispersal hypothesis in the context of the Austroasiatic languages dispersal, as well as laying an important archaeological and chronological framework for studying of the emergence of a settled agricultural lifestyle in Yunnan.

Impact statement

This dissertation makes a substantial contribution to our understanding of the cultural and social development of Late Prehistoric and Early Historic Yunnan. The thesis presents a systematic review of the prehistoric cultural and agricultural development of Yunnan Province, a region within modern China that was previously only sparingly investigated. It allows for previous theories and hypotheses, such as the language/farming dispersal hypothesis, to be re-evaluated and tested against a new solid chronological and archaeobotanical framework, as well as contributing to current debates on rice cultivation spread within South China and beyond.

These results presented here allow us to explore the early connections between Yunnan and the surrounding areas; effectively bridging a gap in our local and regional knowledge of the early network of connections across the wide subtropical area along the border of Yunnan and mainland Southeast Asia.

More widely, this research provides essential comparison data to researchers on subsistence and cultural change in Asia and beyond. The results contained in this thesis contribute to our understanding of the establishment of early agricultural systems in the world, including crop and cultivation changes through time.

Finally, the millennia investigated in this thesis underwent abrupt climatic changes and instability that affected the production of food. The investigation of past coping strategies for climatic uncertainty and food shortage can provide insights into similar challenges faced today.

Acknowledgments

It was only with the unparalleled support and friendship of many people through the years that this research has been possible. First, I would like to thank my supervisors, Prof. Dorian Q Fuller and Prof. Yijie Zhuang, for their continuous support and guidance throughout my 4 years of research at UCL. Particularly helpful were the many insightful suggestions, and the comments and corrections I received on my drafts, which helped greatly improve not only the final written output of this research, but also my knowledge and skills as a researcher. I am also especially grateful to Dorian for having generously supported my numerous research trips to China and other countries. To me this has meant visiting Yunnan for the first time, a place I had attempted to travel to many times before, but never could. Many thanks for making a decade long attempt finally come true.

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CHAPTER 1. Introduction

Our knowledge about the prehistory of Yunnan is still rather limited. Neither English nor Chinese academic literature provide reviews on the topic. The latest English manuals on Chinese Archaeology only marginally mention Yunnan (e.g. Shelach, 2015, pp. 37-38; Liu & Chen, 2012, pp. 249-250), with some not even including it in their overview of Chinese Archaeology (Underhill, 2013). Similarly, recent scholarship on Central and Southwest China, which highlighted how these areas underwent an independent trajectory to socio-political complexity from the Central Plains, only vaguely include Yunnan in this discourse, the focus being prominently on Sichuan, and Tibet (e.g. Flad & Chen, 2013; D'Alpoim Guedes, 2013).

This is due to the fact that until recently, archaeological research in China focused almost exclusively in investigating the area of the Central Plains, located in the Yellow River Basin, and long seen as the "Cradle of Chinese civilisation" (e.g. Von Falkenhousen, 1993; Chang, 1964; Chow, et al., 2008; Shelach-Lavi, 2015). This was in part a response to the claim that Chinese civilisation had a Western origin[1]. The early work of Chinese Archaeology to prove an indigenous origin effectively resulted in the decades long subordination of Archaeology to the reconstruction of national history (Chow, 1960). Until the 1980s, Archaeology in China was often described as the "handmaiden of antiquarian historiography" rather than a discipline in its own right with its own specific

[1] This theory was first proposed in the early 1920s by J.G. Andersson following finds of Neolithic painted pottery in Gansu Province, Northwest China. He claimed a resemblance existed between these and Neolithic painted pottery remains from Central Asia, from where he proposed Chinese civilisation had originated (Liu & Chen 2012).

objectives (e.g. Von Falkenhausen, 1993; Chang, 1981; Chow, 1960). This not only structured most of the early archaeological research agendas in China, but it also biased greatly the geographical span of its research. The great attention devoted to proving the ways and timing of the birth of a Chinese civilisation along the coasts of the Yellow River resulted in the almost utmost neglect of the surrounding regions, seen as "peripheral" and therefore of secondary importance in the pursuit of the main Chinese Archaeological research agenda (Yao, 2010).

In addition to this, the remote location of Yunnan, together with the last century's political instability, undermined the possibility of investigating this region. Even after the establishment of the People's Republic of China in 1949, archaeological investigation in Yunnan was (and to some extent still is) limited to rescue excavations, mostly associated with the modernisation of the country's infrastructure system. Those excavations were often done quickly, with no clear methodology and no environmental sampling whatsoever. Excavators were focusing on pottery or metal remains, and sometimes hand picking any other material that would be visible to the naked eye, such as rice grains.

There are only a couple of early Holocene hunter-gatherers' sites that have been found and investigated in Yunnan. Since the discovery in 1965 of remains of *Homo erectus* in Yuanmou prefecture, Northern Yunnan (Zhou & Zhang, 1984), Chinese Academia focused more on the understanding of how anatomically modern humans populated East Asia and China, often using evidence such as the Yuanmou Man to reject out-of-Africa theories, rather than investigating hunter-gatherer populations local lifestyles and subsistence practices.

Similarly, sites dated to the 3rd and 2nd millennium BC in Yunnan are not numerous; these are cave shelters or shell midden sites located along river valleys and lakes, but they have rarely undergone detailed chronological dating and archaeological investigation (Liu & Chen, 2012: 246). More data is available only from the 1st millennium BC onward, in connection with the flourishing of the Dian and its bronze material culture (Yao, 2016).

This is quite a considerable chronological gap compared to what is known from most of other regions in China, where archaeologists have information about prehistoric sites dating to as early as 7000 BC, or earlier (Liu & Chen, 2012). Moreover, although several theories exist about the beginning of an agricultural lifestyle in Southwest China (see Chapter 2), this chronological gap has caused a general lack of understanding of the precise modes and timing of the transition from hunter-gathering to agricultural food production at a local level in Yunnan. External migrations have been deemed responsible for this transition, however, very little research has been done to understand how agricultural systems developed elsewhere (i.e. the Yangzi River Basin and Northern China) adapted to the peculiar environmental and ecological condition of Yunnan. Furthermore, previous scholarship in Southwest China argued that the spread of agriculture played a decisive role in achieving increased social complexity in areas with otherwise unsuitable conditions for human occupations, such as the high altitudes of Tibet (D'Alpoim Guedes, 2013; D'Alpoim Guedes, et al., 2015; Chen et al., 2015), but whether a similar process happened in Yunnan is still unclear.

This lack of research is remarkable when evaluating the particular geographic location of Yunnan (see fig. 1-1). Situated at the crossroads between Southwest China and Southeast Asia, Yunnan is a fundamental passageway for any kind of movement across the two regions (Higham, 2004, pp. 136-137). The province's extensive river system is thought to have facilitated the creation of contact routes, possibly since prehistoric times (Luo, 1992). These routes would have been the basis for the development of the Southwest Silk Road or Southern Silk Road (also called Ancient Tea Horse Road- *chamadao* 茶马古道) during Tang (618-906 AD) and Song (960-1279 AD) dynasties (Liu & Chen, 2012, pp. 249-250). Yunnan is, therefore, a key region for understanding early migrations and cultural contacts within China, and from China to both Southeast Asia and Southwest Asia. Its specific location also acts as a connection hub between different ecological zones, acting *de facto* as a transitional zone between temperate and tropical East Asia (Tang, 2015). Therefore, investigating Yunnan's early subsistence and cultural practices is of foremost importance for understanding the overall development of agricultural societies, and their similarities and differences, within East and Southeast Asia.

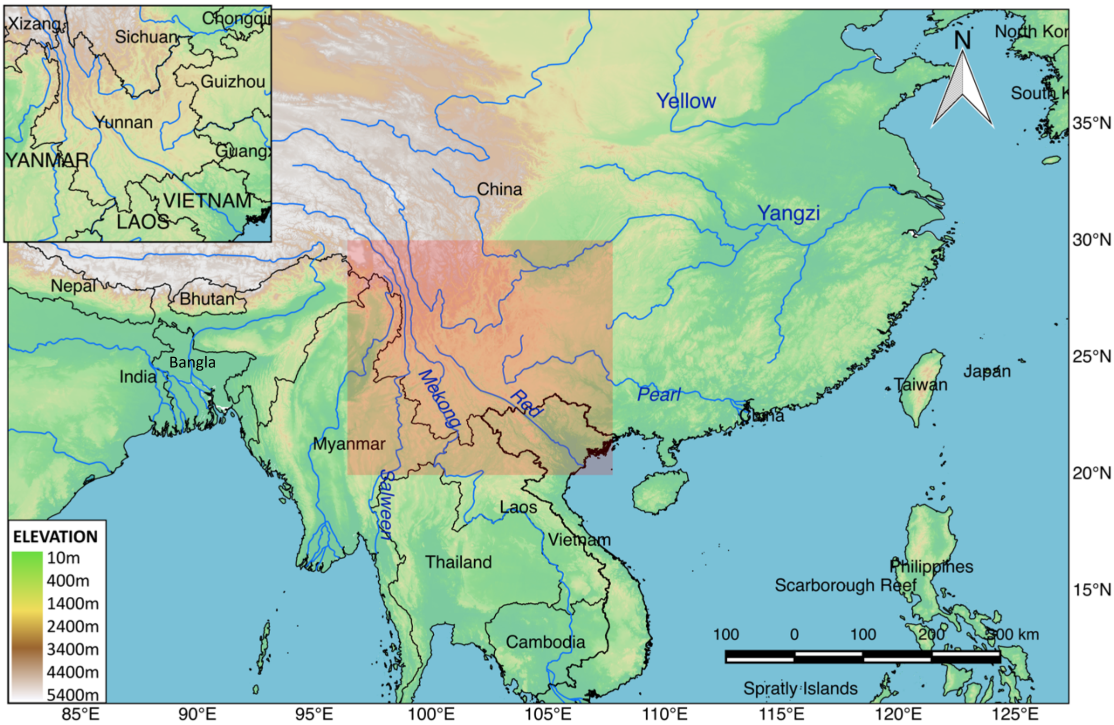

Fig. 1-1: Map showing the location of Yunnan. Made with QGIS.

1.1. Questions and aims

The research carried out for this thesis aims to fill in gaps in both our local and regional knowledge regarding the spread of agriculture to Southwest China and beyond, as well as providing a more general archaeological and chronological framework for future research in the region. The subsistence systems in use in Yunnan from the Neolithic to the Early Bronze Age (c. 3000-300 BC) are here explored for the first time, with a focus on the adaptation of agricultural packages to different environmental and ecological conditions within Southwest China.

The main research questions addressed in this dissertation are:

-What was the basis of early agriculture in Yunnan?

-Given that the first attested agricultural systems in Southwest China appear 3000 to 2000-years later than those associated with domestication centres in North China and along the Yangzi River, to what extent can agricultural practices in Yunnan be derived entirely from migrating farmers, or did adoption (acculturation) by local forager populations play a role?

-What role did native wild plants, such as *Chenopodium*, and buckwheat, play in Yunnan Neolithic and post-Neolithic subsistence? Were there any local processes of domestication underway?

-With regards to rice, what was the ecology of rice cultivation? Did this differ either from source regions in the Yangzi Valley, or from the early systems in Southeast Asia, which have sometimes been suggested to have origins in Yunnan?

Throughout this thesis rice cultivation ecology will be investigated with reference to the wetland-dryland categories outlined in Fuller et al. (2011) and Weisskopf et al. (2015). Wetland systems are characterised by the (seasonal) submerging of the fields, with the construction of embankments or other structures to allow for the retention of water. This can be obtained either by seasonal flooding, or by the means of water reservoirs and the construction irrigation systems. Wetland rice cultivation (also referred to as lowland rice cultivation) is labour intensive but allows for high yields. Dryland rice cultivation (also referred to as upland rice cultivation) instead relies solely on precipitation, it is less labour-intensive as does not require the creation and maintenance of irrigation structures, however, the overall rice yield is also lower than that obtained through wetland rice cultivation (Fuller et al., 2011). It is practiced in hilly areas with a minimum precipitation of 800mm/1000mm (Jaquot & Courtois 1987; Yoshida, 1981). A different suite of infesting weeds characterises each cultivation regime, therefore, the analysis of the archaeobotanical weedy flora, in association with crop remains, can identify which cultivation regime was practiced.

New archaeobotanical evidence from three unpublished sites: Baiyangcun, Haimenkou, and Dayingzhuang, is integrated with already published data from Southwest China and mainland Southeast Asia. The principal aim of this thesis is to reconstruct the crop assemblage and the evolution of early Yunnan agricultural systems through time and space. This will provide a chronological and archaeological framework to discuss the nature of the role that early agricultural communities in Yunnan had, if any, in establishing early contacts with Southeast Asia in the context of the Austroasiatic languages dispersal.

1.2. Thesis structure

This thesis is divided in 9 Chapters. Chapter 2 introduces the current knowledge on agricultural origins and spread within China before the 3rd millennium BC. This includes a review of the main plant species domesticated in China and their botanical characteristics, such as optimal growing requirements, including temperature and water, ripening period, and so on. In this chapter a summary of the conflicting hypothesis regarding the dispersal of the Austroasiatic languages, and the role of Austroasiatic speakers in the spread of agriculture towards Southeast Asia is also introduced. Chapter 2 provides essential information to contextualise the results that will be introduced in the later chapters of this thesis.

In Chapter 3, the environmental and climatic conditions of Yunnan, both modern and ancient, are described. A detail reconstruction of the paleo-environment and climate at the time of occupation of the sites investigated in this thesis is provided, which allows us to explore to what extent past Yunnan populations could sustain specific agricultural systems.

Chapter 4 describes the materials and methods employed for the research outlined in this thesis. Both field recovery processes and laboratory analyses are described. The excavation histories of the sites analysed in this thesis are included in this chapter, with a description of the provenance of the archaeobotanical samples.

The following three chapters (Chapters 5-6-7) include a detailed report of the archaeobotanical results from each of the three sites investigated for this research: Baiyangcun (Chapter 5), Haimenkou (Chapter 6), and Dayingzhuang (Chapter 7). In addition to the presentation of the archaeobotanical results, the chapters provide important comparative information on the material culture, chronology, and animal remains of the sites, so to build a comprehensive understanding of their occupation and the general lifestyles of their respective inhabitants.

Chapter 8 includes a discussion of the results of this thesis in relation to other already published datasets from the surrounding regions. The focus of the discussion is mostly on comparable archaeobotanical material, especially that obtained through systematic flotation, across the wider geographical region of Southwest China (including Sichuan, Tibet, Chongqing, Yunnan, and Guizhou Provinces), as well as mainland Southeast Asia (mostly Thailand). Specific questions regarding the similarities of material culture remains, as well as animal resources, are addressed in this chapter, as these might speak to shared practices and highlight possible connection networks and population movements.

Finally, Chapter 9 summarises the main findings of this research and indicates further directions for archaeological and archaeobotanical research in Southwest China.

Note on the use of Palaeolithic, Neolithic and Bronze Age terminology

Throughout this dissertation the terms “Palaeolithic”, “Neolithic” and “Bronze Age” will be used in line with conventional meanings and current use attested in most Chinese publications. Although in Western scholarship this terminology has received some criticism and has at times been superseded (Rispoli et al., 2013), in Chinese Archaeology these terms are still routinely used to classify archaeological sites according to their sedentism level, subsistence practices, and technology. In published Chinese Archaeology literature the term Palaeolithic (*jiushiqi shidai* 旧石器时代) is used to refer to hunter-gatherer sites with no reported presence of domesticated plants and/or animals, no metal objects, often no pottery, dating usually to several hundreds to few millennia BC; Neolithic (*xinshiqi shidai* 新石器时代) is used to referred to settlements with evidence for agriculture (most often as the presence of domesticated crops and/or animals) and pottery, but no metal objects; finally, Bronze Age (*qingtongqi shidai* 青铜器时代) sites are those with reported finds of metal (bronze or copper-based) objects. This division is not always clear-cut, and especially in South China, there has been evidence of semi-sedentary hunter-gatherer groups with knowledge and use of pottery (e.g. at Miaoyan 17,320-14,710 cal BP, see Kuzmin, 2006; and Zengpiyan 12,000-11,000 BP, see Pearson, 2005). For the context of this thesis, within the province of Yunnan current literature refer to as Palaeolithic sites, any site dating before the 4th millennium BC; Neolithic to between the 3rd and 2nd millennium BC; Bronze Age to between the end of the 2nd and the 1st millennium BC (e.g. Li & Hu, 2009; He, 2001). This differs from other Chinese provinces, and to avoid confusion, throughout the text broad chronological ranges are given when first introducing evidence from each province.

1.3. A short history of archaeobotanical research in China

In the early decades of the People's Republic of China, the recovery of plant remains from archaeological sites depended completely upon chance, with no systematic recovery method employed during excavation. Until about the 1980s, plant remains were recovered either because present in high quantities or in extremely well-preserved conditions, such as waterlogged, and then sent to botanists or agronomists for identification (Zhao, 2007). In these decades finds such as high quantities of millet remains at the sites of Banpo (Xi'An, 1982), Cishan, and Peiligang (Tong, 1984); and rice remains at the sites of Hemudu (e.g. You, 1976; Zhou, 1981), Chengtoushan (Hunan, 2007), Yuchanyan (Yuan, 1996), and Jiahu among others (e.g. Zhang, 1998; Henan, 1999) fuelled the early discussions on the origins of millet and rice agriculture in China. However, these were mostly accidental finds, and they were heavily biased toward larger plant remains, as these are more easily seen by the naked eye (Liu, et al., 2008: 8).

In 1986, an article titled "*Kaogu fajuezhong huishou zhiwuyicun de fangfa zhiyi-baomu fuxuan fa* 考古发掘中回收植物遗存的方法之一 —泡沫浮选法" ("Flotation: a method for the recovery of plant remains in archaeological excavations"; Huang, 1986) described the use of water flotation to recover plant remains from archaeological sites. This sparked some preliminary attempts in plant remains recovery from archaeological sites (e.g. at Bashidang, see Zhang & Pei, 1997), but there was still no standardization in sampling strategies during excavation, nor in flotation procedure (i.e. mesh size used, volume of bulk soil, sorting of samples in the lab, etc.), therefore, the results obtained in this period are highly differentiated (Liu, et al., 2008: 8).

In 1992, a more systematic overview of archaeobotanical principles and research methods was published: "*Zhiwu kaoguxue gaishu* 植物考古学概述" ("Archaeobotany: an overview"; Zhao, 1992). The article described the specific archaeobotanical theoretical principles, field work and laboratory methods, including flotation for the recovery of macro-botanical remains, as well as pollen and phytoliths recovery and analysis, and so on. Prof. Zhijun Zhao's subsequent work (e.g. Zhao, 2001; Zhao, 2004) helped promote archaeobotanical research in China, both the understanding of its theoretical principles, as well as the need for systematic collection methods.

Since, environmental remains collection, specifically soil sampling for phytoliths and pollen analysis, and for flotation for the recovery of ancient plant macro-remains, has become increasingly incorporated in archaeological excavations in China, but especially after the introduction, in 2009, of national guidelines for the sampling and collection of environmental remains in archaeological contexts (Guojia, 2009; see Chapter 4), there has been a substantial increase of archaeobotanical reports published in China over the past ten years, including both site-specific reports on macro-botanical, pollen, and phytolith remains analyses from archaeological sites across China (CNKI, 2019; see fig. 1-2).

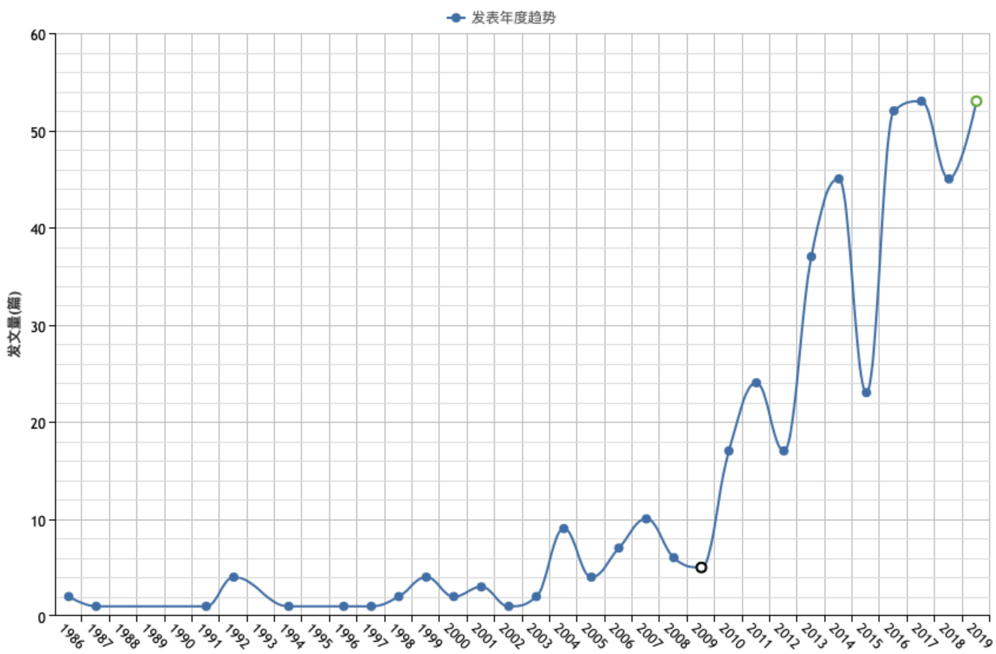

Fig. 1-2: Graph showing the frequency trend of the term "archaeobotanical remains" (*zhiwu yicun* 植物遗存) in Chinese academic publications (articles in journals and theses). Data from CNKI, 2019[2].

In Yunnan, there is no reported systematic archaeobotanical study being carried out at any archaeological site before the turn of the 21st century (Li, 2016; see Appendix 5). Before the early 2000s, many chance findings of rice grains are reported from Neolithic sites, including at the site of Baiyangcun, the main site studied in this thesis (Chapter 5).

[2] The term "*zhiwu yicun*" has been chosen as it is the one most often employed in titles of academic journals' articles when reporting archaeobotanical data. The data retrieved from CNKI, 2019, however, only includes Chinese language publications, and, thus is a likely underestimation of the current total archaeobotanical work from Chinese sites. Nevertheless, it attests to the recent sharp increase of interest and practice of archaeobotany within Chinese Academia.

Although not systematically, flotation was tentatively employed for a first time at the sites of Mopandi, in 2001, and at Shifodong, in 2003 (Li, 2016). Following, it was employed adopting a systematic sampling strategy during the third excavation campaign of Haimenkou in 2008, and since then soil sampling for flotation and phytoliths collection during excavation has been routinely incorporated in all archaeological excavations across the province (Li Xiaorui, personal comment, 2018; Li, 2016). This is in line with the national trend, and even though some problems still persist, such as the overlooking of weed remains in favour of crops, and the need for a more standardised and systematic way of reporting and classifying ancient plant remains in publications, as well as a bias towards the collection and analysis of macro-botanical remains over phytoliths and other kinds of archaeobotanical remains, the increased attention archaeobotany is receiving will result in a deeper understanding of past populations lifestyles and behaviours, especially in regards to food production, consumption and beyond, which the results of the research outlined in this thesis aim to contribute to.

1.4. Potential contribution of archaeobotanical evidence – macro and micro botanical remains

Archaeobotany focuses on the study of past humans' relationships with plants and their surrounding landscapes, as well as past subsistence practices, agricultural practices, including the evolution and spread of cultivation regimes, and cuisine traditions among other aspects of past humans' life. Two main categories of archaeobotanical materials can be distinguished: macro and micro botanical remains. Although the main focus of this thesis is the study of macro botanical remains, mostly in the form of charred seeds, and to a minor extent, phytoliths remains (see Chapter 4), in this section, I will highlight the different potential contribution and constraints each subset of archaeobotanical material can make in archaeological investigations, so to provide a comprehensive contextual background for the analyses carried out in this thesis.

1.4.1. Macrobotanical remains

Macro botanical remains include seeds and other fruit or plant fragments, as well as the impressions these leave on pottery fragments; additionally, wood charcoal and parenchyma (the starchy storage tissue of plants, mostly underground plants such as tubers) are also broadly considered macro botanical remains (Fuller & Lucas, 2014). These can generally be seen with the naked eye (when bigger than 0.25mm) but require a low-power binocular microscope or a SEM (scanning electron microscope) to fully identify and analyse (Fuller & Lucas, 2014). Macro botanical remains can be preserved by means of charring, desiccation, waterlogging and mineralisation (Pearsall 2000); the most widely used method of collection for these remains is through flotation. A bulk of soil is poured into a bucket of water, or a flotation machine. Then through gently stirring or through water jets placed below the soil, the different density of soil and the organic material included in the soil, such as charcoal and other archaeobotanical remains, causes in the soil sinking to the bottom of the bucket or flotation tank, and the archaeobotanical remains to float. The archaeobotanical remains are collected with a sieve; the material is then dried and examined.

Generally speaking, most macro botanical assemblages include a limited set of plant species present in a given area; specifically, these represent those plant species directly linked with human activities, such as those collected for food, fuel, or manufacturing, and brought back on site and preserved through repeated human behaviours, including crop processing or cooking. For these reasons, macro botanical remains are most often used to make inferences regarding agricultural systems and cultivation regimes, as well as related crop processing activities, through the study of the archaeobotanical assemblage composition and the seeds of field weeds present (e.g. Stevens 2003; Song 2011). Macro botanical remains have also been extensively used in the reconstruction of plant species domestication pathways. Morphological and morphometric analyses, including analysing changes in size and morphology of both grains and other key parts of the plants can inform on specific domestication traits of the species, including how much time it took for a species to reach full domestication. In China, spikelet bases are often used to distinguish wild vs. domesticated rice (i.e. Fuller et al., 2009), and rice grain size, including the ration length: width, and shape has also been successfully used to distinguish between subspecies (Castillo et al. 2016).

New recent technology such as microCT scanning has increased the potential contribution of studying cereal grains pottery impressions and inclusions to investigate plants domestication and use in areas of the world where macro botanical remains usually preserve poorly, such as tropical Southeast Asia (Barron et al., 2017). Through the 3D reconstruction of the grains, these technologies allow us to measure and analyse morphometric and morphologic characteristics in a non-destructive way.

The presence of macro botanical remains in archaeobotanical assemblages relies on human procurement and preservation conditions. Therefore, it is often not possible to study past subsistence practices through macro-botanical remains in areas such as the Tropics, where preservation is very poor, and other remains are better suited (see below).

1.4.2. Microbotanical remains

Micro botanical remains include phytoliths, starch and pollen grains, lipids, and isotopes. These are invisible to the naked eye and require extensive lab processing to extract them from sediment or grain samples, mounting on slides and analysing under very high magnification (at least X200 or more, Pearsall 2000).

Phytoliths are plant silica cells deposited into the soil by plants with inflorescences, leaves, stems and roots (Pearsall 2000). The creation and preservation of these remains depends on the plant metabolism and genetics, as well as on climate and chemical and physical soil conditions (Piperno, 2006). Phytoliths are inorganic, and therefore, preserve in conditions where macro remains might not, such as tropical environments, or in situation of less intensive plant exploitation, such as prior to agriculture, when there is usually very low preservation of macro-botanical remains (e.g. Madella et al, 2002; Pearshall, 2000; Piperno 2011). Under good preservation conditions, phytoliths retain diagnostic characteristics of shape and size of the taxa they belong to, which can enable their identification. For example, recent studies on *Echinochloa* have successfully set a baseline of diagnostic morphological characteristics that allow to identify *Echinochloa* subspecies as well as *Echinochloa* vs. other millet species from phytolith remains (Ge et al., 2018). This greatly improves identification potential, and allow to investigate issues of past plant exploitation, as well as more broadly vegetation and environmental conditions present at archaeological sites (Piperno, 2006: 21), especially in absence of other types of archaeobotanical remains. Finally, grass phytoliths can provide indication of past water availability, through the analysis of the ratio of “sensitive” and “fixed” morphotypes (Madella & al., 2009; Jenkins, et al., 2011; Weisskopf & al., 2015). The deposition of sensitive morphotypes is environmentally influenced by the level of water availability through the life cycle of the plant. Fixed morphotypes, instead, are genetically determined, and are deposited in the soil regardless of the water intake of the plant throughout its life cycle. The ratio of sensitive to fixed morphotypes, in association with the presence of crop phytoliths, can inform us about possible irrigation practices and general water availability. The presence of crop remains is necessary to ascertain that phytoliths and the signature they provide are directly correlated with crop waste, and not other plants that could have naturally occurred. Through this type of analysis, past crop cultivation ecologies and early agricultural irrigation practices have been successfully investigated both in China and India (e.g. Weisskopf et al., 2012; Kingwell-Banham 2019a; Kingwell-Banham 2019b).

Phytoliths can be damaged mechanically, and only a limited number of species produce diagnostic phytoliths that allow for species identification.

Starch grains derive from the intercellular starchy storage component of plants. The specific shape of the starch grains is determined taxonomically, therefore allowing for identification of certain plant families, sometimes to the genus or species level (Torrence & Barton, 2006; Piperno, 2011). Starches can be extracted from surfaces and residues of objects that came in contact with the plants, such as harvesting or crop processing tools, storage or cooking vessels and other artefacts as well as from the dental calculus, therefore providing direct evidence of past human diet. In China, starches have provided evidence of pre-agriculture multiple plants usage in the Lower Yangzi Region, specifically highlighting the role *Echinochloa* might have had in the early subsistence system of the region (Yang et al., 2015).

Pollen grains are microscopic particles produced by the male reproductive organ of flowering plants (the anther, located in the stamen); they are responsible for the fertilization and reproduction of these plants. Pollen grains can deposit in the soil, and their study from archaeological sediments can provide indication of vegetation composition (palaeoecology, e.g. Pearsall, 2000; Tarasov et al., 2006), as well as changes in broad subsistence practices, such as deforestation, agricultural intensification (e.g., Dimbleby 1985; Li et al., 2009; Li et al., 2010). A few crop species produce diagnostic pollen grains, including maize, job tears, and buckwheat, therefore, pollen grains form these plants are also useful to investigate past exploitation, especially in lack of relevant macro botanical and other archaeobotanical remains. However, pollen grains cannot be directly dated, and thus rely on the dating of the archaeological context from which they are derived.

Finally, isotopes, lipids and related molecular biomarkers from organic residue and/or paleosoils are also considered micro-botanical remains that can successfully inform on past plant exploitation, local cultivation, and plant species spread. Different values of stable-carbon isotope $\delta^{13}C$ allow to differentiate C3 (i.e. wheat, barley, rice) from C4 (i.e. maize, sorghum, etc) plants (Lightfoot et al, 2018). This distinction has important implication in the reconstruction of palaeodiets.

Similarly, different values of geochemical biomarkers allow to distinguish input from plants vs. animal resources, such as fish (Shoda et al., 2018; Craig et al., 2007). These can therefore inform on composition of past subsistence regimes. Recently, the individuation of a specific biomarker for *Panicum miliaceum* (miliacin, i.e. Motuzaite-Matuzeviciute et al, 2016; Heron et al 2016; Courel et al, 2017; Wang et al, 2017) from organic residue on pottery vessels and from palaeosoil stratigraphically linked with pits, has allowed to investigate the spread of this crop to Europe, its local cultivation, as well as patterns of millet preparation and consumption.

CHAPTER 2. Theoretical and Archaeological Background of the Origins of Agriculture and its Spread in East Asia

2.1. Introduction

In the past decade considerable progress has been made toward the understanding of how plant and animal species became domesticated in different areas of the world, and how this brought about the earliest agricultural systems. A recent review by Larson et al. (2014) individuated at least 11 different domestication foci across the five continents. According to the authors, the Near East is the earliest region were plant domestication took place, at around 10,000 years ago; in China new research has proposed that the domestication of plants happened at about 9-8000 years ago (Larson, et al., 2014).

This chapter includes a brief review of the current knowledge on the domestication of those plant species which have direct relevance to the study area of this dissertation. These include rice, foxtail and broomcorn millets, buckwheat, *Chenopodium* (fat hen), *Echinochloa* (barnyard millet), and soybean. Their domestication trajectories is discussed, as well as their more general botanical background, highlighting seasonality, and main required growing conditions (i.e. temperature, maturing period, water requirements; see table 2-3 for a summary of optimal growing conditions of crops mentioned in text). The domestication trajectory and botanical background of wheat and barley are also discussed here, as these two crops, although not domesticated in China, had an important role in the late Neolithic subsistence of Southwest China. Finally, theories regarding the spread of agriculture, including both examples from studies on agricultural spread in other parts of the world, as well as theories that have informed the spread of agriculture to Southwest China, will be introduced as a comparative framework.

Definitions of key terms

Three main terms are widely used when discussing the origins and production of plant species: domestication, cultivation, and agriculture.

Domestication: the biological and genetic changes that occur in plants after human intervention (see Helbaek, 1960; Harlan, 1975; Harris, 1989).

Human intervention is broadly defined here as the (conscious or unconscious) selection for specific plants' characteristics (or traits) that are often considered the most advantageous for the intended use of said plants. However, often they emerge as a result of the cultivated environment, combined with harvesting and sowing.

In the past, the selection for these traits happened through evolutionary processes over lengthy periods of cultivation.

Cultivation: the variety of human activities undertaken in the production of plants, such as preparing the soil, sowing, weeding, harvesting, and so on (Fuller, 2011a).

It has been demonstrated that an extended period of continuous cultivation resulted in the domestication of plants. Past studies on the domestication trajectories of the main crop species still utilized in our society have demonstrated how their domestication was reached after a relatively long period of time, in which cereals were under human management consisting of tillage, harvesting and sowing, called "pre-domestication cultivation", that lasted up to some millennia, with plants "undergoing domestication" [3] (Fuller, et al., 2014). Following this cultivation/pre-domestication phase, the so-called domestication traits, also called domestication syndrome, emerged (Harris & Hillman, 1989; Fuller, 2007a).

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[3] *Undergoing domestication* is used here to indicate the time period when changes to the plant morphology are still happening; morphological and morphometric characteristics of a population of plants are not fully wild, neither fully domesticated.

Full domestication indicates when all morphological (and molecular) changes have become fixed in the plants, these is also represented by the switching on and off of specific genes.

Domestication traits: broad changes that occur in domesticated plants and differentiate them from their wild ancestors. These include both morphological changes in size, shape of plant parts, as well as in their life-cycle behaviour.

Common domestication traits in plants include the loss of natural seed shattering, loss of seed dormancy, increase in seed size, and thinning and lightening of the seedcoat (Fuller & Allaby, 2009).

Recent genetic studies on domesticated cereals have also shown that some of these phenotypic changes are controlled by specific genes in the plant genomes; the "switching on or off" of these genes during domestication resulted in their fixation in the plant genome (i.e. Doebley et al 2006; Purugganan 2019).

The fixation has also been explained as dependent on the interaction between competing pressures, including gene flow, agricultural behaviours, environmental conditions, and not least by the specific gene inheritance mode in plants (Brown et al, 2009; Allaby 2008; Fuller & Allaby, 2009).

Edge effect

It has also been posited that the fixation of the domestication genes might be an "edge effect", happening when a population is at the geographical boundaries of its species distribution, and it achieves reproductive isolation that allows for the changes to become fixed (Jones & Brown, 2016).

Significance of wild-relative diversity hotspots in domestication studies

In studying past domestication pathways, it is useful to consider the modern wild-relative distribution of a species, and areas of genetic diversity which can provide insights on the most likely areas where hunter-gatherers started exploiting the species, and therefore pinpoint likely centres of domestication (i.e. Hunt et al, 2018).

Finally, *agriculture* indicates the specific subsistence mode of a society, the economical reliance of a population on the cultivation of domesticated plants for its subsistence (Stevens & Fuller, 2017).

The domestication of plants, on one hand simplified their gene pool, with a reduction in genetic diversity in comparison to their wild progenitors and making them more vulnerable and dependent on humans for reproduction and maintenance. On the other hand, domestication also reduced the range of plant species humans were relying on for their subsistence (Dodson & Dong, 2016), in what has been called the "entanglement and entrapment of agriculture" (Fuller, et al., 2016).

2.2. The Origins of Agriculture in China

2.2.1. Domestication studies in China

The origin of agriculture has been a topic of interest among Chinese scholars ever since the beginning of modern Archaeology in the country. The first evidence for cereals exploitation came from an impression, produced by rice grains, on a Neolithic potsherd found by J.G. Andersson at the Yangshao village, in Henan, in 1929 (Ho, 1977). Following this find, Andersson proposed that "rainy Southern Asia" was the homeland of rice domestication (Andersson, 1934), and set the course for the next decades of research around three main topics (Lu, 1999):

- Where did agriculture originate in China?
- What species were indigenously domesticated?
- What agricultural technology was employed?

In 1970 Li (1970) published "The origin of cultivated plants in Southeast Asia", a comprehensive review of domesticated species in East Asia, and their specific origin within that region. The area considered for his study and called by Li "Southeast Asia" comprised the broad region falling between the Gobi Desert, North China, and part of the Korean peninsula to the north, the Himalaya and Tibetan Plateau to the west, and Insular Southeast Asia (including the Philippines and Sumatra) to the south. Many of Li's hypotheses regarding species' original domestication centres were not supported by archaeological or archaeobotanical evidence, which was still largely lacking at the time. Li's theories were instead based on historical accounts and modern evidence of wild species distribution. In 1979 he also published a translation with commentaries of the AD 304 work of Chi Han, "A Fourth Century Flora of Southeast Asia," which complements his 1970 publication, as well as summarizing the kind of historical resources he was basing his hypotheses on.

Li further divided his study region into four main sub-regions, or latitudinal belts, as shown in fig. 2-1. The dividing criteria were based on phytogeography and ethnobotany information.

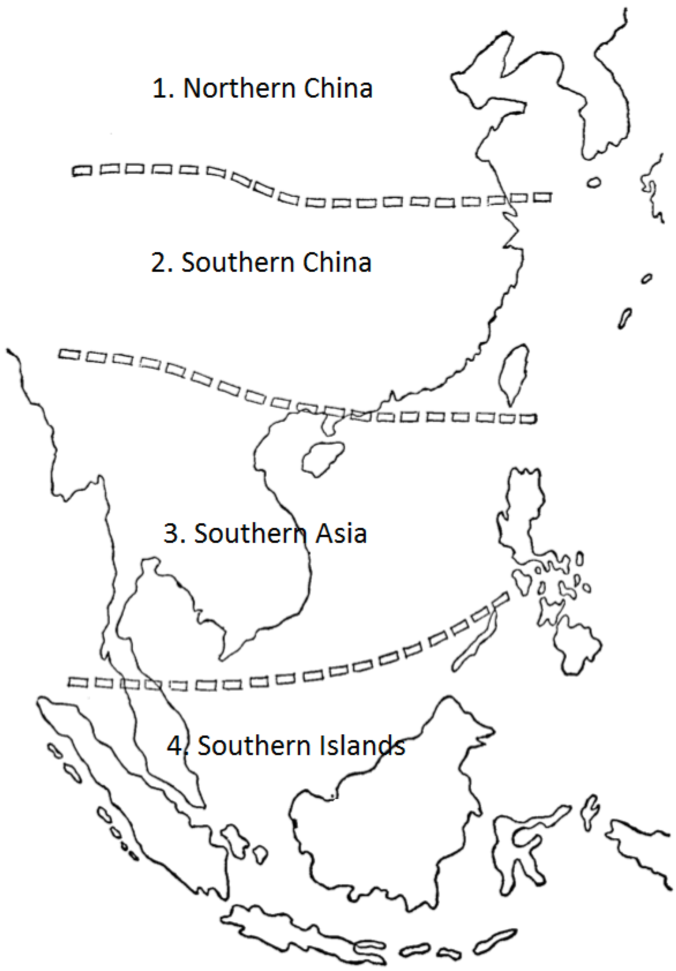

Fig. 2-1: Li's latitudinal belts on the origin of domesticated plants in East Asia. Redrawn from Li, 1970.

The first belt, Northern China, included the Yellow River Valley, Northeast China and the Korean Peninsula, with the Qingling Mountains marking its southern limit (fig. 2-1: 1). This region is characterized by the presence of loess soil, and by a cold and temperate climate. According to Li, the main domesticates from this region were millets, several fruit trees, and soybean.

The second belt, Southern China, included the area between the Qingling Mountains on the north and the Nanling Mountains on the south, with emphasis on the Yangzi River Valley (fig. 2-1: 2). This region presents a warmer and wetter climate compared to the first region and included parts of subtropical South China. He proposed that here tea, many vegetables, citrus fruits and some aquatic root crops were domesticated.

The third belt, "Southern Asia" (mainland Southeast Asia), included tropical continental Asia, Burma, Thailand, and the Indo-Chinese peninsula (excluding the Malay Peninsula, fig. 2-1: 3). Li identified this region as the domestication centre for rice, as well as tropical tuber crops and vegetables. This was also the main region discussed in Chi Han's botanical treatise, where he highlighted the almost insignificance of legumes to the agriculture of the region, as well as strong reliance on animal resources and on external influences (Li, 1979).

Finally, the fourth belt, “Southern Island Belt” (insular Southeast Asia), included the Malay Peninsula, Indonesian Islands, the Philippines, and Sumatra (fig. 2-1: 4). This region has a fully tropical environment. According to Li, this region is characterized by an abundance of tropical fruits, no important cereals, or legumes, and the near absence of vegetables.

With the expansion of archaeological research across East and Southeast Asia, as well as the more systematic use of scientific methods such as flotation for the recovery of ancient plant remains in archaeological sites, many of Li’s theories can now be evaluated. An updated version of Li’s list of domesticates and their place of origin, including Li’s original hypotheses with corrections, is provided in Appendix 1.

2.2.2. Major Chinese domesticates

Numerous plant species were domesticated in China. These include two species of millet, rice, and possibly buckwheat, soybean, tea, several *Brassica* varieties, hemp, and several fruits such as oranges, tangerines, peaches, apricots, and pears (see Dodson & Dong, 2016 for the latest review on domesticates in East Asia, and Simmons, 1990 for a comprehensive collection of plant species and their uses in China). Generally speaking, the domestication of grain crops received relatively more attention and investigation compared to the other plants.

2.2.2.1. Rice

Domestication trajectory

Before archaeobotanical flotation was systematically applied in archaeological excavations in East Asia, it was long held that rice domestication occurred somewhere between Northeast India, Southwest China, Upper Myanmar, Northern Thailand, Laos, and North Vietnam (Rocheviz, 1931; Ramiah, 1937; Chatteerjee, 1951; Chang, 1964; Morinaga, 1967; Chang & Bunting, 1976; Li, 1970). This view was mainly supported by studies on the modern distribution of wild populations, as well as historical and mythological accounts from Chinese texts (Chang & Bunting, 1976; Li, 1970). In the 1920s and 1930s, wild rice populations were found in Guangdong by agronomist Ding Ying, as well as in Yunnan. Moreover, Yunnan province had the highest concentration of wild rice species, and for this reason it was seen as the most probable centre for rice domestication (Chang & Bunting, 1976; Xu, 1998; Li, Y., 1975; Wang, 1977; Li, 1981). This view claimed that rice agriculture originated in the Yunnan-Nepal-Assam-Myanmar region, and from there it diffused northward to the Yellow River Valley, and eastward through Vietnam following a coastal route to the lower Yangzi Basin (see fig. 2-2). Some linguistics evidence was also used in support of this hypothesis (Chen, 1989).

A somewhat similar hypothesis proposed that the centre of rice domestication was Southeast Asia (Li, 1970), from where it would have spread north to China and west to India.

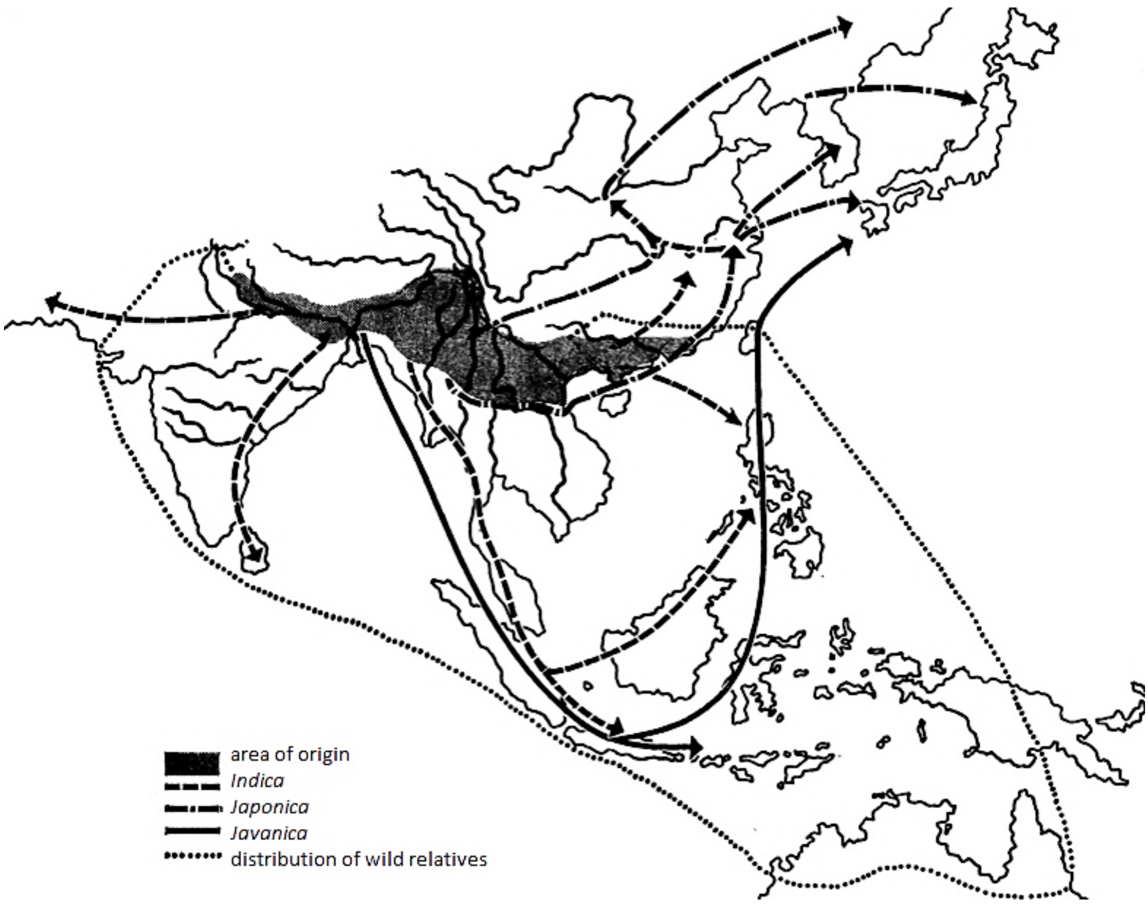

Fig. 2-2. Wild rice populations distribution and Yunnan rice spread hypothesis. Redrawn from Li 1970.

Recent studies on rice domestication have highlighted how modern-day distribution of wild populations might not be necessarily a true reflection of the original centre for rice domestication (Fuller, 2011a). With the increasing inclusion of systematic archaeobotanical investigation in more major excavations around China, more hard evidence has been accumulated, leading to the dismissal of those theories.

Genetic studies on rice grains have also contributed to the debates surrounding the single vs. multiple origins of domesticated rice, including an early attempt at sequencing of the rice genome (i.e. Choi et al, 2017; Huang et al, 2012; Civan et al, 2015; Garris et al., 2005; Huang & Han 2005- Goff et al. 2002; Yu et al. 2002; Sang & Ge, 2007a). Through the comparison of modern and wild population genotypes, wild progenitors of rice species have been individuated in *Oryza rufipogon* as the wild progenitor of *Oryza sativa* subsp. *japonica*, the rice species domesticated in China (Choi et al., 2017). *O. nivara*, instead, is considered the main wild ancestor of two Asian rice subspecies, *indica* and *aus*. *Aus* rice shows close genetical relationship with *indica* rice (Garris, et al., 2005). Some scholars argued for *aus* rice independent domestication (Civán, et al., 2006), however, recent genetic studies seem to suggest that *aus*, similarly to *indica*, resulted from gene flow between a distinct wild population with *japonica* rice (Choi, et al., 2017). *Aus* rice divergence was probably the most recent to develop among the three, taking place at around 6000 years ago (Choi et al., 2017).

Most recent genetic studies have also contributed to better understanding the specific loci responsible for rice domestication traits (i.e. Izawa et al., 2009; Thurber et al., 2013), including white seed hull colour (Bh4; Zhu et al. 2011; Sweeney et al. 2007); seed shattering (qSH1 and sh4; i.e. Konishi et al. 2006; Li et al. 2006; Sang & Ge 2007b; Lin et al. 2007; Zhang et al. 2009); and erect plant structure (PROG1; i.e. Jin et al. 2008; Tan et al. 2008).

Japonica rice cultivation began in the Yangzi Valley at around the 7th millennium BC (Fuller et al., 2016); the fixation of domestication traits occurred by 6000 BC at the latest (Fuller, et al., 2010). Domestication traits for rice include the development of non-shattering spikelet bases; increase in grain size, especially width; a more erect growth of plants; and white grain pericarp (Fuller et al., 2010).

Three possible domestication centres for rice have been identified in China (see fig. 2-3 for location of sites mentioned in text):

1. Lower Yangzi Valley;
2. Middle Yangzi Valley;
3. Han and Huai River Valley.

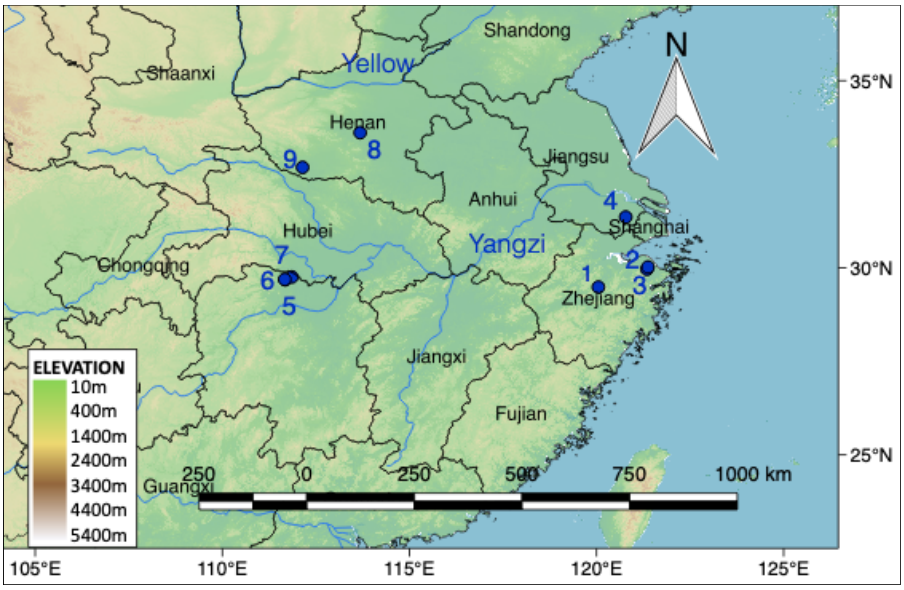

Fig. 2-3: Locations of rice domestication sites mentioned in text: 1. Shangshan; 2. Hemudu; 3. Tianluoshan; 4. Caoxieshan; 5. Pengtoushan; 6. Bashidang; 7. Chengtoushan; 8. Jiahu; 9. Baligang.

Within the Yangzi Valley, the lower Yangzi region is so far the best studied area for early rice agriculture and proposed as one of the three possible centres for the domestication of rice in China. Major sites in this area are Shangshan Culture sites, dated to about 7000 BC, and the waterlogged sites of Hemudu and Tianluoshan, located in the Yangzi River Delta, dated to about 5000 BC. Their excavation and the high number of well-preserved ancient rice remains provided essential data for the understanding of the domestication process of the crop (see Fuller, et al., 2009; 2014). Detailed rice morphometrics and spikelet base analyses from Tianluoshan contributed significantly in understanding the pre-domestication cultivation pathway of rice. Here, recovered rice spikelet bases show a clear increase in domesticated (non-shattering) forms through time. Following this study, the analysis of rice spikelet bases became widely used to distinguish the domestication vs. wild nature of archaeologically recovered rice remains. At Tianluoshan rice was under cultivation but hunting and gathering practices were also still taking place, as shown by the large quantity of acorns found through flotation (Zhao, 2011; Fuller & Qin, 2010).

The analyses of rice remains at early sites along the Lower Yangzi Basin showed that rice underwent a period of long domestication process lasting at least 2-3 millennia. The crop became fully domesticated at around 4000-3800 BC, as shown by Caoxieshan remains. At Caoxieshan very little wild food was recovered, the great majority of spikelet bases were of the domesticated type, and preserved field systems were excavated, indicating intensive wet rice cultivation was taking place (Fuller et al., 2009; Fuller, 2011a; Fuller et al., 2014; see also Qin, 2012; Fuller et al., 2016).

Data from the middle Yangzi is less clear. It has been hypothesised that rice became domesticated in this region also at around 6000 BC (Nasu, et al., 2012; Gross & Zhao, 2014). However, sites that yielded rice remains, such as Pengtoushan, and Bashidang, are not very well dated, and spikelet bases were not recovered. Preserved fields for intensive wet rice cultivation were found at Chengtoushan, dating to about 4500 BC (Fuller, 2011a).

More recently, investigation of early Neolithic sites along the Hanshui/ Upper and Middle Huai River Valley has revealed that this could be another centre for early rice agriculture (Gross & Zhao, 2014; Silva, et al., 2015; Deng, et al., 2015; Stevens & Fuller, 2017). New data presented by Deng et al. (2015) proposed that rice reached full domestication in the Hanshui by 6300 BC, and its domestication had also started in the Lower Huai region well before 6000 BC, with the Shushanji Culture (Nanjing, 2016).

Debates exist regarding the domestication status of rice remains found at the site of Jiahu, along the Upper Huai River, in Henan Province, and dated to between 7000-6600 BC (Henan, 1999). Some scholars arguing for its domestication (i.e. Zhang & Wang, 1999; Liu, et al., 2007) and others, instead, arguing that Jiahu rice remains belong to a wild variety that did not participate in the later domestication of the crop (Fuller et al., 2007). The lack of spikelet bases, as we have seen the most reliable method to assess domestication status of rice from archaeological sites, makes rice finds at Jiahu ambiguous; nevertheless, the overall proportion of rice remains at Jiahu is rather small, suggesting that it occupied a minor role, and hunting and gathering were the main subsistence strategies (Zhao & Zhang, 2009).

Botanical background

Oryza sativa subsp. *japonica* can be further divided in several varieties according to their different requirements for optimal growth. According to its water requirement, rice can be either rainfed (upland rice), or irrigated (lowland rice). Rainfed varieties can only grow where there is an annual rainfall higher than 800mm (Jaquot & Courtois, 1987)/ 1000mm (Yoshida, 1981). For this reason, upland (rainfed) rice requires less labour than lowland rice. Upland rice is usually cultivated after forest clearance through slash and burn practices. Lowland rice needs a higher water input than upland rice and can be grown in a spectrum of water systems, from irrigated, to flooded, and fully submerged (Fuller & Weisskopf, 2011).

For *japonica* rice to be able to germinate it needs a temperature of at least of 10°C or higher, however, optimal temperatures for growth are between 20-35°C (Yoshida, 1981), and it needs a period of between 120/130 to 150 days (with an average temperature of at least about 25-30 °C) to successfully ripen (Yoshida, 1981). Generally speaking, *japonica* rice is a summer crop, usually sowed between February and May, and harvested between June and October. Today, in North China rice is planted in April/June, and then harvested in September. In warmer and wetter areas of China, such as South China, double cropping of rice is practiced; the second cropping is planted between June and July, and harvested until November at the latest (Yoshida, 1981).

Moreover, domesticated rice can be further subdivided into temperate or tropical *japonica*, deriving this name mostly from the general climate of the region where the specific variety is grown (Fuller & Weisskopf, 2011). Temperate *japonica* rice is highly sensitive to photoperiodicity (changes in day lengths from season to season); tropical *japonica* instead is less sensitive to changes in day lengths, and requires longer periods for ripening, up to 200 days (Yoshida, 1981). Tropical rice is usually planted in June/July and harvested up until December (Yoshida, 1981).

In Southern China, today *O. indica* rice is also cultivated. This rice species derives from the hybridisation of domesticated *japonica* rice with a hypothesised proto-indica rice, which derived from a *O. nivara* wild population brought under human management and cultivation in the Ganges Valley around the 10^{th}/9^{th} millennium BC (Choi, et al., 2017; Fuller, 2011a; Fuller, 2011b; Fuller et al., 2010; Fuller & Qin, 2010). *Indica* rice has slightly different growing requirements than *japonica* rice, and the ripening season is shorter.

However, to date most of the archaeological rice recovered in early China has been identified as *O. japonica*.

Intensive irrigated rice cultivation in paddy fields often have higher soil fertility through processes of other plants and animals in the systems, including nitrogen fixing *Azolla* ferns, decay of various plant and also the potential inclusion of carp or other fish in the fields (Ellis & Wang, 1997). In addition, various sources of fertilizer, such as from domestic waste or the cleaning out of irrigation canals, can help to enhance field fertility and productivity, and increased input of this kind can be inferred from historical sources for the Lower Yangzi region since the Han period (Ellis & Wang, 1997). Terracotta funerary objects depicting paddy fields with carps have been found in Han tombs in Sichuan and Shanxi provinces (Cai & Morishima, 2002), further attesting their use in rice paddy field cultivation since at least Han Dynasty times.

2.2.2.2. Chinese millets

Domestication trajectory

Two species of millets are believed to have been domesticated in northern China: broomcorn (*Panicum miliaceum*) and foxtail (*Setaria italica*) millets. This hypothesis was first proposed by N.I. Vavilov in the 1920s, and subsequently supported by many scholars, including Ho (1969) and Li (1970).

The wild ancestor of foxtail millet is *Setaria viridis* (green bristlegrass; Eda et al., 2013; Le Thierry d'Ennequin, et al, 2000). Modern day, *Setaria viridis* populations are widely distributed across northern Eurasia, however, the analysis of rDNA revealed that East Asia, and especially Japan, Korea and China show the highest diversity index in modern *Setaria viridis* landraces. Within China, domesticated landraces showing the highest diversity have been individuated in the middle Yellow River Basin (Huang et al., 2014; Wang et al., 2012), indicating this region might be a likely centre for this *Setaria italica* origin. Additionally, clear geographical differentiation was attested in modern *Setaria* genetics between Central Asia, South Asia, and East Asia indicating that genetic exchange between these regions were not common (Eda et al. 2013). A complete germoplasm genome for *Setaria viridis* and *S. italica* has been sequenced (Bennetzen et al., 2012) which will greatly aid in the future genetic studies of these species.

There is not yet conclusive evidence for the ancestor of broomcorn millet and its domestication. The weedy *Panicum miliaceum* var. *ruderale* is distributed across Eurasia and has been indicated as a possible wild progenitor candidate, but others have also been put forward, including *P. repens* and *P. capillare*, however this is a native to the New World and therefore future studies are needed to establish broomcorn millet wild progenitor, and it is quite possible that broomcorn millet's wild ancestor is now extinct (Sakamoto, 1987; De Wet, 2000; Hunt, et al., 2011; Hunt et al., 2014; Hunt et al., 2018; Liu et al., 2018; Miller et al., 2016). Genetic studies on *P. miliaceum* have been more challenging, no complete genome has been sequenced yet, currently available data points to a low genetic diversity in modern landraces, with two major gene pools distinguished in eastern and western China, however, this is accompanied by a high morphological diversity (i.e. Hunt et al. 2011; 2013).

Debates have also focused on a single vs. multiple domestication origin of the species, as many early finds have been reported across separate areas in Northern China, namely in Western and Northeast China (Xu et al., 2019); however, whether these represent separate domestication or exchanges is still unresolved (i.e. Hunt et al., 2008; Hunt et al., 2011; Jones, 2004; Motuzaite-Matuzeviciute et al., 2013). The most recent review and new genetic analyses have proposed that the centre for broomcorn millet domestication might be in Western China, at the limit of the Loess Plateau (Hunt et al. 2018).

Millets ability to thrive under harsh environmental conditions (see below) made their cultivation particularly suitable to early northern and central China, and millet agriculture is considered to have been the essential basis for the emergence of the first Chinese states (Liu & Chen, 2012). A common domestication trait in millets is the increase of grain thickness (Fuller et al., 2014).

Archaeologically, the early occurrence of millets is found in northern China at sites along the Yellow and Wei River Basins dating from the pre-Yangshao to the Yangshao period (c. 7th millennium BC, Fuller et al., 2016).

Recent research conducted on those sites has identified 5 possible centres for the domestication of millets in North China (Stevens & Fuller, 2017; see fig. 2-4 for location of sites mentioned in text):

1. Southern Hebei, represented by Cishan Culture sites;
2. Northern Henan, represented by Peiligang Culture sites;
3. West Shandong, represented by Houli Culture sites;
4. Gansu, represented by Dadiwan sites;
5. Manchuria, represented by Xinglongwa Culture sites.

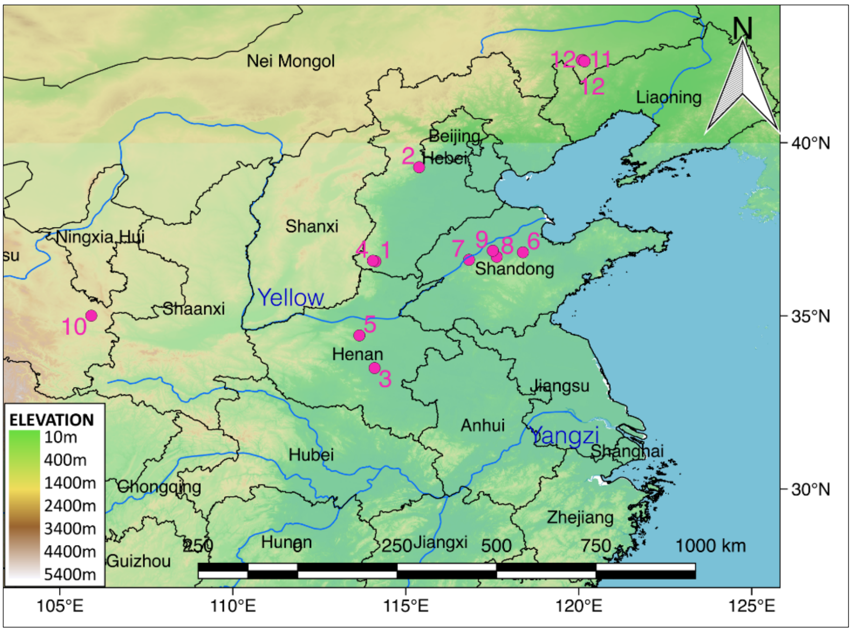

Fig. 2-4: Location of millet domestication sites mentioned in text: 1. Cishan; 2. Beifudi; 3. Shangpo; 4. Niuwabao; 5. Peiligang; 6. Houli; 7. Yuezhuang; 8. Xihe; 9. Xiaojingshan; 10. Dadiwan; 11. Xinglongwa; 12. Xinglonggou; 13. Zhaobaogou.

The first two centres include sites that are roughly contemporary, dating to the 7th/ early 6th millennium BC. These are associated with the Cishan culture, in Southern Hebei, and the Peiligang culture, in northern Henan, named after the main sites respectively, Cishan and Peiligang (fig. 2-4).

The Cishan site was excavated in the late 1970s (Handan & Handan, 1997; Hebei & Handan, 1981), and revealed numerous underground storage pits, where millets husks, ethers, and phytoliths were retrieved (Lu, et al., 2009; Cohen, 2009). It has been claimed (Yan, 1992) that an equivalent of 50 kg of fresh millet was recovered from the 474 storage pits, although this claim is questioned by some scholars (Lu, 1999). Millets from Cishan have been identified as both broomcorn and foxtail millets (Lu, et al., 2009). The main Cishan culture sites are distributed in the North China plain, east to the Taihang

Mountains, and include Beifudi, Shangpo and Niuwabao (Zhu, 2013). However, other than at Cishan, millet remains have been found only at Niuwabao.

Peiligang site, located just south to Cishan and also excavated in the late 1970s (Kaifeng, et al., 1979; Kaifeng & Xingzheng, 1978; Henan, 1984), dates to no earlier than 6500 cal BC (Liu & Chen, 2012). Foxtail millet remains were found, along with stone tools such as sickles, spades and hoes, that might be associated with cultivation activities.

Moreover, charred wild acorns were found at other Peiligang Culture sites, which are distributed along the Jiaru River valley to north of the Funiu Mountains (Zhu, 2013).

Houli culture sites date to about 6500- 5000 BC (Crawford, et al., 2006; Jin, 2014). Most sites are distributed along the alluvial plain north of the Taiyi Mountains (Wang 2013). Foxtail millet remains have been found at the sites of Yuezhuang and Xihe, however no cultivation tools have been retrieved yet, and stable isotope analysis from Xiaojingshan showed that millet consumption made up less than 25% of the total dietary protein intake (Hu, et al., 2008).

Millet consumption is attested from sites in Gansu, such as Dadiwan and Lixian, dated to the early 6th millennium BC (Bettinger, et al., 2010). Small broomcorn millet seeds have been retrieved from Dadiwan, as well as spades for cultivation (Barton, et al., 2009). Later sites' millet grain measurements showed increase in size (Barton, et al., 2009), suggesting that millet in this area had not fully evolved all domestication features until the 4th millennium BC (Stevens & Fuller, 2017).

Finally, in Northeast China (modern Inner Mongolia) at the site of Xinglonggou, large quantities of millet grains, predominantly broomcorn, with smaller quantities of foxtail, were retrieved. Xinglonggou belongs to the Xinglongwa culture, which sites are dated between 6200-5400 cal BC (Zhao, 2011a). Although very few sites within Xinglongwa culture yielded direct archaeobotanical remains for millets, there exist a common cultivation technology tradition that continues to the 4th millennium at the site of Zhaobaogou (Shelach & Teng, 2013).

Although numerous sites dating to the 7th and 6th millennia BC in northern China have yielded evidence for millet consumption and possibly cultivation, such as those seen above, a general lack of hard evidence (and maybe a bias in the recovery of millets through flotation techniques) makes it difficult to establish with certainty where and when this cereal was first domesticated, and how many independent episodes of domestication occurred. Archaeobotanical evidence retrieved at the sites described above showed that grain size was still rather small, indicating that millets were still in the pre-domestication cultivation stage, with full domestication occurring around the late 5th millennium (Stevens & Fuller, 2017).

Botanical background

Millet, although generally described as a warm season crop, can withstand rather harsh environmental conditions, and is cold and drought resistant, surviving well even with minimal rainfall (Weber & Fuller, 2008).

Foxtail and broomcorn millets have slightly different characteristics. Generally speaking, both species grow well in semi-arid conditions, producing grains with 330-350mm of annual rainfall (Oelke, et al., 1990; Lyon, et al., 2008), but withstanding as little as 200mm of annual precipitation (Ceccarelli & Grando, 1996).

Foxtail millet (*Setaria italica*) is frost tolerant, it requires a temperature of at least 10°C or higher to germinate, and it ripens in 60-120 days, with an average temperature of at least 10°C (Liu, 2009).

Broomcorn millet (*Panicum miliaceum*) handles water shortages better than foxtail millet, however, it requires higher temperatures, but a shorter growing season than foxtail millet (Saseendran, et al., 2009). It needs around 20°C to germinate (Kamkar, et al., 2006), and between 45-100 days to ripen (Liu, 2009).

2.2.2.3. Buckwheat

Domestication trajectory

China is home of 16 *Fagopyrum* species, all of which are endemic to Southwest China (Ohnishi and Yasui 1998; Chauhan et al. 2010). These include two currently domesticated and exploited varieties, *Fagopyrum esculentum* (common buckwheat), and *Fagopyrum tartaricum* (tartary buckwheat), and their wild progenitors, *Fagopyrum esculentum* ssp. *ancestralis and Fagopyrum tartaricum* spp. *potanini,* respectively.

The comparison of genetic data between wild and domesticated landraces populations in Southwest China has individuated *Fagopyrum esculentum* ssp. *ancestralis* as the ancestor of common buckwheat (Ohnishi & Matsuoka, 1996; Ohnishi, 2004; Konishi et al., 2005; Konishi & Ohnishi, 2007; Ohnishi, 2009). This species has been found on rocky hills at the border of northwest Yunnan, southwest Sichuan, and eastern Tibet, in a small region of only 250km of radius (Ohnishi 1998; Ohnishi & Yasui, 1998; Ohnishi & Konishi, 2001; Ohnishi & Tomiyoshi, 2005). This has led scholars to hypothesise that buckwheat was domesticated somewhere in Southwest China, possibly even in the *Sanjiang* area (at the crossroad of the Yangzi, Mekong and Salween rivers; see Ohnishi & Konishi, 2001; Konishi, et al., 2005; Ohnishi, 1991; Ohnishi, 1998; Ohnishi, 2004).

Fagopyrum tartaricum spp. *potanini* is considered the possible progenitor of tartary buckwheat. This has also been reported from areas in Sichuan, Tibet, Pakistan, and Kashmir, and to a minor extent in Gansu and Qinghai too (Hunt, et al., 2018). However, no archaeological tartary buckwheat remains have been reported yet from any archaeological sites in China (see table 2-1, fig. 2-5).

A recent paper by Hunt et al. (2018) reviewed the available archaeological and palynological evidence for buckwheat across China. 26 total occurrences of either micro or macro-fossils from archaeological sites were reported. Of these, 14 instances come from pollen remains from a variety of contexts: loess-palaeosol, alluvial sediments, lake cores, peat, and one from an archaeological cultural layer from a historic site in Inner Mongolia (Hunt et al., 2018). 2 instances come from starch remains, and the remnant are constituted by macro-fossil remains throughout both North and South China (Hunt et al., 2018). A few buckwheat nutlets from the site of Haimenkou, in Yunnan, were found, and these are the earliest macrofossil evidence for the species retrieved from archaeological contexts in China so far (Xue, 2010, see table 2-1). At the site of Xueshan, also in Yunnan (south of Kunming), 149 charred buckwheat seeds have been reported (Wang, 2014) but have only been dated through cultural association. Other remains of charred buckwheat, not included in table 2-1, have been found in pottery containers from Han tombs at sites along the Yellow River, however no systematic flotation was undertaken at those sites (Hunt et al., 2018). Finally, four charred buckwheat seeds have been found at two Liao Dynasty sites in Northwest China, dating to the 1st millennium AD (Hunt et al., 2018).

Data from pollen and starches is not well understood, as depositional processes for these remains were not investigated in depth at the sites of retrieval. This makes it difficult to determine whether they are results of human activities, or natural processes, such as the possible presence of wild populations nearby. Moreover, they cannot provide useful indicators on the domestication status of buckwheat, or the certainty of taxonomic status as *Fagopyrum esculentum*. Finally, they lack the potential to have antiquity confirmed through direct AMS radiocarbon dating. For these reasons, only macrofossil remains are considered here, which, by being preserved by charring, are more likely to be indicators of direct human activities (see table 2-1; fig. 2-5).

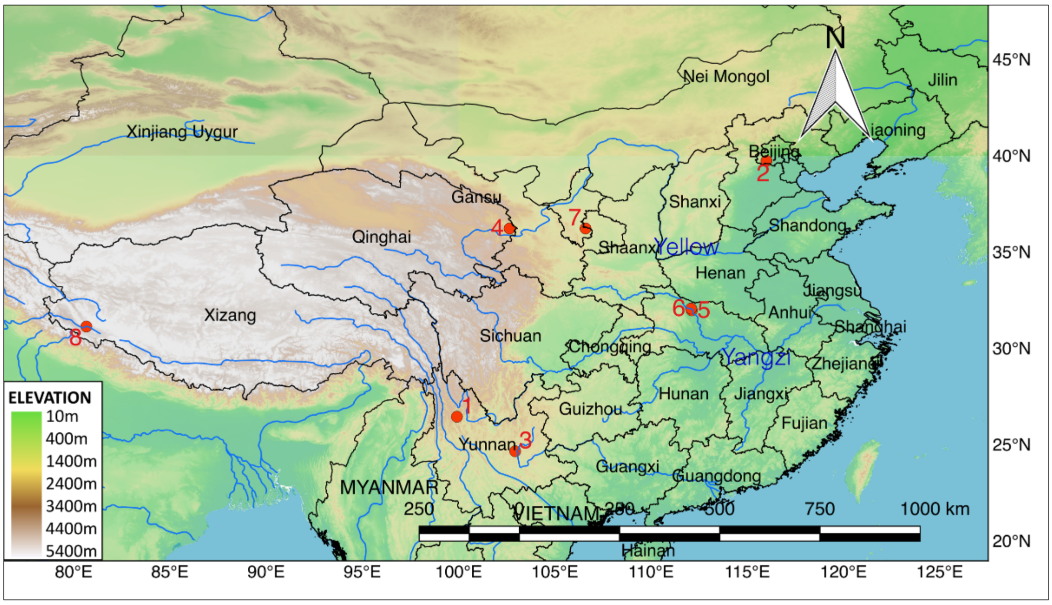

Fig. 2-5: Location of buckwheat sites mentioned in text: 1. Haimenkou; 2. Dingjiawa; 3. Xueshan; 4. Yingpandi; 5. Yangjiawan; 6. Maquan; 7. Mozuizi; 8. Kuyng-lung mesa.

Table 2-1: Archaeological occurrences of charred buckwheat seeds recovered through systematic flotation across early sites in China. Adapted from Hunt et al., 2018.

	Plant remains	Site	Province	Chronology	Dating method	References
1	*F.* cf *esculentum*	Haimenkou	Yunnan	1400-400 cal BC	AMS	Xue, 2010
2	*F. sagittatum (esculentum)*	Dingjiawa	Beijing	c. 700-300 BC	Cultural association	Zhao, 2008
3	*F. esculentum*	Xueshan	Yunnan	c. 430 BC-60 AD	Cultural association	Wang, 2014
4	cf *Fagopyrum*	Yingpandi	Qinghai	250 BC	AMS	Jia, 2012
5	cf *Fagopyrum*	Yangjawan	Shaanxi	c. 150 BC-60 AD	Cultural association	Shi, 1977
6	cf *Fagopyrum*	Maquan	Shaanxi	c. 150 BC- 60 AD	Cultural association	Li, 1979
7	cf *Fagopyrum*	Mozuizi	Gansu	BC 150-70 AD	Cultural association	Zhu, 2011
8	*Fagopyrum* sp.	Kyung-lung Mesa	Tibet	220-880 cal AD	AMS	D'Alpoim et al., 2014

These remains, although extremely preliminary, would suggest that buckwheat might have been widely exploited in the past, from at least c. 1500 BC in Southwest China, as evidenced from charred macrofossil remains, and possibly from the 3rd millennium BC or earlier, based on pollen identification (Hunt et al., 2017; Weisskopf & Fuller, 2013, Boivin et al., 2012).

It is worth noting that there are similar discrepancies in central and western Europe, where well dated macro-remains indicate introduction in Medieval time only (e.g. Rosch, 1998; Rosch, 2005; Brown, et al., 2017; Deforce, 2017), whereas some pollen-based studies locate buckwheat as part of Neolithic Europe (e.g. Konigsson, et al., 1997; Janik, 2002; Jones, et al., 2011; Alenius, et al., 2013). Such discrepancies, together with the fact that to date no morphological or morphometric studies have been undertaken on any of these remains, makes it challenging to assess this crop domestication timing and trajectory.

Botanical background

Buckwheat is considered a "pseudo-cereal". As seen above, two varieties of domesticated buckwheat exist: *Fagopyrum esculentum* (common buckwheat), and *Fagopyrum tartaricum* (tartary buckwheat). The main difference between the two is tartary buckwheat can withstand harsher growing conditions and is currently grown at high altitudes in the Himalayan region. Common buckwheat, instead, is cultivated as minor crop in temperate northern Eurasia, and is not frost-resistant (Kalinova & Mouldry, 2003; Bonafaccia & Fabian, 2003).

Buckwheat is a summer crop, usually planted in June and harvested at the end of the summer. It is very sensitive to harsh environmental conditions (buckwheat is neither frost nor drought tolerant), and it grows most successfully in cold and moist climates, with well-draining soils (Oplinger, et al., 1989). Buckwheat requires at least 5/7°C to germinate, and between 70-90 days to reach maturity, with at least 15 °C temperature during ripening (Kalinova & Mouldry, 2003).

2.2.2.4. Echinochloa

Domestication trajectory

Today, two species of *Echinochloa* are cultivated both as minor human crops and animal fodder: *E. frumentacea* (Indian sawa millet), and *E. esculenta* (Japanese barnyard millet; see Sood, et al., 2015).

E. frumentacea is thought to be domesticated from *E. colona*, which is currently still harvested as a wild cereal in tropical areas of India (Fischer, 1934). Both species show the same genomic constitution (Yabuno, 1962; Yabuno, 1966). Morphologically, *E. colona* has proportionally smaller spikelets, and membraceous glumes than *E. frumentacea* (De Wet, et al., 1983) *E. colona* was possibly domesticated in India, but archaeological examples are scarce. Finds of *Echinochloa* since early Harappan times in Northwest India could relate to domestication in this region, with some evidence of probably domesticated types before the end of the 3rd millennium BC (Murphy & Fuller; 2016: 346; Murphy & Fuller, 2017). Finds from South India may indicate the cultivated form of this species was present by the Iron Age, although samples are limited (Dorian Fuller, personal comment 2019; see also Cooke, et al., 2005; Cooke & Fuller, 2015), while it was cultivated in northern Sri Lanka by c. 100 BC (Murphy, et al., 2018).

(Yabuno, 1987)

E. esculenta (syn. *E. crus-galli* var. *utilis*) has been historically important in Japan as famine food in those regions unsuitable to water irrigation and affected by cold weather conditions (Yabuno, 1987). Early cytological studies on *Echinochloa esculenta* and a wild relative pointed to E. crus-galli as the most likely ancestor (Yabuno 1966), however local differentiation of landraces is still poorly understood (Nozawa et al, 2006). It has also been posited that Japanese barnyard millet was domesticated around the 3rd/2nd millennium BC, as shown by morphometric studies on seed size (Crawford, 2011; Takase, 2009; Crawford, 1983), as well as by sharing genomic constition (Yabuno, 1962; Yabuno, 1966; Yabuno, 1987). *E. crus-galli* is still a very widespread and aggressive weed of irrigated fields in temperate East Asia, which has been reported as successfully growing in a number of different habitats, featuring in dry soils to flooded rice fields, where it can survive in submerged conditions up to 40 days (Maun & Barrett, 1986).

Few reports of prehistoric use of *Echinochloa* are available from China, the most recent from phytoliths and starch analysis on cereal processing stone tools from the Lower Yangzi region. Here, by 7000 cal BC, at the site of Shangshan (Yang et al., 2015; see fig. 2-3:1), *Echinochloa* phytoliths and starches have been found on stone tools, possibly suggesting the use of the wild plant as food resource (Yang et al., 2015). However, morphological or genetic studies are still scarce, and therefore the domestication process of this species is still under investigation.

Botanical background

Echinochloa grows best in areas with at least 650-720mm of annual rainfall, but it can survive with as little as 350-420mm annual precipitation (Rojas-Sandoval & Acevedo-Rodríguez, 2018).

E. frumentacea is cultivated as crop, often in mixed fields, together with other cereals such as *Setaria italica,* and *Eleusine coracana*–finger millet across India. *E. frumentacea* is also cultivated in East Yunnan (Chen & Phillips, 2006), where it's also used in the production of a local alcoholic beverage (Dorian Fuller, personal comment 2017). *E. frumentacea* can withstand dry or semiarid conditions, and it takes usually less than 2 months to ripen (De Wet, et al., 1983).

E. esculenta is currently cultivated in temperate East Asia, including Japan, Korea, and Northeast China, as well as in Yunnan (Yabuno, 1987). Here, is especially cultivated in those areas that do not support irrigated rice agriculture (Yabuno, 1987), and at higher elevation (sometimes above 2000m; Gupta, et al., 2009). Similarly to *E. frumentacea*, barnyard millet has a very short growing period, and it only requires between 45-60 days to ripen (Padulosi, et al., 2009), and it grows best in areas with at least 650mm of annual rainfall. *Echinochloa* is a summer crop and needs about 27-33°C degrees for optimal growth, but it can grow with at least 15-22°C degrees (Muldoon, et al., 1982). *E. esculenta* can generally withstand lower temperatures than *E. frumentacea* and is not sensitive to changes in day length (Mitich, 1990). The ability of *Echinochloa* to grow in unwelcoming environments under harsh conditions have generated recent interest in the study of this species as possible "crop for the future" (Sood, et al., 2015).

2.2.2.5. Chenopodium

Domestication trajectory

The genus of *Chenopodium* belongs to the Amaranthaceae (Caryophyllales) family, Chenopodioidae subfamily (Fuentes-Bazan, 2012; Hong et al., 2017). It comprises of between 150-250 annual perennial species, of which only a few have economic importance today, cultivated either as grain crop or as leafy vegetable. These include *C. quinoa, C. pallidicaule,* and *C. berlanderi* subsp. *nuttalliae* in the Americas (Risi & Galwey, 1984; Bhargava et al., 2005) and *C. album* in the Himalayas, and China (Singh & Thomas, 1978; Kapoor & Partap, 1979; Kang, et al., 2012; Kang, et al., 2014). Comparatively more studies have been undertaken to understand the domestication of Americas chenopod cultivars, and they are briefly introduced here to provide a framework for comparison.

Chenopodium berlandieri subsp. *jonesianum* (known as goosefoot) was an exploited domesticated variety (derived from *C. berlanderi* suubsp. *berlanderi*) in pre-maize North America (Smith, 2007); *Chenopodium quinoa* (known as quinoa, and possibly derived from *C. hiricinum*, see Pearsall, 2008: 107) and *C. palludicaule* (common name kanawa), instead, are believed to have been domesticated in the Andean region (Bruno, 2006). Morphological studies of the differences between the domesticated and their wild counterparts have resulted in the recognition of the following domestication traits in chenopod cultivars: a more compact florescence; the loss of natural seed shattering; a thinning of the testa; a lightning and smoothing of the seed coat; increase in seed size heterospermy, and the development of a bigger "nose" (e.g. Bruno, 2006; Smith, 2007). Not all of these traits, however, can easily be detected in archaeobotanical remains, and most archaeological studies aiming to trace the domestication of chenopods have focused on detecting and measuring morphological and morphometrical changes, particularly measuring the progressive thinning of the testa (e.g. Smith, 2007; Bruno, 2006), and the increasing in seed diameter (Fuller, et al., 2014).

No similar studies have been undertaken yet for understanding the domestication of Eurasian chenopod cultivars. In East Asia, *Chenopodium album* (fat hen) is currently cultivated across the Himalayan region as minor (winter) crop, or as famine crop (Partap & Kapoor, 1985a; Partap & Kapoor, 1985b; Partap & Kapoor, 1987). Ethnobotanical surveys undertaken in the late 1970s across the southwestern Himalayan region have found that fat hen was collected by small communities living in remote, isolated, high altitudes (1300-1500m) areas, where its consumption was linked with a poor economic background (Pratap & Kapoor, 1985a).

At least 19 species of *Chenopodium* are reported as present in China, including *C. giganteum* and *C. album* which are cultivated, both for their seeds and leaves, among the Formasan tribes in highland Taiwan (e.g. Fogg, 1983), as well as in Tibetan villages in southern Gansu, where the crop is systematically collected and either exploited as food or traded (Kang et al., 2012; Kang et al., 2014).

A complete chloroplast genomes of *C. quinoa* and *C. album* have recently been obtained through next generation sequencing (Su et al., 2017). Genetically, *Chenopodium* presents great polyploidy (having more than two sets of chromosomes); this has been explained as most likely derived from hybrid speciation processes (Rahiminejad & Gornall, 2004; Bhargava et al., 2006; Fuentes-Bazan, 2012). *C. album* aggregate shows different ploidy levels (i.e. diploid, tetraploid, hexaploid and decaploid) across its subspecies (Mandak et al., 2012). Debates still exist surround the specific ploidy of *C. album* sensu stricto, some proposing it is a diploid or tetraploid (Barghava et al., 2007; Taylor & Mullingan 1968), however, more recently *C. album* sensu stricto has been increasingly reported as hexaploidy (Rahiminejad & Gornall, 2004; Uotila, 1973), possibly derived from the hybridisation of a tetraploid and diploid (Krak et al., 2016).

Archaeologically, *Chenopodium* remains have been reported across temperate Eurasia dating to as early as the $7^{th}/5^{th}$ millennium BC in China (e.g. Lee, et al., 2007;

Zhao, 2007), and 6th/5th millennium BC in Europe (e.g. Bakels, 1978; Boogard, 2004; Bogaard, 2011; Kreuz & Schafer, 2011; Knorzer, 1967).

In China, however, these usually constitute a small percentage within the overall archaeobotanical assemblage recovered at a specific site and are dismissed as potential exploited crop and instead routinely regarded as a weed of dryland cultivation.

In Europe, notable finds of high quantities of charred *Chenopodium album* ($18cm^3$) have been reported from the pre-Roman Iron Age site of Gordin Hede in Denmark, where *Chenopodium* remains were found in a vessel inside a house, and therefore interpreted as intentionally collected for food (Helbaek, 1954; Stokes & Rowley-Conwy 2002). Further in support of this, *Chenopodium* grains were also recovered from the stomach of several peat bog bodies (i.e. the Tollund Man and Grabaulle Man; Helbaek, 1958; Helbaek, 1950).

Finally, in India, large quantities of *Chenopodium album* have been retrieved from sites dating to the Harappan Rojdi period (2500-1700 BC, Weber, 1991).

More recently, rather high quantities of charred *Chenopodium* grains have been found at Haimenkou, in Yunnan, dating to about 1500 BC (Xue, 2010; see fig. 2-5:1).

All these finds prompt discussions on the most appropriate way to classify *Chenopodium* remains from archaeological contexts, and how to distinguish when this species was exploited for food. To date no systematic reporting of morphometric measurements or any other morphological description of archaeological *Chenopodium* grains is available in the published literature. For these reasons the only criteria employed by scholars to explore the domestication status of archaeological remains of *Chenopodium* has been the quantity of the crop in the overall archaeobotanical assemblage, implying that high quantities indicate exploitation and possible domestication. Until more morphological studies are undertaken on early archaeological *Chenopodium* remains, its domestication trajectory in the Old World remains unclarified.

Botanical background

Chenopodium album presents non-shattering utricles, apical dominance, heterospermy, and seed coat colour variability (Partap & Kapoor, 1985b). *Chenopodium album* is a summer crop, usually planted in April/May, and harvested in

September/October. It needs a temperature of about 10-15°C to germinate, and of about 15-20°C to ripen (Partap & Kapoor, 1985). In the areas of the Himalaya where it is currently cultivated, annual rainfall is attested between 400-1200mm, most of which falls between June and September. *Chenopodium* is non-dormant, providing a 100% germination rate (Partap & Kapoor, 1985). Return rates of fat hen are broadly similar to those of other cultivated cereals, such as wheat, making this species a very viable alternative in times of failed harvests (Stokes & Rowley-Conwy, 2002).

2.2.2.6. Soybean

Domestication trajectory

The wild progenitor of soybean (*Glycine max*) is *Glycine soja*. Li (1970) proposed that the soybean was domesticated in China; this view is still generally accepted today, although the majority of scholars now believe that there might have been multiple domestication events, occurring within the wide area comprised between northern and central China (along the Yellow River Basin), Japan and possibly Korea (i.e. Lee, et al., 2011; Xu et al., 2002).

The Yellow River Basin as one of the centres of origin for the domesticated soybean has been supported by genetic studies highlighting the high degree of SRR diversity (i.e. Li et al., 2008; Dong et al., 2004; Li et al., 2013). This has also recently been supported by studies on the global diversity of modern soybean landraces (Liu et al., 2019).

As opposed to multiple domestication centres, a few scholars also argue for a single domestication origin, to be individuated in South China, due to the high diversity in modern wild populations (Gai et al., 2000; Wen et al., 2009; Guo et al., 2010). Finally, a disjunct population has also been found in Southwest China (Dong et al., 2011).

Few studies have been made in understanding the genes involved in the domestication traits of soybean, including pod shattering patterns (Funatsuki et al., 2005), and seed coat thinning and permeability which are traits believed to be controlled by multiple genes (possibly 4 genes, Sakamoto et al., 2004).

Archaeologically, the increase in seed size has been used as main measureable morphological characteristics (Lee et al. 2011; Fuller, et al., 2014; Fuller et al., 2011). Early finds of archaeologically preserved soybean seeds have been reported at the sites of Jiahu (fig. 2-6; 7000-6600 BC; Zhao & Zhang, 2009), Baligang (6700-6500 BC; Deng, et al., 2015), and Bancun (6000-5000 BC; Kong, et al., 1999). At those sites, soybean might have been in a pre-domestication phase, as the grains were rather small and within the wild-range size in relation to the modern crop measurements.

Within China a possible domestication centre has been identified in the Yellow River Basin, where seed size increases during the Yangshao period into the Longshan period (4th and 3rd millennium BC, see Lee et al., 2011; Fuller et al., 2014). Charred remains of soybean have been reported in Southwest China only at two early sites (fig. 2-6): Yingpanshan in Sichuan (ca. 3300 BC, Zhao & Chen, 2011), and Baiyangcun in Yunnan (2500-1800 cal BC, Dal Martello et al., 2018).

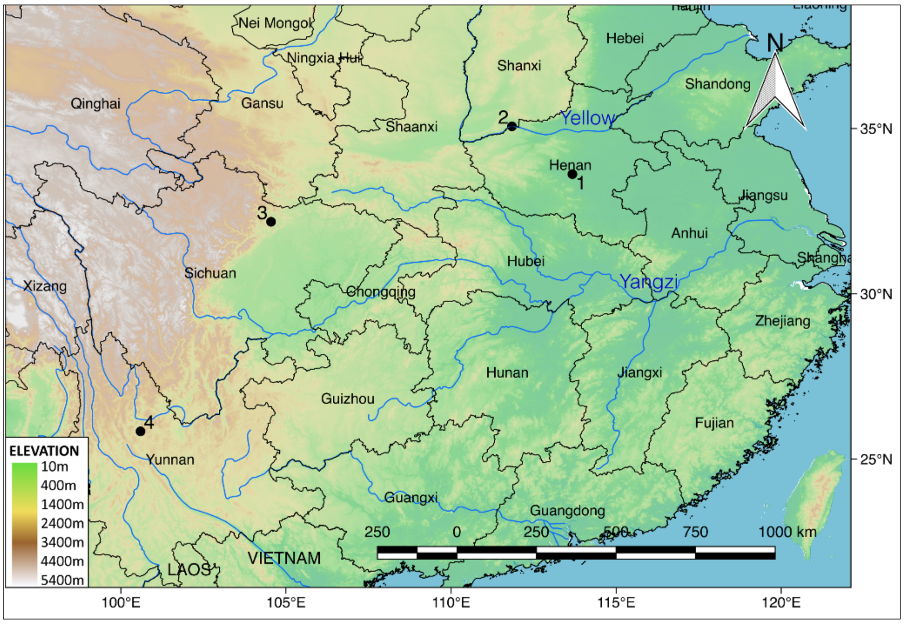

Fig. 2-6: Location of early sites in Southwest China with finds of soybean: 1. Jiahu; 2. Bancun; 3. Yingpanshan; 4. Baiyangcun.

Botanical background

Soybean is grown during the warm season. It is usually planted in spring, sown in June/ July, and harvested 70-90 days after 50% flowering (Yadav, 2002). Soybean is photoperiod sensitive and requires 600-800mm of water and 25-30°C temperatures for optimal growth (Yadav, 2002). As with other pulses, soybean is considered "green manure"; this crop can be used in conjunction with several other crops in rotation or through inter-cropping to restore nutrients in the soil (Zohary, et al., 2012).

2.2.2.7. Selected fruits

Peach & apricot

Prunus persica (syn. *Amygdalus persica*, peach) belongs to the Rosaceae family. The peach tree is a deciduous tree widely distributed across temperate regions of the world, which starts producing fruits after the 2nd/3rd year of life, and gradually declines in productivity after 10-15 years (Bassi & Monet, 2008). The wild ancestor of modern domesticated peach is unknown (Lu & Bartholomew, 2003), or even possibly extinct (Yazbek & Oh, 2013). Recent genetic studies have proposed peach underwent either a single domestication with subsequent development of several feral varieties, or multiple independent domestications for each variety (Akagi, et al., 2016).

China is considered by many scholars as the centre for the domestication of peach (e.g. Li, 1970; Keng, 1974; Huang, et al., 2008; Weisskopf & Fuller, 2014). Early Chinese historical texts described the northern region as the centre for peach domestication (Keng, 1974), and although several wild varieties are still found here today, this is contradicted by early archaeological remains, which are mostly found along the Yangzi Basin and in Southwest China (Fuller & Stevens, 2019).

To date, the earliest evidence for peach has been found at sites of Kuahuqiao and Tianluoshan, along the Lower Yangzi Basin, in Zhejiang Province, dating to between c. 6000-5000 BC (Zheng, et al., 2014). The excellent preservation conditions present at the sites allowed for the recovery of abundant plant remains, including high quantity of acorns and rice (which was undergoing domestication). Peach stones at both sites were recovered from pit contexts (Zheng et al., 2014). Based on morphological and morphometric analysis, the authors of the study recognized at least two different populations present at the sites of Kuahuqiao and Tianluoshan. These also differ from later peach stone remains found at the Liangzhu sites of Bianjiashan, Maoshan, and Qianshanyang, dated between c. 3300-2300 BC (Zheng et al., 2014). At these sites, peach stones have been found from a variety of contexts associated with other food remains, including rice, melon, foxnut, water chestnut, apricot, etc., and they have morphological characteristics resembling those of the modern fruit (Zheng et al., 2014). Overall, peach stone remains from early archaeological sites in the Lower Yangzi show a decreased round shape through time, accompanied by a substantial increase in overall size during the 4th/3th millennium BC (Zheng, et al., 2014). This would suggest a long domestication process for peach, that lasted at least 3 millennia, and the Lower Yangzi as a possible centre of its domestication (Zheng et al., 2014).

China has also been proposed as one possible centre of the domestication of apricot (*Prunus armeniaca*, syn. *Armeniaca vulgaris*), although its wild ancestor is also still unknown (Fuller & Stevens 2019). Modern wild populations are found all across China, and early archaeological finds are equally dispersed across the country (Fuller & Stevens, 2019: fig. 10). Both peach and apricot trees usually flower in March-April and produce fruit in August-September.

2.2.3. Western domesticates: Wheat and Barley

A brief overview of the domestication trajectory and botanical background of wheat and barley is included in this section, as these two crops become later incorporated in the agricultural regimes in China, especially those of Early Southwest China. Their revision is therefore particularly relevant for the themes and topics of this dissertation.

Domestication trajectory

Wheat

Wheat was domesticated in the Near East around c. 8000 BC (Zohary, et al., 2012). To date, the only wheat variety that has been recovered from China has been the so-called bread wheat-*Triticum aestivum*, an hexaploid species that exist only in cultivated form was until recently believed to be derived from the crossing of the tetraploid *T. dicoccum* (domesticated emmer wheat) with the diploid *Aegilops tauschii* (a wild weed species; Zohary, et al., 2012: 47; Salamini et al., 2002; McFadden & Sears, 1946; Kihara, 1944). However, more recent genetic studies have indicated that *T. aestivum* more likely dervived through introgressions of free-threshing tetraploid wheat *Triticum turgidum* with *Aegilops tauschii*, with later back-crossing with *T. dicoccum* giving rise to spelt wheat (Dvorak et al. 2012). Hexaploid wheat has been attested in Turkey as early as 6,600-5,800 BC, suggesting that *T. aestivum* might have first developed in that area (Nesbitt et al., 2001).

The main domestication traits attested in *Triticum aestivum* include the evolution from a tough to a brittle rachis (controlled by the gene *br;* Gill et al., 2007; Salamini et al., 2002), softening of the glume and free-threshability (controlled by recessive mutations of the *Tg* gene on the *Q* locus; Jantasuriyarat et al., 2004; Simonetti et al., 1999; Kerber & Rowland, 1974); increased seed size (controlled by the fixation of *GPC-B1*; Uauy et al., 2006); a more plant erect growth, and reduced seed dormancy (Dubcovsky & Dvorak, 2007).

Nowadays bread wheat constitutes 90% of the total wheat grown in the world (Zohary, et al., 2012: 47). One advantage of this wheat is that it is free-threshing, thus reducing its processing time considerably.

Barley

Barley (*Hordeum vulgare*) was domesticated in the Near East from its wild progenitor *Hordeum vulgare* ssp. *spontaneum* (Harlan & Zohary, 1966). However, recent genetic studies on wild and domesticated modern barley landraces has revealed a polycentric origin of the domesticated crop, with different genetic contributions from possibly five wild barley source populations, respectively from Mesopotamia, the Northern and Southern Levant, the Syrian Desert and Central Asia (Allaby, 2015; Poets et al., 2015; Morell et al., 2014; Zohary et al., 1999).

There are three main domestication traits that distinguish wild and domesticated barley; these include the evolution from a tough to a brittle rachis, genetically controlled by genes *btr1* and *btr2* (Takahashi & Hayahi, 1964). Phenotypic changes from a 2 to a 6-row spike, genetically controlled by the recessive gene *vrs1*, found in all cultivated phenotypic 6-row barleys (Lundqvist *et al.*, 1997; Komatsuda et al., 1998; Tanno et al., 2002; He et al., 2004; Komatsuda & Tanno, 2004; Komatsuda et al., 2007). Finally, a naked caryopsis, controlled by the recessive gene *nud* (Scholz, 1955; Fedak et al., 1972). These changes gave a considerable advantage to the domesticated crop, making it easier to process for dietary use after harvest, and the development of a 6-row spike, with each spike yielding three times as many seeds than its 2-row counterpart, allowed for the production of a considerably higher overall yield.

Further domestication traits include a reduced dormancy (mostly controlled by genes *SD1* and *SD2*, located in different loci of the chromosomes and separately responsible at times; see Li et al., 2014); a reduced vernalisation period (with spring growing varieties controlled by the *Sgh1 Sgh2 Sgh3*; Takahashi et al., 1963; Takanashi et al., 1968), and a reduced photosensitivity (controlled by *Ppd-H1*; Laurie *et al.*, 1995; Karsai *et al.*, 1997; Decousset *et al.*, 2000).

By about 6500 BC, the earliest evidence for 6-row barley is found in Neolithic sites in Southwest Asia (Zohary, et al., 2012). Following the finds of populations of a variety of *H. vulgare* subsp. *spontaneum* in Tibet in the 1980s, some scholars had argued for a separate origin of domesticated barley in Tibet (e.g. Xu, 1982; Ma, et al., 1987). However, this hypothesis has been dismissed by recent genetic studies (Yang, et al., 2008), and the similarities between modern Chinese barley and Tibetan wild populations (now infesting modern barley fields) has been explained as the result of gene flow after the introduction of domesticated barley to the region rather than independent domestication (Dai, et al., 2012).

The spread of wheat and barley to China

There are still debates on the specific timing and routes these two Western domesticates took to reach China, with both a northern and a southern route possible (e.g. Stevens, et al., 2016; Liu, et al., 2017; Lister et al., 2018).

Finds of wheat and barley grains have been reported from sites in Turkmenistan dating as early as the mid-7th millennium BC (Harris, 2010; Miller, 2003), and in Pakistan dating to as early as the 5th/4th millennium BC (e.g. Petrie, et al., 2010; Thomas & Cartwright, 2010; Desse, et al., 2008; Tengberg, 1998). Later finds in Central Asia have been reported from the site of Sarazm, in Tajikistan, dating to the 4th/3rd millennium BC (Spengler & Willcox, 2013); at Shortugai, in Afghanistan, dating to the second half of the 3rd millennium BC (Willcox, 1991); and at the sites of Anau South, Gonur Depe, and Okaly/1211, in Turkmenistan, dating to about the first half of the 2nd millennium BC (Moore, et al., 1994; Spengler, et al., 2014).

To today, finds of wheat in China have always been identified as free-threshing wheat.

Table 2-2 summarises current knowledge regarding securely dated early finds of wheat and/or barley from archaeological sites in China (see also fig. 2-7; only the earliest occurrence of the crop is indicated per each site, with date given referring to crop on same line when multiple crops are present). According to these finds, wheat first spread from the Near East to Central Asia, and then reached China through an "Inner Asian Mountain Corridor" arriving in Northwest China at the end of the 3rd/ beginning of the 2nd millennium BC (Stevens, et al., 2016). From here, it spreads through the Hexi corridor to Central China, and south to Southwest China (see Stevens et al., 2016; Liu, et al., 2014; Dodson, et al., 2013; Flad, et al., 2010). Whether barley arrived in China in conjunction and following the same route as wheat has not been conclusively determined yet, as interior direct dates on barley grains (on the north-eastern Tibetan Plateau) are earlier than those from both Xinjiang and Tibet, from which the crop would have had to go through when following either a northern or a southern route. At the site of Xiasunzhai, barley grains have been dated to 2136-1959 cal BC (Liu, et al., 2017), whereas at the sites of Sidaogou and Yanghai, in Xinjiang, barley dates to 978-831 cal BC and 750-405 cal BC respectively, and at Khog gzung and Bangtangla, on the south-western Tibetan Plateau, it dates to 1393-1211 cal BC, and 1263-1056 cal BC respectively (Liu, et al., 2017; Lister, et al., 2018). Some scholars advocate for a northern route for barley, similarly to wheat, through the Inner Asian Mountain Corridor, while others advocate for a southern route, through the southern Tibetan Plateau from India, due to earlier direct dates on barley grains from sites in Kashmir (2467-2236 cal BC) than from sites in Central Asia (i.e. Ojakly in Turkmenistan 1617-1498 cal BC; Tasbas in Kazakhstan 1437-1233 cal BC; and Aigyrchal-2 in Kyrgyzstan 1630-1497 cal BC; see Lister, et al., 2018). However, neither Central Asia, Xinjiang, and Northeast India are very well investigated, and due to the very patchy evidence, until more data is available the route through which barley reached China remains unclear; more work is needed in the future to clarify this issue.

Botanical background

Two seasonal varieties of wheat and barley exist: winter and spring varieties. Winter wheat is extremely cold tolerant (it can resist up to -20°C) and needs a period of vernalisation to develop reproductive structures. Winter wheat is planted between September and October and goes dormant until temperatures reach >5°C in spring, after which it flowers (FAO, 2012). It then needs temperatures of about 10-12°C for between 180-250 days to mature before being harvested (Edwards, 2012).

Similarly, winter barley is frost resistant up to -7°C and needs a vernalisation period to flower in spring (North Dakota State University, 2012).

Spring varieties, instead, are not frost-resistant, and are planted in between March and April. Both spring wheat and barley need a maturing period of between 100-130 days, with temperatures around at least 15-20°C (McMaster, et al., 2011), and are usually harvested between July and August (Klepper, et al., 1998; Sanseendran et al., 2009). In terms of water requirement, both winter and spring varieties requires around 450-650mm of water.

In Southwest Asia, barley became domesticated as a winter variety, but early Chinese historical texts dating to the 1st millennium BC indicate that varied sowing and harvesting times were practiced in different parts of China, ranging between spring and autumn sowing, and May and September harvest (Liu, et al., 2017). This could indicate that summer varieties had already developed at least by the 1st millennium BC (Liu, et al., 2017).

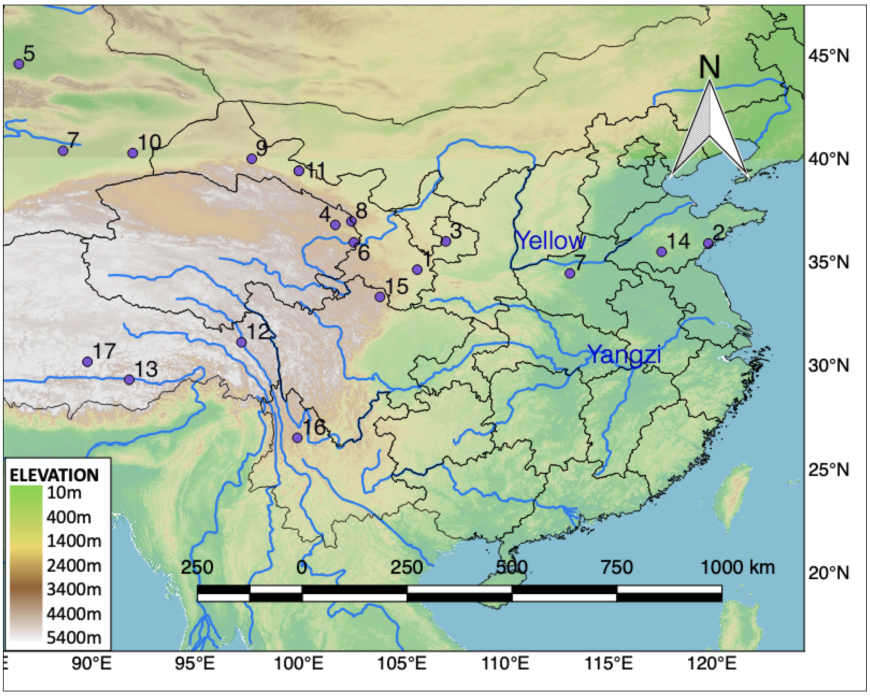

Fig. 2-7: Key sites with finds of wheat and/or barley mentioned in text: 1. Xishangping; 2. Zhaojiazhuang; 3. Laohuzui; 4. Xiasunjiazhai; 5. Huoshiliang; 6. Gongshijia; 7. Wangchenggang; 8. Xiaohe; 9. Huoshaogou; 10. Gumugou; 11. Donghuishan; 12. Karuo; 13. Changguogou; 14. Daxizhaung; 15. A'shaonao; 16. Haimenkou; 17. Khog gzung.

Table 2-2. Finds of early (pre- 1st millennium BC) wheat and barley from China.

Site, Province	Cal. AMS date BC	Crops present	Reference
Xishanping, Gansu	2700-2350	*T. aestivum; H. vulgare*	Li, et al., 2007; Flad, et al., 2010
Zhaojiazhuang, Shandong	2562-2209	*Triticum aestivum*	Jin et al., 2008
Laohuzui, Gansu	2464-2210	*T. aestivum*	Chen, et al., 2015
Huangniangniangtai, Gansu	2172-1746	*Triticum aestivum; H. vulgare*	Dodson et al., 2013
Xiasunjiazhai, Qinghai	2136-1959	*Hordeum vulgare*	Chen et al., 2015; Liu et al., 2017
Huoshiliang, Gansu	2135-1896	*T. aestivum; H. vulgare*	Dodson, et al., 2013
Gongshijia, Qinghai	2118-1894	*Hordeum vulgare*	Chen et al., 2015; Liu et al., 2017
Jinchankou, Qinghai	2021-1891 / 1878-1664	*H. vulgare/ T. aestivum*	Chen et al. ,2015
Ganggangwa, Gansu	2026-1762	*Hordeum vulgare*	Dodson et al. 2013
Changning, Qinghai	2020-1880	*Hordeum vulgare*	Liu et al., 2017
Wangchenggang, Henan	1900-1500	Triticum *aestivum*	Zhao, 2007; Yuan & Campbell, 2009; Flad et al., 2010
Xiaohe, Xinjiang	1896-1697	*Triticum aestivum*	Liu et al., 2016
Huoshaogou, Gansu	1885-1620	*T. aestivum; H. vulgare*	Dodson et al., 2013
Gumugou, Xinjiang	1886-1746	*Triticum aestivum*	Liu et al., 2016
Xintala, Xinjiang	1883-1628	*Triticum aestivum*	Dodson et al., 2013
Heishuigou, Gansu	1880-1535	*H. vulgare T. aestivum*	Liu et al., 2017
Donghuishan, Gansu	1880-1430/ 1625-1451	*T. aestivum; H. vulgare*	Dodson et al., 2013; Flad et al., 2010
Shaoguoliang, Gansu	1876-1533	*Triticum aestivum*	Dodson et al., 2013
Mogou, Gansu	1689-1528	*Hordeum vulgare*	Liu et al., 2017
Karuo, Tibet	1665-1518	*Triticum aestivum*	Liu et al., 2016
Jiaoridang, Qinghai	1514-1412	*Hordeum vulgare*	Chen et al., 2015; Liu et al., 2017
Aiqingya, Qinghai	1501-1323	*Triticum aestivum*	Chen et al., 2015
Sidaogou, Xinjiang	1496-1127	*Triticum aestivum*	Dodson et al., 2013

Table 2-2. Finds of early (pre- 1st millennium BC) wheat and barley from China.

Site, Province	Cal. AMS date BC	Crops present	Reference
Yanshishangcheng, Henan	1492-1319	*Triticum aestivum*	Liu et al., 2016
Changguogou, Tibet	1450-800	*T. aestivum;* *H. vulgare*	Fu, 2001; Jin, 2007; Jin, et al., 2008; d'Alpoim Guedes, et al., 2014
Daxinzhuang, Shandong	1442-1290	*Triticum aestivum*	Liu et al., 2016
Tawendaliha, Qinghai	1437-1288	*Hordeum vulgare*	Chen et al., 2015; Liu et al., 2017
Xiariyamakebu, Qinghai	1431-1283	*Hordeum vulgare*	Chen et al., 2015
Luowalinchang, Qinghai	1417-1213	*P. miliaceum* *S. italica* *H. vulgare* *T. aestivum*	Chen et al., 2015; Liu et al., 2017
Huidi, Qinghai	1416-1216	*T. aestivum;* *H. vulgare*	Chen et al., 2015
Hongshanzuinanpo, Qinghai	1417-1261	*Hordeum vulgare*	Chen et al., 2015; Liu et al., 2017
Qiezha, Qinghai	1415-1236	*Hordeum vulgare*	Chen et al., 2015; Liu et al., 2017
Lagalamaerma, Qinghai	1411-1231	*Hordeum vulgare*	Chen et al., 2015; Liu et al., 2017
A'shaonao, Sichuan	1400-1000	*T. aestivum;* *H. vulgare*	d'Alpoim Guedes, et al., 2014
Haimenkou, Yunnan	1400-600	Triticum *aestivum*	Xue, 2010
Dongfengxinan, Qinghai	1392-1123	*Hordeum vulgare*	Chen et al., 2015; Liu et al., 2017
Shuangerdongping, Qinghai	1391-1211	*Triticum aestivum*	Chen et al., 2014
Kalashishuwan, Qinghai	1388-1134	*T. aestivum;* *H. vulgare*	Chen et al., 2015; Liu et al., 2017
Khog Gzung, Tibet	1390-1050	*Hordeum vulgare*	Liu et al., 2017
Bangtangbu, Tibet	1263-1056	*Hordeum vulgare*	Liu et al., 2017
Tuanjie, Qinghai	1226-1014	*S. italica* *P. miliaceum* *H. vulgare*	Chen et al., 2015; Liu et al., 2017
Erfang, Qinghai	1209-1011	*S.italica* *P. miliaceum* *H. vulgare* *T. aestivum*	Chen et al., 2015; Liu et al., 2017
Weijiabao, Qinghai	1207-1008	*P. miliaceum* *H. vulgare*	Chen et al., 2015; Liu et al., 2017

Table 2-2. Finds of early (pre- 1st millennium BC) wheat and barley from China.

Site, Province	Cal. AMS date BC	Crops present	Reference
Wenjia, Qinghai	1195-979	*S. italica* *P. miliaceum* *H. vulgare* *T. aestivum*	Chen et al., 2015; Liu et al., 2017
Wupaei, Xinjiang	1188-911	*Triticum aestivum*	Dodson et al., 2013
Bayan, Qinghai	1111-941	*T. aestivum* *H. vulgare*	Chen et al., 2015; Liu et al., 2017
Talitalliha, Qinghai	1108- 917	*Hordeum vulgare*	Chen et al., 2015; Liu et al., 2017
Caodalianhuxi, Qinghai	1083-906	*Hordeum vulgare*	Chen et al., 2015; Liu et al., 2017

Table 2-3. Summary of growing requirements for main species mentioned in text.

Species	Frost resistance	Min. temp. for germination	Flowering optimal temp.	Annual rainfall mm	Days required to ripen	Notes
Oryza sativa	None	10°C	20-35°C	Irrigated; Rainfed: at least 800-1000	120/130-150; Tropical: up to 200	Temperate variety is photoperiod sensitive
Setaria italica	Some	10°C	16-25°C	200-330/350	60-120	Drought resistant
Panicum miliaceum	Some	20°C	20-25°C	200-330/350	45-100	Drought resistant
Fagopyrum esculentum	None	5/7°C	15 °C		70-90	
Echinochloa frumentacea	None	15-22°C	27-33°C	350/420-650/720	45-60	
Chenopodium album	Some	10-15°C	15-20°C	400-1200	90-120	
Glycine max	None		25-30°C	600-800	70-90	
Triticum aestivum (winter variety)	High (-20°C)	-7°C	10-12°C	450-650	180-250	Requires vernalisation
Hordeum vulgare (winter variety)	High	-7°C	10-12°C	450-650	100-130	Requires vernalisation
Triticum aestivum (spring variety)	Some	4°C	15-20°C	450-650	100-130	
Hordeum vulgare (spring variety)	Some	4°C	Above 12°C	450-650	60-100	

2.3. The spread of agriculture: a comparative framework

Being the focus of this research to trace how agriculture spread to and beyond Southwest China, this section will not include a review the origins of agriculture in other parts of the world, but rather it will set a comparative framework regarding the main theories and approaches that have been employed by past scholars in explaining the spread of agriculture from a centre of origins to its surrounding regions. For a comprehensive review of the domestication of plants and the origins of agriculture for the Old World see Zohary, et al. (2012); for the New World see Smith (1995).

Agriculture can arise in an area either independently, through the domestication of local wild plant species, or secondarily, through the introduction of domesticated plant species that did not evolve from local wild ancestors (Fuller, 2011b: S350).

Those areas where domesticated crops evolved from local wild ancestors through cultivation, are usually defined as "primary centres for domestication" of a certain species, and the core area for that species agricultural origins. In this regard, the cultivation of a plant species can be "pristine", if stemmed from local population of hunter-gatherers that had no contacts with farmers; "inspired" if result of contacts between hunter-gatherers and farmers; "additive" when farmers already possessed other crops (Fuller, 2011b).

The spread of agriculture outside its core areas has been explained as the result of either

1. migration, following the movement of agriculturalists and their crops/animals from an area to another, also referred to as "demic diffusion" (Bellwood & Renfrew 2002; Fuller, 2011b);
2. or adoption, following the obtaining of new crop plants through trade/contacts, also called "cultural diffusion".

A variety of approaches have been employed to attest which of the two was responsible for the spread in specific regions, including linguistics, ancient DNA, analyses of archaeological material culture (ceramics, stone tools and other implements, features), radiocarbon dating, archaeobotany, and zooarchaeology among others (Bellwood & Renfrew, 2012).

Linguistic studies focusing on the spread of language families have long been employed to attest and explain the spread of agriculture, in what has been called "the farming/language dispersal hypothesis" (Bellwood & Renfrew., 2012). The main assumption behind this theory is that an increased population caused more pressure on resources, leading to the migration of part of the population into the surrounding areas. This spread can be traced linguistically, through the close examination of vocabulary related to agricultural practices and food plants terms. This kind of demic diffusion linked with the expansion of agriculture has been attested through ethnographic studies in Borneo, where native Iban swidden rice cultivators would periodically spread to neighbouring areas following demographic increase (Freeman, 1970).

DNA evidence has also been successfully employed in testing theories of demic dispersal, on the assumption that migrating populations would leave a traceable genetic mark. Mitochondrial-DNA and Y-chromosome DNA analyses from Neolithic sites in Europe have both shown a Near Eastern contribution in the genetic pool of early European farmers (although the percentage of this contribution is still debated; see Pinhasi, et al., 2005). Similar analyses in Southeast Asia (Bellwood, et al., 2011; Matsumura & Oxenham, 2014) have shown an inferred genetic relationship (from skeletal remains) between mainland Southeast Asia early Neolithic populations with earlier Northeast Asian populations, thus supporting demic diffusion arguments proposed by the Austronesian languages dispersal hypothesis. Although the precise point of origin and the timing of these spreads is still debated, genetic analyses have added support to the linguistic and archaeological evidence for demic diffusion.

Ancient DNA analyses on skeleton remains from sites in mainland Southeast Asia have recently individuated that parts of the population present at early sites, specifically at Man Bac (2100-1600 BC) in Vietnam, and at Ban Chiang (1500-400 BC) in Central Thailand was of shared descent with modern Austroasiatic speakers (Lipson et al., 2018). The authors argue that this "provides genetic support for the hypothesis that agriculture was first practiced in mainland Southeast Asia by (proto-)Austroasiatic-speaking migrants from southern China" (Lipson et al 2018: 3). However, these data could not fit with the adoption of farming from China into Austroasiatic speaking groups in the

Neolithic (see Chapter 8). Moreover, we lack comparable genetic data from Yunnan, or any other Southwestern Chinese provinces, as similar ancient genetic studies have not been undertaken at any of the sites analysed in this thesis. This is not to say that there were no contacts between Yunnan and Southeast Asia during the 3rd and 2nd millennia BC, but simply that we need to use caution with our assumptions and inferences.

Changes in typologies of material culture has been shown to reflect the arrival of new cultures into an area, such as the appearance of the so-called Cardial pottery in Southeast Europe, or that of Linear pottery in Central Europe, which in conjuction with changes in the archaeobotanical and faunal assemblages have been interpreted as evidence for the arrival of Neolithic colonisers (e.g. Price, 2000; Bellwood, 2005a; Bellwood 2005b; Bogucki, 2000; Bogucki, 2003; Scarre, 2002).

Finally, plant remains, being naturally the direct evidence of plant production and consumption, have been used to identify changes in plant use and the point at which domesticated crop cultivation becomes visible within the archaeological record. Equally, they can be used to identify cultural change, with approaches to archaeobotany and archaeology increasingly incorporating analyses of food culture and preferences over the last decade (e.g. Fuller & Rowlands, 2011; Smith, 2006; Twiss, 2012; Spataro & Villing, 2015).

The need of “genetic adaptation of crops to the different climatic conditions” that existed outside their domestication centre has been regarded as one of the possible reasons for the delay often attested in the agricultural spread outside its core regions (Harris, 1989). This genetic selection process needed before the crops can successfully move and be grown in new environments results in the emergence of a subset of diversified cultivars within a species (e.g. Isern & Fort, 2010; Isern, et al., 2012; Bogucki, 1996; Bonsall, et al., 2002). However, in addition to crop evolution, agricultural adaptation can also happen through cultural processes of innovation in cultivation (Fuller & Lucas, 2017). Therefore, while moving plants to these areas, the emergence of different cultivars corresponds with the emergence of diversified agricultural systems, each with different specific ecologies (Evans, 1993).

In northern Europe, another possible explanation for the delay in the spread has been attributed to the possible high presence of local hunter-gatherers, with which migrants would have had high competition over land control and ownership, therefore slowing the advance of the spread (e.g. Isern et al., 2012).

Finally, the spread of agriculture outside its original domestication area has recently been explained as a three stages process (Stevens & Fuller, 2017):

1. First, cultivation technologies reach areas where wild populations of the same species exist, and cultivation activities replace collecting practices;
2. Secondly, not yet fully domesticated species extend within the ecological limits of the wild progenitor species;
3. Finally, fully domesticated species spread beyond the original ecological limits of the wild progenitor, and eventually adapt to new ecological conditions. Semi-domesticated taxa can also spread outside their initial domestication centre, as attested for wheat moving to Cyprus (Lucas, et al., 2012).

In the second phase, the accumulation of surplus resources allowed an increase in human population, and it has been suggested that in the 3rd phase language families spread along with the spread of agriculture, possibly through migrations (Stevens & Fuller, 2017).

2.4. The Spread of Agriculture to Southwest China: a review of the current evidence and theories

2.4.1. The Farming/Language Dispersal Hypothesis in the Context of Southwest China

Current scholarship argues that agriculture in Yunnan originated following southward movements of agricultural communities from Central China (Zhang & Hung, 2010), who then possibly migrated further south, spreading agriculture to mainland Southeast Asia (Higham, 2004). This has been informed by studies surrounding the Austroasiatic (AA) language family dispersal (e.g. Bellwood & Renfrew, 2002), and has been supported by the fact that the first agricultural evidence in both Yunnan and Southeast Asia dates to at least 3000 years later than that in Central China.

The general theoretical framework behind this theory is the so-called farming/language dispersal hypothesis. First formulated by Renfrew and Bellwood (Renfrew, 1987; Renfrew, 1992; Renfrew, 1996; Bellwood, 2001; Bellwood & Renfrew, 2002), the farming/language dispersal hypothesis proposes that an early spread of the major language families occurred after the establishment of an agricultural lifestyle and the increased population densities it brought about, which ultimately led to the migration of part of those communities from their agricultural homeland (see Bellwood, 2005b for an overview of the hypothesis in the East Asia context). This hypothesis has received widespread support among scholars, however Fuller (2011a) has highlighted that, although the migration of farmers certainly played a role in the spreading of agriculture, other contributing factors might have also been involved, such as diffusion and adoption, and these need to be kept in mind when researching this issue.

In the context of the AA languages dispersal, the so-called “Austric hypothesis” (Reid, 1996a; Reid, 1996b; Blust, 1996; Higham, 1996a) also gained prominence for discussing the transition to an agricultural lifestyle in Yunnan. First proposed by Schmidt (1906), according to the Austric hypothesis, AA and Austronesian (AN) languages shared a common ancestor, named Austric. AA languages including the Munda languages in Eastern India and the Mon-Khmer languages in mainland Southeast Asia (see fig. 2-8); AN languages instead are spread across insular Southeast Asia and include the Malay-Polynesian languages (see fig. 2-9).

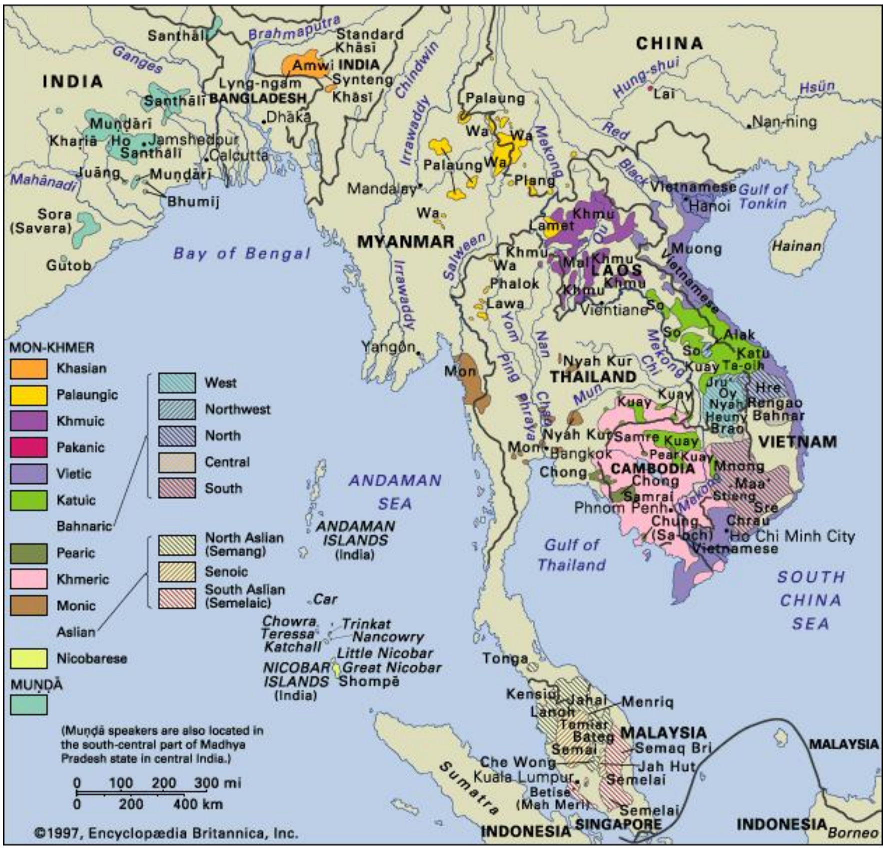

Fig. 2-8: Major divisions and modern geographical distribution of Austroasiatic (AA) languages. Image taken from Encyclopaedia Britannica, Inc. url: https://www.britannica.com/topic/Austroasiatic-languages/images-videos/media/44541/2104 accessed on 10/04/2019.

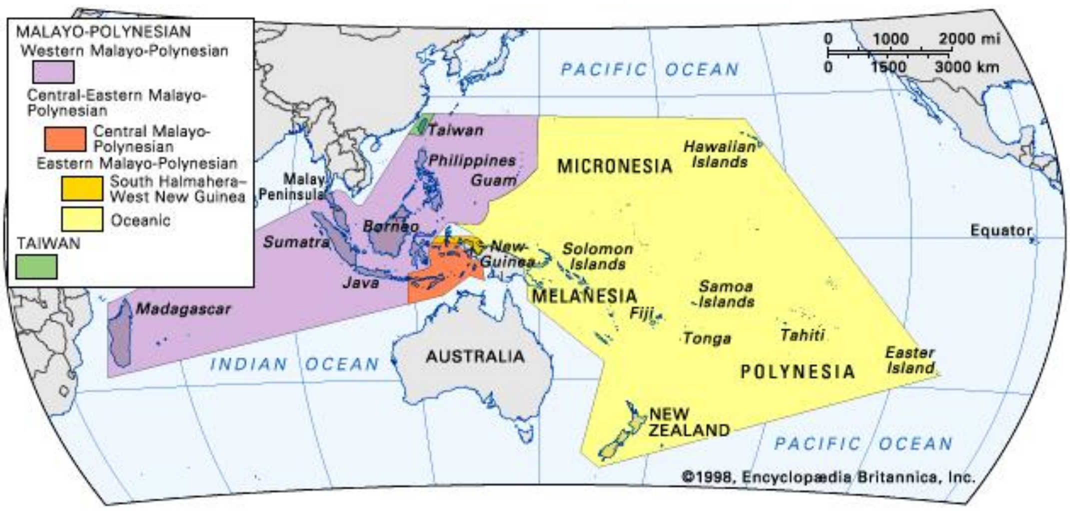

Fig. 2-9: Major division and modern geographical distribution of Austronesian (AN) languages. Image taken from Encyclopaedia Britannica, Inc. url: https://www.britannica.com/topic/Austronesian-languages/images-videos/media/44563/2108 accessed on 10/04/2019.

Schmidt's main argument for the Austric hypothesis was the fact that multiple linguistic similarities between AA and AN languages existed. Although Schmidt presented this idea at the very beginning of last century, the Austric hypothesis gained increasing interest only in the past three decades following works by Diffloth (1994), Reid (Reid, 1996a; Reid, 1996b; Reid, 1999), and Blust (1996). Diffloth compiled a preliminary vocabulary of what he called "lexical agreements", showing the supposed genetic relation between AA and AN. Reid further highlighted the similar morphological and syntactic characteristics that exist between the two families. Finally, Blust located the homeland of Austric speakers along the borders of modern Yunnan and Myanmar, in the *Sanjiang* 三江 area between the Yangzi, Mekong and Salween Rivers (Blust 1996). He thus proposed this area as being the origin point of agriculturalist migrations to Southeast Asia.

This claim found large support in Higham (e.g. 2004; 2002; 1996b). He saw evidence for this single origin of agricultural spread from China to Southeast Asia in the shared incised/impressed pottery remains found at the Baiyangcun site in Yunnan, and in several other sites in Southeast Asia, such as Phung Nguyen, Samrong Sen, Ban Chiang, Non Pa Wai, and Khok Phanom Di sites. Higham hypothesized that the Austric homeland was somewhere along the Yangzi Valley (Higham, 1996a), and suggested that agriculturalists from Yunnan could have moved down following various north-south rivers, such as the Mekong, into Southeast Asia (Higham, 2002; 1996a; 1996b).

Finally, supporters of the Austric hypothesis also proposed that AA speakers spread rice agriculture from Yunnan to India, through the Assam region (Bellwood, 1995; Higham, 2004).

However, the existence of Austric is not widely accepted among scholars. Benedict (1999) believes that the similarities detected between AA and AN are due to "areal factors": geographical vicinity between the two families' original homeland, rather than to a genetic relationship. Sagart (2008) also suggested that Austric has been put forward on the insufficient grounds of morphological similarities only, and he instead proposed a genetic relationship between AN and Sino-Tibetan (ST, see Sagart, 1993; 2001). Sagart proposed that Proto Sino-Tibetan Austronesian (STAN) speakers lived along the Yellow River Basin and would have been responsible for the initial domestication of millet, between 6500- 5500 BC (Sagart, 2005), and its later spread south to Taiwan and Insular Southeast Asia via the Shandong Peninsula. He further proposed that *indica* rice originated among AA speakers in Yunnan and then spread to India (Sagart, 2008). Van Driem also rejects the existence of Austric and attributes the origin of rice domestication to AA speakers, whose homeland is to be found in the Assam/ Yunnan region (Van Driem, 2012). He proposes this as the origin point for the spread of rice cultivation both to the Yangzi Valley (although this spread would involve Tibeto-Burman speakers, see below), and to Southeast Asia.

Finally, other authors have contradicted these theories on the basis that proto-Austroasiatic linguistic reconstructions have failed to find terms relating to wetland rice cultivation, but instead show closer relation with dryland/ hilly cultivation of crops, and lacustrine resources (Sidwell & Blench, 2011; Blench, 2005). According to the model proposed by Sidwell and Blench (i.e. The Southeastern Riverine Hypothesis), proto-AA homeland was possibly located along the middle reaches of the Mekong Basin, and before the introduction of crops into mainland Southeast Asia, they relied on tuber (taro- *Colocasia esculenta*) cultivation and lacustrine resources exploitation (Blench, 2005; Sidwell & Blench 2011). According to the Southeastern Riverine Hypothesis, initial differentiation within the AA language family had occurred already amongst fishing and taro eating groups living along the Mekong Basin, who then underwent rapid geographical expansion (and subsequent linguistic fragmentation) during the Neolithic after cultural changes that included the adoption of (rainfed) rice, and prompted expansion both north-southward, and west-eastward along the broader Mekong Basin and nearby river system (Sidwell & Blench, 2011:338).

As opposed to a route through Yunnan, Rispoli (2007) and Fuller (2011) have proposed a southern coastal route for the spread of agriculture from China to Southeast Asia. According to this theory, agriculturalists from the Middle-Lower Yangzi would have descended to Guangdong and Guangxi through the Lingnan and Pearl Rivers, and finally reached mainland Southeast Asia through Vietnam. The main support for this theory is the fact that, although multiple sites from Yunnan to Southeast Asia do indeed share the same incised/impressed pottery style, possibly indicating a single cultural entity or at least some contacts, interior sites with agricultural evidence up the Mekong and Salween Rivers in Yunnan date later than those sites further south or near the Vietnam coast (see Rispoli, 2007). Rispoli believes that geophysical and environmental constraints in Yunnan, specifically the rugged landscape and high-altitude present throughout the region, caused delays in the beginning of agriculture. She also suggested that, although indeed present, the incised/impressed pottery style remains from sites in Yunnan are more of a sporadic find than a major expression of the ceramic material culture of the region. For this reason, she suggests this kind of remains in Yunnan represent the extreme frontier for the dispersal of rice agriculture through the southern route mentioned above.

Rispoli also proposed that agriculture in Yunnan began following the expansion of Sino-Tibetan (ST) languages from North China. Similarly, Van Driem (2005; 2002; 1999; 1998) argued that Northeast India Neolithic derives from Tibeto-Burman, as he prefers to call this language family, spread from Sichuan through the Himalayas. He further argued for a second spread from Sichuan down to Southeast Asia, but this would have happened only at about 1000 BC. ST/TB languages have been primarily linked with millet agriculture, therefore, according to this theory, the beginning of agriculture in Yunnan was primarily linked with the expansion of millet agriculture, with rice occupying a somehow secondary role in the overall agricultural system.

2.4.2. Archaeological evidence for the spread of agriculture to Southwest China

Following their domestication by around 5000 BC for millets, and by 4000 BC for rice, both species began to spread outside their initial domestication centres. During the 4th millennium BC, millets spread over a very vast area in North China in conjunction with the expansion of the early Neolithic Yangshao culture. Rice is found cultivated together with millets at the Yangshao site of Nanjiaokou, in Sanmenxia (Western Henan, see Stevens & Fuller, 2017; fig. 2-10). So far this is the earliest attested co-occurrence of rice and millet agriculture in Northern China. By the end of the 4th millennium BC several sites show evidence for both rice and millet agriculture; these include Baligang in Henan (Weisskopf, 2014), and Chengtoushan in the middle Yangzi Valley (Nasu et al., 2012; fig. 2-10). After 3500 BC, rice and millet agriculture started to spread further away from their initial domestication centres, reaching areas with no previous attested cultivation, such as Northwest and Southwest China (see Stevens & Fuller, 2017 for a complete list of sites and dates attesting this spread).

Moving into Southwest China, early agriculture is attested at around 3300 BC in Western Sichuan, where millets have been found at the sites of Yingpanshan and Haxiu (D'Alpoim Guedes, 2013; fig. 2-10). At Haxiu, both broomcorn and foxtail millets, along with some fruit species, have been reported, and at Yingpanshan soybean has been retrieved through flotation (Zhao & Chen, 2011; D'Alpoim Guedes, 2013). Finally, cereal crops, specifically broomcorn and foxtail millets, have been retrieved at Karuo, in Tibet, dating to c. 2700-2300 BC (D'Alpoim Guedes, et al., 2013).

D'Alpoim Guedes (2013) suggested that the initial spread of agriculture into Southwest China was linked with the southward Majiayao expansions. According to this hypothesis, this would also explain why millet agriculture is the first to reach this area. Recent scholarship about the spread of agriculture to Southwest China (e.g. D'Alpoim Guedes, 2013; D'Alpoim Guedes, 2015; Chen et al., 2015) supported this theory, at times suggesting that, due to this crop ability to withstand harsher environmental conditions, millet cultivation was the first and most responsible agent for the expansion of agriculture into Southwest China.

Many parts of Southwest China present different ecological and climate conditions from those where agriculture first emerged in China. This is particularly true for rice agriculture, which originated in a lowland type of environment, whereas Southwest China presents a very rugged landscape with differentiated elevation throughout. The whole region is crossed vertically by rivers and has abundant water resources, but less than 10% of the land was originally arable. The region is also under the influence of the subtropical monsoon, which causes strongly demarcated dry and wet seasons, and more than 60% of the total annual rainfall falling in a short period over the summer months (see Chapter 3). The considerable amount of time needed for the crops to adapt and evolve to successfully grow in different ecological and environmental conditions has been seen as the most likely reason for the 3000-year delay that took for agriculture to spread to Southwest China (D'Alpoim Guedes, 2013). In this context, D'Alpoim Guedes (2013) argued that a mixed millet-rice crop agricultural system was adopted in an attempt to minimize crop failure risk in those areas which lied beyond the original ecological zone where the crops came from.

To date, the earliest evidence for mixed millet-rice agriculture in Southwest China is found at Baodun, in the Chengdu Plain (2700-1700 BC; D'Alpoim Guedes, 2013). During excavation, the archaeobotanical remains recovered included *Coix lacryma-jobi* (Jacob's tear), *Vigna* sp., *Perilla* sp., *Crataegus* sp. (Hawthorn), *Sambucus* sp., and *Prunus persica*, which are considered possibly local wild additions. However, the origin of Baodun is still disputed. The many archaeological surveys undertaken in the Chengdu Plain have not attested the presence of earlier settlements (D'Alpoim Guedes, 2013).

Some have attributed this lack of remains to both the frequent seasonal floods, as well as a possible hunter-gatherer's high mobility (D'Alpoim Guedes, 2013). Focusing on the presence of a wall at the site of Baodun and finding similarities with settlements belongin to the Taijiagang Culture, Daxi Culture, Qujialing Culture, and Shijiahe Culture, other scholars have proposed that people at Baodun had contacts with rice agriculturalists in East China (Zhang & Hung, 2010). Yet, other scholars claim that Baodun originates from the southward Majiayao expansion (Huang & Zhao, 2004; Jiang, 2001). Baodun is so far the earliest and only attested evidence for a mixed millet and rice agriculture in Southwest China. To today, in lack of other evidence, Baodun has also been indicated as the ultimate source for the spread of rice agriculture into Yunnan (Stevens & Fuller, 2017).

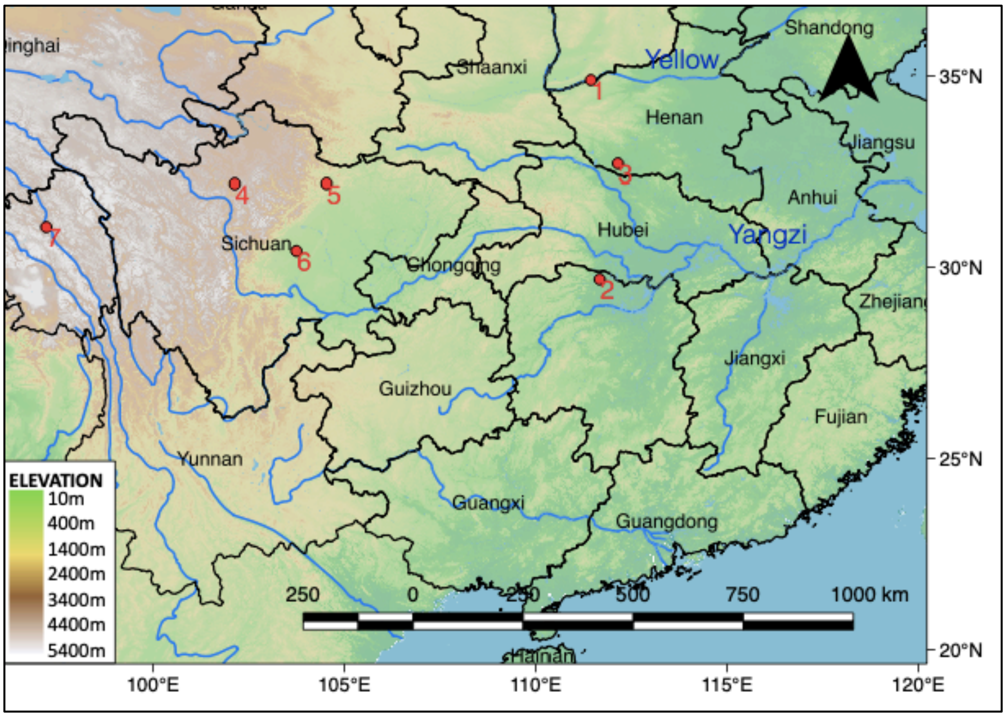

Fig. 2-10: Location of early sites in China with evidence for millet and rice remains, mentioned in text: 1. Nanjiaokou; 2. Chengtoushan; 3. Baligang; 4. Haxiu; 5. Baodun; 6. Karuo.

2.4.3. Prehistoric sites in Yunnan: introduction

Yunnan province has the lowest reported prehistorical site density (less than 1:1000 km^2), together with the provinces of Tibet and Xinjiang (Hosner, et al., 2016[4] after Guojia, 2001). Although this could be due to the somewhat inhospitable topography of the provinces, the shorter history of archaeological research and surveys, as well as the underdeveloped industrial and infrastructural systems in all these three provinces might also be an important contributing factor. The majority of archaeological excavations in China is, in fact, still linked with rescue campaigns associated with the construction of motorways, railways, and other public infrastructures. Unsurprisingly the highest site density is reported from Shandong province (45: 1000 km$^{2;}$ Hosner et al., 2016), an area densely populated and with a long history of archaeological research.

Within Southwest China, sites classified as belonging to "undistinguished Neolithic Cultures" (referring to the time period before the appearance of Bronze/Iron Age type archaeological cultures) are 311 in Sichuan, and these date between 5000-2000 BC; in Yunnan instead, there are only 153 reported Neolithic sites, but these date to between 6000-1000 BC (fig. 2-11; see Hosner, et al., 2016: fig. 2 and fig.3, pages 5-6). Finally, in Tibet 145 Neolithic sites have been reported, dated between 3000-1000 BC (Hosner, et al., 2016). These chronological and quantitative differences might suggest that each province underwent an individual and distinct cultural and social developmental trajectory. However, upon close examination of the data for the province of Yunnan, the so-called "undistinguished Neolithic cultures" sites have actually a much wider chronological range than that indicated in Hosner et al. (2016), including early hominid sites dating to before 6000 BC (Guojia 2001). These group of sites is referred to in the Atlas as "Stone Age sites" (*shiqi shidai* 石器时代; Guojia, 2001: 30-31+54-55), and they notably include the Yuanmou Man site (dating to c. 1,700,000 years ago, with finds of *Homo erectus*, see Chapter 1); the sites of Tangzigou, Mujiaqiao, Zhangkoudong, and Laolongdong, four early Holocene hunter-gatherer sites dated to c. 8000 BC (see below); the Dadunzi and Baiyangcun sites, which recent archaeological work has dated to

[4] The data reported by the Hosner et al. is based on the information listed in the "Atlas of Chinese Cultural Relics" (*Zhongguo wenwu ditu ji* 中国文物地图集) series, a publication edited by the *Guojia Wenwuju* (国家文物局 Chinese Ministry of Cultural Relics), and divided in volumes (one per each Chinese Province) listing all known archaeological sites in each province to date of publication of the Atlas (1999 for the Yunnan Atlas).

between the 3rd millennium BC and the 2nd millennium BC (Jin, 2014; Dal Martello et al., 2018), as well as the Yeshishan site (recently dated to c. 1300-900 BC) and the Qinghuadong site where bronze objects have been unearthed (Liu & Sun, 2009). Therefore, rather than "undistinguished Neolithic cultures", these should be classified as "undistinguished Prehistoric cultures", in line with the Chinese heading from the Atlas (Guojia 2001: 30), and, with the exclusion of the Yuanmou Man site, possibly referring to a chronological range between c. 8000-1500 BC.

It is unclear how these sites became dated to between 6000-1100 BC in Hosner et al. (2016), as the author could not find any reference to such chronological range within the Atlas itself, nor in other publications dealing with Yunnan Prehistoric chronology (e.g. Li & Hu, 2009; Xiao, 2001). Moreover, according to information reported in the Atlas, known (to date of publication of the Atlas: 1999) so-called Palaeolithic sites in Yunnan account to 27, of which 17 have been excavated; Neolithic sites account to 314, of which only 32 have been excavated, and Bronze Age sites account to 205, of which 48 have been excavated. Specifically, among the 314 Neolithic sites, 191 are settlement sites; 7 are cemeteries, and 116 are defined as "locations with evidence of lithics" (*shiqi chutu dian 石器出土点).* Among the Bronze Age sites, 8 are settlements, 121 are cemeteries, and 76 are "locations with evidence for bronze objects" (*qingtong chutu dian 青铜出土点*). This is in contrast with the figure reported by Hosner et al. (2016), which reports a total of 279 sites (as opposed to a total of 519 as outlined in Guojia, 2001: 54-55) across both undistinguished Neolithic and Bronze Age cultures. The number provided by Hosner et al. (2013) is primarily based on coordinate points as outlined in the introductory maps of the Atlas (Guojia, 2001: 30-34), which have been arbitrarily classified as "undistinguished Neolithic Cultures" without taking into account qualitative and, if known, chronological differences between the mapped sites (which are clarified in Guojia, 2001: 54-55). Due to the constraints of this research, as well as to the fact that little to none published information is available for the majority of the sites listen in Guojia (2001), it is not possible to further classify the sites mapped into sub-categories and these are shown here with the unsatisfactory label "Undistinguished Prehistoric Cultures" (fig. 2-11). Nevertheless, the data presented in Hosner et al. (2016) in its current format needs updating and does not reflect, for the province of Yunnan, current understanding on the prehistorical chronology of the province as established by radiocarbon dating on excavated sites (see below).

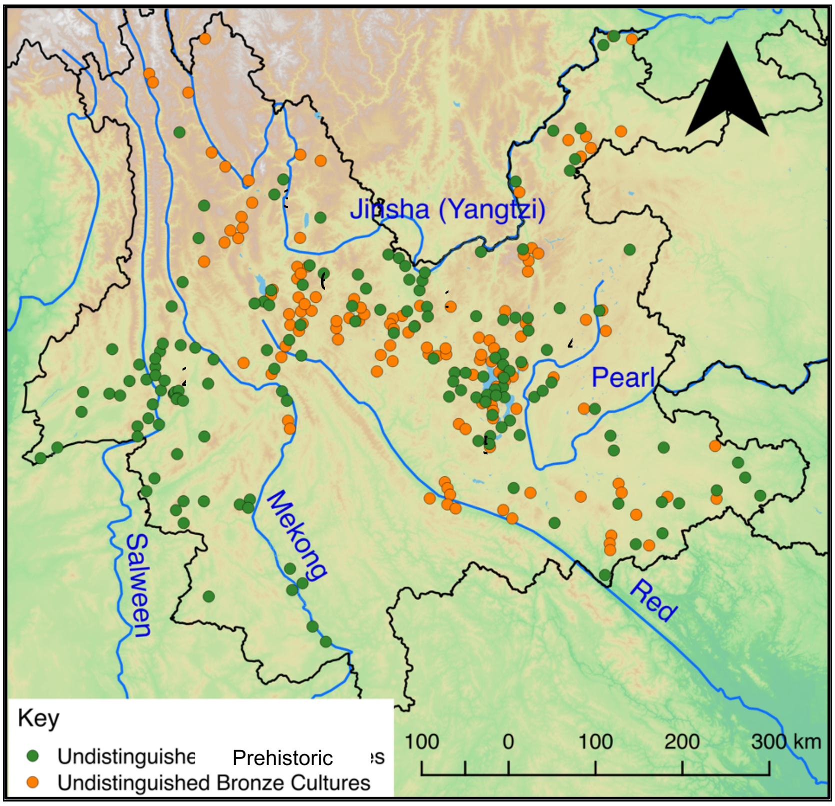

Fig. 2-11: Map showing location of known prehistoric Yunnan sites, including early Palaeolithic to Bronze Age, with indication of location of sites mentioned in text: 1: Yuanmou; 2: Tangzigou; 3: Mujiaqiao; 4: Zhangkoudong; 5: Laolongdong; 6: Dadunzi; 7: Baiyangcun; 8: Yeshishan. Data from Hosner et al., 2016 (from Guojia, 2001), supplemental data retrieved at PANGAEA, https://doi.org/10.1594/PANGAEA.860072 [accessed on 09/07/2019]. Made with QGIS.

2.4.3.1. Early Holocene Hunter-Gatherers in Yunnan

Generally speaking, Yunnan Holocene Hunter-gatherers sites are cave sites (rarely open air) along the main mountain ranges and close to water reservoirs. To date, among the few excavated Palaeolithic sites in Yunnan, two have been systematically investigated and relatively securely dated, ad finds from these sites in presented below (fig. 2-12).

Tangzigou is an open-air site located in the Baoshan Prefecture, along the Pupiao River, in a remote area at the southern edge of the Gaoligong mountains (western Yunnan). It was discovered and excavated in 1987, when it became known as the "Pupiao Man" site, thanks to finds of modern human remains. In 2003 and 2006 further excavations were carried out as part of the Chinese-American collaborative Gaoligongshan Biodiversity Project led by the California Academy of Sciences and the Chinese Academy of Sciences (Jin, 2010; Jin et al, 2012). AMS dating furnished a date of about 9000-8800 ± 40 BP (Jin et al. 2012). Lithic tools retrieved during the last excavation campaigns included flaked choppers and scrapers, as well as few polished stone tools. Faunal remains included small cervids, some large cervids and bovids, as well as some micromammals, such as rodents, which might have also been consumed (Jin, 2010; Jin, et al., 2012). No pottery, open fire or hearth-like structures were found during excavation, and Jin (2010) suggested this indicates that heating through fire and boiling were not part of the subsistence strategies. However, according to analyses on the faunal assemblage, Tangzigou was a rather specialized butchering site and not a camp site, which could be the reason why cooking activities were not detected (Jin, 2010). Analyses on the exploitation strategies also indicated that the Tangzigou people were not under resource stress, and no sign of clear over time intensification of animal resources exploitation has been found (Jin, 2010). This could possibly suggest, as already pointed out by some authors (Liu & Chen 2012: 73) that due to the available abundant natural resources, local hunter-gatherers in Yunnan did not play a big role in the transition to agriculture.

Zhangkoudong is a cave site located about 90km east of Kunming, along the Jinxiang Valley. Discovered in 1989, and excavated the following year, the occupation of the site has been divided into two phases due to faunal assemblage differences in the deep deposit (Hu, 1995). Faunal remains comprised mainly of wild animals such as boar, rhino, deer, and dog. Remains of fully anatomically modern humans were found in the upper stratum, together with a wide lithic assemblage, including flaked scrapers, choppers, hammers, anvils (Hu, 1995). Radiocarbon dates from animal bone remains furnished respectively 14,550 $\pm$ 450 years ago for the early phase, and 9965 $\pm$ 110 years ago for the later phase (Hu, 1995). There is currently no evidence of presence of anatomically modern humans in Yunnan before c. 10,000 BP.

A few other sites, such as Mujiaqiao in Lijiang (Wei et al. 1984), Laolongdong in Eshanyi prefecture (Bai 1998), have been found mostly clustered in Northwestern Yunnan (Li & Hu 2009) yielded anatomically modern human remains associated with a similar lithic assemblage to that found at both Tangzigou and Zhangkoudong; however, they have not been radiocarbon dated and no environmental analyses have been carried out.

The general lack of clear evidence of a Palaeolithic-Neolithic transition during the Holocene reinforces the hypothesis of migrating agricultural communities as the main players in the shift to agriculture in Yunnan. However, the lack of evidence could also be largely due to the insufficiency of systematic archaeological investigation.

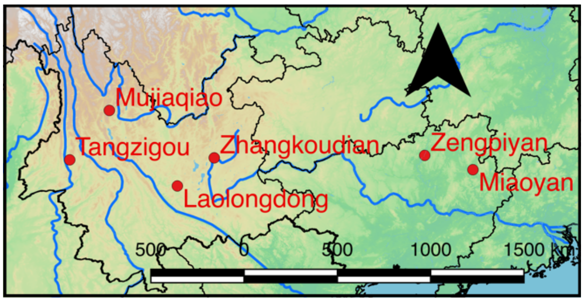

Fig. 2-12: Location of early Holocene sites mentioned in text.

As opposed to Yunnan, there is plenty of Palaeolithic evidence from the surrounding regions, especially from Guangxi, where cave sites are abundant, as well as Southeast Asia (Higham, 2014). In Guangxi, there is also some among the earliest evidence for ceramic remains in South China, dating to around 17,320-14,710 cal BP at the Miaoyan site (Kuzmin, 2006), and at 12,000-11,000 BP at the Zengpiyan site (Pearson, 2005; although the chronology of this site is still disputed). The invention and production of ceramics in these areas do not relate to the emergence of agriculture, instead, it has been hypothesized that ceramic vessels were mainly used to store and cook food in order to increase their digestibility, in the context of an increasingly sedentary life style (Lu, 1999; Pearson, 2005; Fuller & Castillo, 2016; Needham, 2000). The use of pottery and development of boiling practices effectively broadened the range of food resources that could be exploited by hunter-gatherers, as boiling aids the ingestion/digestion of food, including those that need soaking to detox any toxin naturally included in the plant/nuts (Fuller & Rowlands, 2011). This can also be considered as a kind of resources intensification through post-harvest practices (Wollstonecroft, 2007), that slowly prepared the way towards an agricultural lifestyle.

Yunnan was most probably inhabited since as early as at least the 8th millennium BC. However, due to a lack of systematic subsistence analyses from Palaeolithic sites, it is still difficult to determine clearly how late Palaeolithic populations were engaging with the surrounding environment. The faunal records from the Tangzigou site are too limited to be able to make hypotheses about the overall patterns in subsistence strategies in Yunnan before the emergence of agriculture. According to paleoclimate and vegetation reconstruction, in the early and middle Holocene Yunnan was a heavily forested region, with species such as *Lithocarpus, Quercus, Pinus,* and *Castanea* (see Chapter 3). It is safe to assume that local population would have engaged in wild fruits and other edible species gathering, however, the lack of botanical remains data as exploited by hunter-gatherers makes it difficult to determine what kind of contribution local plants had in the subsistence of Yunnan's early Holocene population. For these reasons, assessing what kind of role the local population had (if any) towards the establishment of a sedentary agricultural life style is still a challenging and unresolved task.

2.4.3.2. Neolithic sites in Yunnan

According to the available published literature, there is no reference to a so-called Yunnan Neolithic before the early 3rd millennium BC (e.g. CASS, 2010: 720-723; Li & Hu, 2009; Xiao, 2001; Guojia, 2001; Yunnan, 1999; Liu & Chen, 2012). Given the very high number of sites present in Yunnan (fig. 2-11), and the little systematic radiocarbon dating undertaken at these sites, this might change with future research, nevertheless at present it is suggested that Yunnan was inhabited since early Holocene times, it was an important area for early hominid spread, and sedentary villages are attested in the province since at least the 3rd millennium BC.

Generally speaking, only slightly over 30 Neolithic sites have been systematically excavated so far (Li & Hu, 2009). Of these, less than 10 underwent systematic environmental collection during excavation (see Appendix 5 for a complete summary of excavation history, material culture and environmental remains for each site mentioned in text). Precise radiocarbon dating is still not widely carried out, and the majority of these sites has been dated through the cultural association of ceramic remains (see Appendix 6).

To date, known Neolithic sites in Yunnan are located along the major river basins, and around the main lakes. The sites along river valleys are open-air settlements, sites on the banks of lakes are mostly shell-midden, and finally, a few cave-sites have been reported, clustering on the western side of the province.

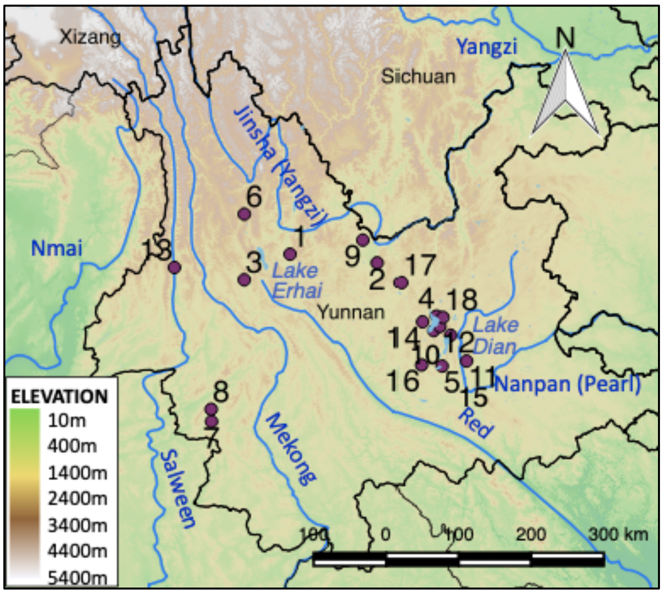

Fig. 2-13: Location of sites mentioned in Appendix 6: 1. Baiyangcun; 2. Dadunzi; 3. Xinguang; 4. Haidong; 5. Xingyi; 6. Haimenkou; 7. Shifodong; 8. Nanbiqiao; 9. Mopandi; 10. Shizhaishan; 11. Hebosuo; 12. Anjiang; 13. Shilingang; 14. Dayingzhuang; 15. Xueshan; 16. Guanfentou; 17. Yubeidi; 18. Xiaogucheng.

3rd to 2nd millennium BC sites

The earliest known sites, dating between c. 2600-1600 BC, are Baiyangcun, Dadunzi (located in the Jinsha River Basin; Dal Martello et al., 2018; Yunnan, 1981; Jin 2014; Yunnan, 1977), Xinguang (located in the upper Mekong River Basin, Yunnan), Haidong, and Xingyi (located on the banks of the Lake Qilu; see He, 1990; Xiao 2001; Yunnan, 2017). The first three cluster in the north-western corner of the province; Haidong and Xingyi, instead, are located in central Yunnan, however, Haidong chronology is uncertain and it could not be verified as the original data is lost; similarly, Xingyi has insofar been dated through cultural association only and radiocarbon dates are still awaited (see Appendix 6).

Several similarities are shared across these sites. Most of the houses excavated at Baiyangcun, Dadunzi, and Xinguang are of the wattle and daub type, the most common dwelling structure reported throughout Yunnan's Neolithic, with a minority of semi-subterranean houses (Yunnan, 1981; Yunnan, 1977; Yao, 2010). At Dadunzi a few stilt houses have also been found. Dadunzi also seems to present a variety of burial types not present at the other sites. Most early Neolithic graves in Yunnan are rectangular shaft pits with the dead placed in extended supine position; at Dadunzi a couple of stone cist burials have also been reported (Yunnan, 1977). This type of burial becomes very common during the later millennia and is characteristic of the Yunnan Bronze Age (Yao 2016).

No metal objects have been reported from any of these sites. The material culture uncovered at these sites includes ceramic vessels, stone and bone tools.

The ceramic remains at the sites of Baiyangcun and Dadunzi shows many close similarities, both in vessel repertoire and decoration designs, suggesting that the two sites were part of a broader sphere of cultural connection. The vessel assemblage is characterized mostly by coarse greyish temper vessels with flat/round bases, ovaloid body, and outward protruding opening *guan* jars, that increase in size during the later periods of occupation (fig. 2-14: 1-4; Yunnan, 1981; Yunnan, 1977). These vessels have been interpreted as suitable to cook and serve liquid and/or semi-liquid substances. Very occasionally later phase jars present double handles, high neck, or spouts, which might indicate they were utilized to pour liquid substances, but no residue analysis has been undertaken on these remains yet (fig. 2-14:7-10). Eating vessels such as *bo* bowl and *pen* basins/plates are common at all sites (fig. 2-14: 11-15; Yunnan, 1981; Yunnan, 1977; Yunnan, 2002).

At Xinguang the ceramic assemblage is also fairly similar to that present at Baiyancun, with heavy presence of flat base, round belly and outward protruding opening *guan* jars (fig. 2-14: 5,6; Yunnan, 2002). The decoration at these sites is characterised by geometrical and dotted designs which have been described as "incised/impressed pottery style" (fig. 2-14 bottom; see also Rispoli, 2007). At Xinguang, traces of red and white paint were found on some of the vessels, especially those retrieved from the lower levels of the site; their presence gradually decreases through time (Yunnan, 2002).

Haidong and Xingyi are shell midden sites; the ceramics recovered at both sites differed from those at the north-western Yunnan sites as they are of the corded ware type (Yao, 2010). Although no flotation was undertaken at the sites of Xinguang and Haidong, rice remains (hand-picked) were recovered during the excavation (Yunnan, 2002; He, 2000).

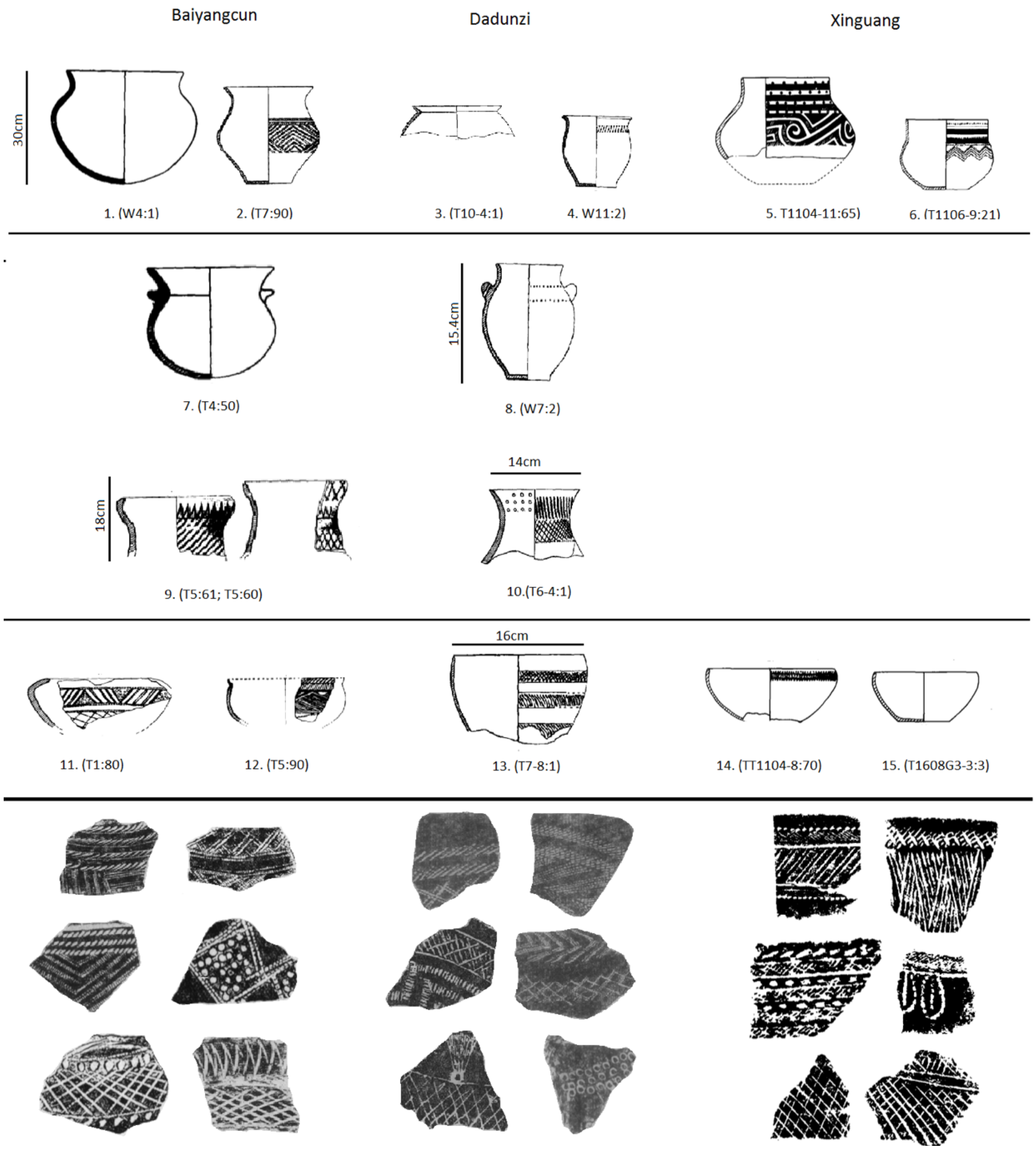

Fig. 2-14: Main vessel types and examples of decoration styles represented in pot sherds (bottom) at the sites of Baiyangcun, Dadunzi, and Xinguang. 1-6: guan vessels; 7-8: double handles guan vessels; 9-10: gaoling guan "high neck" vessels; 11-15: bo bowls. Redrawn from Yunnan, 1981; Yunnan, 1977; Yunnan, 2002.

Systematic flotation from Dadunzi revealed the presence of a mixed millet-rice economy, with predominance of *Setaria italica*-foxtail millet over *Panicum miliaceum*-broomcorn millet (Jin 2014). Similarly, preliminary archaeobotanical analyses from the site of Baiyangcun have shown an assemblage composed of mixed rice-millet remains (Dal Martello et al., 2018). At both Dadunzi and Baiyangcun, crop remains constituted the majority of the recovered archaeobotanical remains (over 80%); common field weeds species attested include *Fimbristylis* sp. and *Scirpus* sp., possibly indicating a wetland environment (Jin 2014); Dal Martello et al., 2018). Finally, other species recovered also include pulses (*Glycine* sp.-soybean, at Baiyangcun only); and wild fruits and nuts (i.e. *Prunus* spp and *Euryale ferox*). A preliminary assessment of archaeobotanical remains at Xingyi showed the possibility of a small-scale rice cultivation, in a largely lacustrine resources-based economy (Min Rui, personal comment 2016). Lacustrine resources had also been reported from the Haidong site, with prevalence of *Margarya* sp. (Li & Hu, 2009; Yunnan, 2017).

2nd to early 1st millennium BC sites

The sites of Haimenkou, Mopandi, Shifodong, and Nanbiqiao started being occupied during the mid-2nd millennium BC. Differences in house and burial structures are reported among the sites (see Appendix 5).

At Mopandi houses are of the wattle and daub type, but burials are of the stone cist type (Yunnan, 2003). The ceramic assemblage is very similar to that found at Baiyangcun, with many flat base, round body, outward protruding opening *guan* jars (fig. 2-15: 1-2; Yunnan, 2003). The decoration is also of the incised/impressed pottery style, and motifs are fairly similar to those found at Baiyangcun. However, incised/impressed ceramics at Mopandi constitute only a minority, and most vessels are characterised by reddish undecorated coarse temper (fig. 2-15 bottom left; Yunnan, 2003).

The ceramic remains found at Haimenkou share the most similarities with those found at the earlier sites of Baiyangcun and Dadunzi, especially for the first phase of occupation of the site (e.g. Yunnan, 2009; see also Chapter 6). Haimenkou ceramic repertoire is characterized by the presence of flat base, outward protruding opening *guan* jars, with incised/impressed decoration motifs that were encountered at Baiyangcun and Dadunzi (fig. 2-15: 2-4; 10-11). Differently from Baiyangcun and Dadunzi, houses at Haimenkou are of the stilt type (Yunnan, 2009).

From the second phase of occupation of Haimenkou onward, metal objects appear accompanied by the presence of painted pottery and double-handled vessels (fig. 2-15: 6-7). An increase of tree chopping stone tools, wooden posts (and thus total number of houses), sheep/goat remains, and wheat and barley is also reported from this period. This all points to an increased population due to the arrival of migrants, who most likely came from Northwest China, as evidenced by strong similarities in cultural traditions (see Chapter 6).

Finally, Shifodong is a cave-site with numerous hearths found inside inferred to indicate dwelling-like structures dividing the internal space of the cave (Liu & Dai, 2008). Here, the ceramic assemblage is dominated by *fu* cauldrons (fig. 2-15: 5) and drinking *dou* goblets, in addition to *guan* jars, *bo* bowls, and *pen* basins/plates. The *fu* cauldron is similar in shape to the *guan* vessel, but usually comes in a much bigger size, and has a restricted opening. *Dou* goblets are characterised by a pedestal or stem where a small cup is attached. Ceramic vessels at Shifodong present both incised/impressed decorations, as well as corded ware decorations; incised/impressed decorations show a strong resemblance with earlier Yunnan incised/impressed pottery style, as well as contemporaneous Southeast Asian ceramics. However, no in-depth report has been published yet (Yunnan 1983; Liu & Dai 2008).

Nanbiqiao site is also a cave-site, located close to the site of Shifodong, with which it shares strong cultural similarities (Yao, 2010).

Archaeobotanical investigation were undertaken at Haimenkou (Xue, 2010; Jin 2013); and at a smaller scale at Shifodong and Mopandi, where only few selected contexts where samples for archaeobotanical analysis (Zhao, 2010; Zhao 2003). These analyses revealed a mixed crop economy, based on millet (mostly *Setaria italica*-foxtail millet) and rice at all sites, with the introduction of western domesticates *Triticum aestivum*-wheat and *Hordeum vulgare*-barley, attested at the sites of Haimenkou only, from at least c. 1400 BC (Xue, 2010; Jin, 2013).

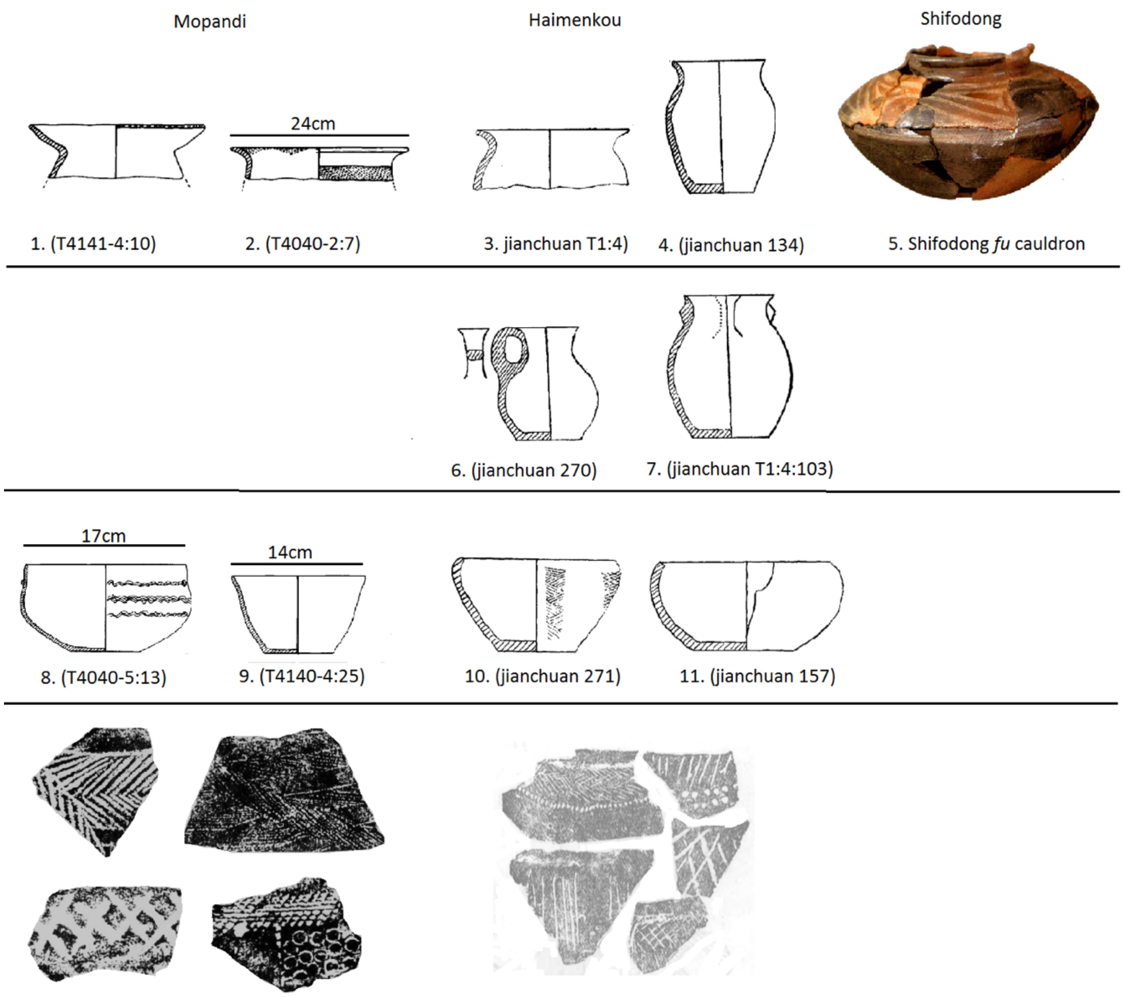

Fig. 2-15: Main vessel types and examples of decoration styles represented in pot sherds (bottom) at the sites of Mopandi, Haimenkou, and Shifodong. 1-4: guan jars; 5: fu cauldron; 6-7: double-handled guan jars; 8-11: bo bowls. Redrawn from Yunnan, 2003; Xiao, 1991; Li & Dai, 2008.

1st millennium BC sites

During the 1st millennium BC the number of reported Neolithic/Bronze Age sites in Yunnan increases. With the exclusion of the site of Shilingang, located on the western edge of Yunnan Province in the Middle Langcan (Salween) River Basin, close to the Myanmar border, the other sites are all clustered in central Yunnan, around the Lake Dian. Radiocarbon dating and systematic flotation has been applied more widely at these sites, thanks in part to the fact that they have been excavated within the last 5 or 10 years (see Appendix 5).

Sites located in the Dian Basin are connected with the broader sphere of influence of the Dian Culture (previously known as Shizhaishan culture), also sometimes referred to as Dian “Kingdom” (Yunnan et al., 2015). At all of these sites small metal objects have been found. These are usually small tools, such as axes or arrowheads, and personal accessories, such as bracelets. Moreover, elite graves (corresponding to c. 1% of the total graves excavated, see Yao, 2017) from Dian sites often contain elaborated bronze drum-shaped cowrie shell containers often depicting scenes celebrating the achievements of the deceased (Yao, 2017). These have become diagnostic of the Dian Culture (Yao, 2016). They differ greatly from bronze vessels from other parts of China, both in terms of stylistic and craftsmanship characteristics. Metal composition analyses on over 500 bronze artefacts belonging to the Dian Culture have shown that earlier bronze objects (which can be classified as small weapons, tools, and personal accessories) were composed mainly by tin bronze alloys or pure copper; almost no lead was detected (Zou, et al., 2017). In later bronzes, however, increasing quantities of lead become incorporated. Different methods were employed to produce different objects: hot forging was employed for small weapons and tools; casting was used for elaborated patterns on large objects; finally tinning and gilding were also utilized (Zou, et al., 2017). Among the known Dian sites, a few have been classified as specialised smelting centres; among these Guangfentou has been recently determined to be the production site (with smelting, melting, and casting activities all taking place) for bronzes found at the cemeteries of Shizhaishan and Lijiashan (Zou, et al., 2017)

Systematic flotation at the sites of Shilinggang (Li et al., 2016), Xueshan (Wang, 2014), Guangfentou (Li & Liu, 2016), and Yubeidi and Hebosuo (Yang, 2016), attested a highly mixed economy incorporating both Chinese domesticates rice and millets, as well as western domesticates, especially wheat. Moreover, other noteworthy economic species recovered include soybean at Xueshan, Yubeidi, and Hebosuo, and a relative high number of possibly buckwheat seeds (over 100 seeds) at Xueshan.

2.4.3.3. State of prior knowledge on the development of early agriculture in Yunnan

A three-phases agricultural development for Yunnan has been recently proposed on the basis of the recent archaeobotanical work (Li, et al. 2016):

1. Rice-based economy (c. 2800–1900 BC);
2. Mixed rice-millet economy (c. 1900–1400 BC);
3. Introduction of Western domesticates, and mixed rice, millet, wheat and barley economy (c. 1400–300 BC).

However, through research done for this dissertation, and partly published before submission (Dal Martello, et al. 2018) this has been recently counter-indicated. The first phase outlined in Li, et al. (2016) was proposed based on hand-picked rice remains from Baiyangcun, recovered as part of the first excavation campaign in 1973, and recent systematic archaeobotanical work has shown that both rice and millet were present at the site since its earliest occupation (Dal Martello, et al. 2018; see also Chapter 5).

This evidence of absence might also be interpreted absence of evidence, as presently not many sites in Yunnan have undergone systematic excavation and environmental remains collection. Whether or not an earlier rice-only agricultural system was present in Yunnan, this can only be attested through future excavations and systematic archaeobotanical studies on chronologically earlier sites in the future.

At present, settled villages with evidence for agricultural practices with the exploitation of both rice and millets are attested from at least the mid-3rd millennium BC; from the mid-2nd millennium BC, Western domesticates are introduced to Yunnan and are successfully incorporated in the agricultural system.

CHAPTER 3. The Climate and Environment of Yunnan

3.1. Introduction

Yunnan is located in Southwest China (N 21.9-29.15; E 97.39–106.12), a region that comprises of Chongqing Municipality, Sichuan, Tibet, Yunnan, and Guizhou Provinces. Southwest China is a very diverse area, with a changing landscape that ranges from subarctic with permanent snow mountains on the west, to humid subtropical forests with perennially above 16˚C degree temperatures to the south. Yunnan is the further southwest province, bordering with Myanmar to the west, and Laos and Vietnam to the south. It has an area of about 394,000 km^2, and although this accounts only for 4% of modern China, Yunnan presents an extremely rich diversity of landforms, vegetation and climatic conditions. In relation to the neighbouring regions, Yunnan stands as a transitional zone between Western and Eastern Asia, and their relative temperate and tropical flora and climate (Tang, 2015).

Yunnan's topography is characterized by an exceptionally rugged landscape: 94% of the whole surface is covered by mountains and highlands; the remnant 6% is constituted of basins and valleys (Tang, 2015, see fig. 3-1). North to South, a series of mountain ranges run parallel to each other, gradually decreasing from over 4000m of altitude to slightly less than 100m above sea level (Zhu, 1985). This altitudinal gradient affects greatly the environmental and climatic conditions of the province.

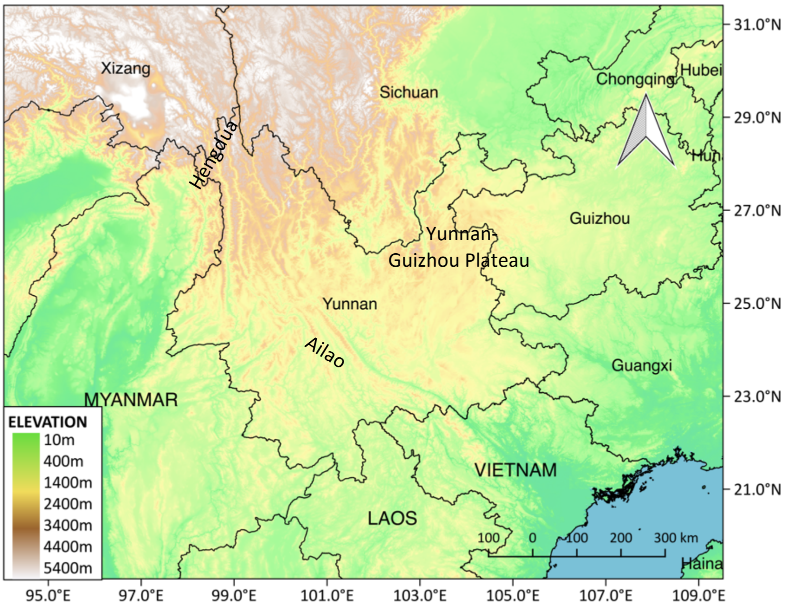

Fig. 3-1： Map showing Yunnan elevation. Made with QGIS.

In the northwest of the province, at the border with Tibet and Sichuan Provinces, the Hengduan Mountains range (N 22-32.05; E 97-103) averages 4000m above the sea level, with the highest peak, Gonggashan, reaching 7556m (Tang, 2015). Connecting the Hengduan Mountains range with the central-eastern part of the province is the Ailao Mountains range (N 23.49, E 101.33) runs for about 800km in NW-SE direction. The Ailao Mountains range effectively creates a sort of environmental and climatic divide between the south-eastern and north-western sides of the province, lessening the effects of the Southwest Summer Monsoon on the south-eastern area (Tang, 2015). Central-eastern Yunnan is occupied by the Yunnan-Guizhou plateau, which presents an altitude between 1500-3000m, only occasionally reaching above 4000m (Zhao, 1994). The highest peaks of the plateau are respectively Yaoshan, 4,042m high, and Jiaozishan, 4,344m (Tang, 2015).

Finally, in the south of the province the altitude gradually descends to only about 100m above sea level. The lowest recorded elevation point is at the bay of the Yuanjiang River, at the border with Vietnam, with an altitude of only 76,4m asl.

The hilly typography of Yunnan is intermingled with deep river gorges and valleys, as the region is crossed vertically north to south by a complex river system, as well as

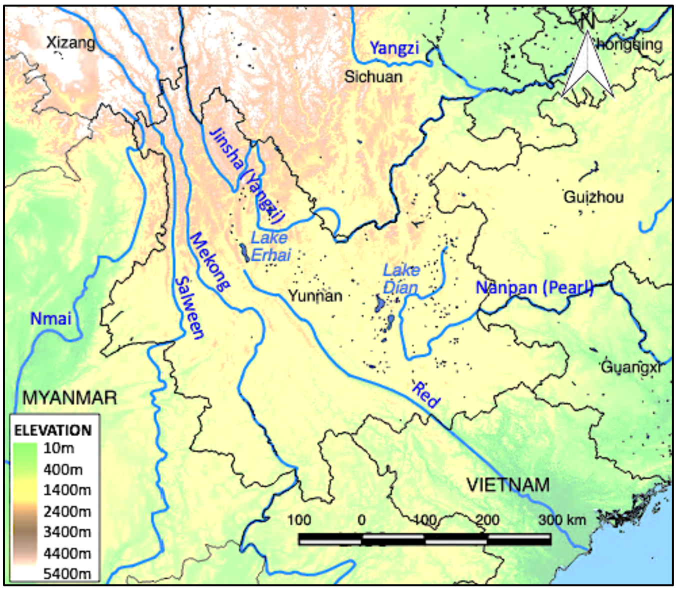

Fig. 3-2: Map showing major lakes and rivers running through Yunnan. Made with QGIS.

presenting numerous lakes (fig. 3-2). Three major Asian rivers run through Yunnan: the Yangzi (*Changjiang* 长江 in Chinese), Mekong (*Langcan* 澜沧), and Salween (*Nujiang* 怒江) rivers. In the northwest of the province, eastern of the Ailao Mountains, these rivers run parallel with each other, lying less than 100km apart, in an area referred to as “*Sanjiang*” (三江 meaning Three Rivers). In addition to the numerous rivers, Yunnan presents more than 40 lakes. The two largest ones are the Lake Dian, near Kunming, with a surface of 312 km^2, followed by the Lake Erhai, near Dali, of about 250 km^2. Early archaeological sites studied for this dissertation are located closed to these two important water reservoirs, which have been present since ancient times.

3.2. Modern day climate

Overall, Yunnan Province lies within the subtropical belt and is affected by the Southwestern (Indian) Monsoon on the western side of the province, and the Southeastern (also called Pacific) Monsoon on the eastern side (Zhao, 1994: 237). These create general short and dry winters, and long and wet summers (Kottek, et al., 2006).

The effects of the Southwestern Monsoon are lessened on the northwest by the presence of the Hengduan Mountains, which effectively protect the interior of the province, creating hotter and drier conditions in the interior valleys of Yunnan (Tang, 2015). The Ailao Mountains, at the limit of the Yunnan Plateau, further allow for slightly drier and warmer conditions on the south-eastern part of the province. Finally, the Qinghai-Tibetan Plateau on the north of province, mitigates the effects of the cold Siberian winds in winter, providing general warmer temperatures and mild climate in the whole province throughout the year. These topographical features and their effects on the climate create suitable conditions for the presence of a truly subtropical climate and vegetation in the most interior parts of the province (Tang, 2015).

Under the influence of the monsoons, contrasting dry and wet seasons are clearly marked throughout the province. The rainy season generally goes between May and October, during which 80-90% of the annual precipitation occurs (Chen, 2001; Zhao, 1986; see fig. 3-3). Mean annual precipitation varies greatly across Yunnan, between 500 and 2000mm (see fig. 3-3). On average of 1500mm of mean annual precipitation occurs in the lowlands, as well as on the Yunnan Plateau; up to 1750mm of annual precipitation have been recorded in the southernmost area, at the border with mainland Southeast Asia.

The numerous mountain ranges also create contrasting humidity indexes between the western and eastern side of the province (Tang, 2015).

Moreover, most of inhabited Yunnan is a frost free region for most of the year, and this favours agriculture, allowing the production of up to three crops per year in some parts of the province (Zhao, 1986; 1994: 38).

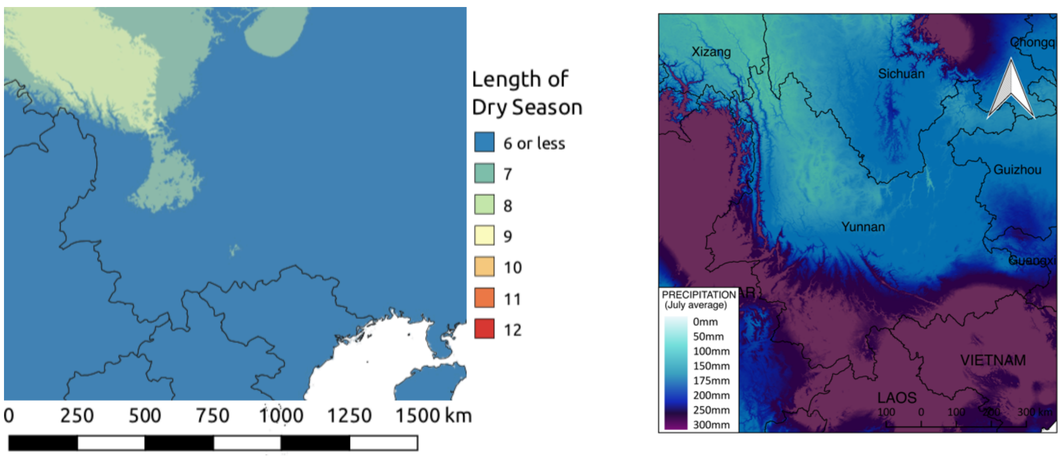

Fig. 3-3: Left: Dry season lenght in Southwest China; right: Yunnan average precipitation for the month of July. Made with QGIS.

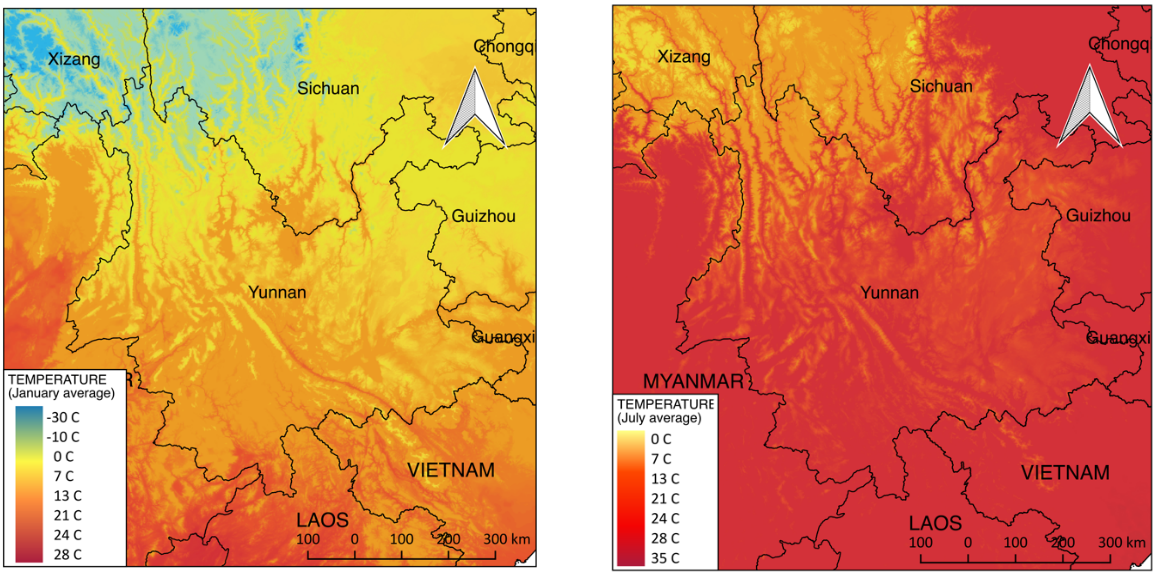

Fig. 3-4: Map showing average temperatures for the months of January (left), and July (right).

The altitude drop also causes a northwest to southeast temperature gradient, with mean annual temperatures gradually increasing as we descend south, and almost 10 ˚C degrees' difference between the north and the south areas. For this reason, Kunming is known as the "eternal spring city". Here winter mean temperature (calculated in January) is around 8-10˚C degrees, and summer average temperature (calculated in July) is around 19-22˚C degrees (see fig. 3-4). In this part of Yunnan occasionally occurring spring droughts pose risks to agriculture (Zhao, 1986). In the southern part of the region, winter mean temperature is around 12-16˚C degrees, and the summer average is around 22-26˚C degrees.

3.3. Modern day vegetation and agriculture

Elevation, climate and flora are strictly correlated, and change accordingly throughout Yunnan, creating a landscape characterized by a so-called "biogeographical vertical zonation" (Zhao, 1986; Jin, 1998). However, according to Lin et al. (1986) only about 10% of modern Yunnan's vegetation accounts for its original distribution and pattern, and this is mostly confined to remote alpine and subalpine areas with difficult access, where human activities could not reach and thus did not effectively impact the original vegetation composition and structure (Tang, 2015). Modern day vegetation, especially in the lowlands, is therefore characterized by a highly disturbed agricultural landscape that displaced greatly the original vegetation, with primary forests removed through human intervention, and replaced by the drought-tolerant Yunnan pine and eucalyptus species (Zhao, 1986; 1994).

Yunnan's vegetation can be described broadly as subtropical evergreen broadleaved forest. Yunnan biogeographical vertical zonation results in a sequence of several vegetation belts that follow the altitude present in each area, transitioning between tropical, subtropical, temperate, subalpine and alpine patches (Tang, 2015). Modern day vegetation can be divided as follow:

1. Northern Yunnan and areas surrounding the Yunnan Plateau:
   - Between 1600/1800-2500/2800m: mid-montane humid evergreen broad leaved forest.

     Dominant species: *Cyclobalanopsis lamellosa, C. oxyodon, C. myrsinifolia; Lithocarpus variolosus, L. hancei, L. pachyphyllus, L. xylocarpus, L. echinotholus*; and *Castanopsis echidnocarpa, C.wattii,* and *C. remotidenticulata*.

     Further species commonly found include: *Machilus longipedicellata, M. viridis, Cinnamomum iners, Phoebe faberi, Schima khasiana, S. argentea*, *S. villosa*, *Manglietia gongshanensis, M. insignis*, and *Alcimandra cathcartii*. Epiphytes and lianas are abundant in this vegetation type, and annual rainfall here is at the provincial highest, between 1700-3700mm (Tang, 2015; Shen, et al., 2006).
   - Above 2800m and up to 3200m: mixed conifer woodland.

     Due to human interventions, *Pinus yunnanensis* is the most dominant species found today; secondary stands of *P. massonica, Alnus nepalensis, Quercus acutissima*, and *Platycarya strobilacea* are also present. *Tsuga* is present in areas of little human activity.
   - 3100-3800m: fir forest.

     Species include *Abies forrestii*, with strand of conifers such as *Larix potaninii*, *Pseudotsuga forestii Cephalotaxus fortune, Taxus chinensis, T. wallichiana*, *Taiwania cryptomeriodoides, T. flousiana*, and *Pinus excelsa*.

Tsuga species (i.e. *T. yunnanensis, T. dumosa*) are present in areas of little human activity (Zhao, 1994).

- At higher altitudes, between 3800-4500m: alpine scrub meadow landscape.
- Above 4500m: perennial snow (Zhao, 1994).

2. Central and Eastern Yunnan (Yunnan Plateau):

- Between 1500-1900/2400m: semi-humid subtropical evergreen broad-leaved forest.

  Dominant species include oak and oak-chestnut species such as *Cyclobalanopsis glaucoides*, *C. delavayi, Castanopsis orthacantha*, and *Lithocarpus dealbatus*.

  In this area, modern annual rainfall is attested between 900-1200mm (Tang, 2015).

3. Southern Yunnan:

- Between 800/1000-1800m of elevation: humid subtropical forest.

  Dominant species are *Castanopsis hystrix, C. fleuryi, C. calathiformis; and Lithocarpus truncatums, L. polystachyus, L. fenestratus*. Secondarily *Cyclobalanopsis augustinii, C. kerrii, Trigonobalanus doichangensis, Cryptocarya calcicola, C. calciflora, Beilschmiedia yunnanensis, Schima wallichii*, and *Anneslea fragrans* are also found.

  Annual rainfall is between 1100-1700mm (Tang, 2015).

4. In the very south a humid tropical monsoon forest landscape dominates.

   This area is characterized by an inversion of temperature that allows the tropical forest to extend up to 800-1000m of elevation (Zhao, 1994), followed by a deciduous monsoon forest at higher altitudes, where there is a slightly longer dry season compared to the rest of the province, and precipitation is less than 1600mm.

   Low elevation dominant species are *Hopea haimonensis*, *H. mollissima*, *Dypterocarpus tokinensis, D. pilosus*, *Myristica cagayanensis*, *M. sinnarum*. Here there is an overall very rich flora with very close similarities with Southeast Asian and Malaysian floras (Zhu & Hu, 2006).

This very varied landscape provides Yunnan with the richest plant biodiversity within modern China (Walker, 1986; Myers, 1998). Yunnan supports 14,822 species of native seed plants (Wu, 1977-2006). This amounts to 49% of the total seed plants in China. For this reason, Yunnan has been defined as the "treasure garden" of the country (Zhao, 1994). One thing that is notable is how many of the zones, up to above 2000m are dominated by edible acorns producing taxa (i.e. *Cyclobalanopsis, Castanopsis, Lithocarpus*), which can easily serve as starchy staples for hunter-gatherer cultures.

Interestingly, the vertical zonation of Yunnan's landscapes provides insights into the distribution of the ethnical minorities inhabiting the province, which systematically occupy similar landscapes that share elevation, vegetation and climate, and life ways across the region (Zhao, 1994).

In the lowlands abundant water resources are available, both from the hydrological networks of rivers and lakes and from the conspicuous precipitation. Here double or triple cropping of irrigated rice takes place; these areas have been historically occupied by the Dai people practicing wetland rice agriculture (Bray, 1984: 21).

Today, above 1000m double cropping of rice-winter wheat is practiced, and above 2400m usually only one crop of dry farmland is possible (Zhao 1994: 38). Here, there is a long historical record of many ethnic groups practicing slash and burn agriculture (see below; Bray 1984:21).

Other crops currently grown in Yunnan also include maize, cotton, hemp, tobacco, tea, and various vegetables, fruits, and legumes, including melon, mung bean, and soybean (NBS, 2019).

3.4. Ancient Yunnan Climate and Flora

Data from lake sediments in Yunnan have provided a long and uninterrupted paleoclimate record for the region (see Hillman, et al., 2017; Jones, et al., 2012; Shen, et al., 2006; Brenner, et al., 1991; Fang, 1991; Hodell, et al., 1999; Long, et al., 1991; Whitmore, et al., 1994; Yu, et al., 1990; Walker, 1986), on the basis of which some past climate change models have been proposed (Chen et al., 2014; Yu, et al., 2001; Liu, et al., 2002; Chen, et al., 2002). In addition, cave speleothems, such as those from Dongge cave, located only about 750km East from the Erhai region in Northwest Yunnan, provide a high resolution climate record and data on monsoon intensity for the region (Dykoski, et al., 2005).

There is general agreement that the following periods can be recognized based on the available data:

- Pre- Holocene, c. 15,000- 10,000 BC: cold and semi-humid conditions were present in Yunnan, with the winter monsoon stronger than the summer monsoon (Hodell, et al., 1999).

  In this period montane conifer forests dominated by *Tsuga* species occupied most of the region, even at low elevations. Nowadays this species can only be found in northwest Yunnan at elevations higher than 2300m (Tang, 2015).

- Early Holocene, c. 10,000-6000 BC: general fluctuating climate, with warmer and wetter conditions. Temperatures were 2/3˚C higher than present day (Shi et al., 1994); mean annual precipitation has been estimated to have been between 20-40% greater than today (Chen, et al., 2014). The increased intensity of the summer monsoon caused a very strong seasonality, with wet summers and very dry winters, as opposed to the previous millennia. Speleothem records from Dongge Cave, located at only about 750km from the Erhai region, suggests that the summer monsoon had its intensity peak at around 8000-6000 BC (Dearing, et al., 2008; Dykoski, et al., 2005; Yang., et al., 2005). Moreover, rise in lake sediment flux at the Lake Erhai further suggests increased precipitation (Shen et al., 2006; Tang, 2015; Sun, et al., 1986).

  Following the warming of the climate, evergreen broad leaved forests composed of *Cyclobalanopsis, Lithocarpus,* and *Castanopsis* species expanded. The vegetation started a complexification trend characterized by altitudinal differentiations (Tang, 2015).

- c. 6000-4000 BC: from this time onward, subtropical evergreen forests (dominated by oaks and chestnuts species, as well as *Pinus* and *Quercus* species) start to occupy the lowlands, and montane humid evergreen forests (dominated by *Lithocarpus*) the highlands (Lin et al., 1986). Conifer woodlands start occupying areas above 2800m of altitude, and *Picea, Abies,* and *Tsuga* species set an altitudinal limit of 3000m and above (Tang, 2015).

- Mid-Holocene, c. 4000-3500 BC: the summer monsoon intensity starts weakening and the temperature cooling. This general drying and cooling trend caused a decline of the evergreen broadleaved forest with a decrease of *Cyclobalanopsis*, *Castanopsis*, and *Tsuga.* At the same time, there was a retreat of the subtropical and tropical woodlands to the limit we currently see today (Shen et al., 2005). Current vegetation composition and patterns were mostly set during this time (Wrinkler & Wang, 1993).
- c. 3500-1500 BC: Due to the continuous weakening of the monsoon and cooling of the temperature, the evergreen broadleaved forest continued its trend of decline. Lake sediments and pollen records analysed from the Erhai region in Northwest Yunnan indicate that human activities started to exercise a greater role in local environmental processes, which culminated at around 2800 BC, when according to Dearing et al. (2008) there was the shift from a "nature-dominated" to a "human-dominated" environment. During this time *Pinus,* Poaceae, Chenopodiaceae and *Artemisia* species all increase (Shen et al., 2006). These species are classified as "disturbance taxa", and, therefore, interpreted as direct indication of greater human activity, specifically agricultural practices. *Pinus* especially has been linked with deforestation by fire, and its increase would therefore be evidence for the practice of slash and burn agriculture or forest clearance (see below). The rise of disturbance taxa could also be linked with an increase of open landscape, possibly wetland and shallow lake landscape (Shen, et al., 2005). Further analyses of river discharge showed an increase at about 2300 BC, which could indicate human intervention on natural water resources for agriculture irrigation (Shen et al., 2005). These data indicating human influences on vegetation and erosion are congruent with the archaeological evidence for establishment of Neolithic farming communities by the middle

of the 3rd millennium BC, such as that represented by the founding of Baiyangcun, as studied in this thesis[5].

- c. 1500 BC-1000 AD: Acceleration of the weakening of the monsoon and temperature cooling, with a sharp drop event at around 1500 BC (Dykoski, et al., 2005). Drastic changes of the vegetation and the landscape due to rapid agricultural intensification and urbanisation, including the development of intensive agricultural systems from at least 16 AD, as attested by historical documents (Yao, et al., 2015).

3.5. The paleo-climatic and paleo-environmental context of the beginning and spread of agriculture in China

Between the 6th and 3rd millennia BC, pollen and paleoclimate records from the Middle and Lower Yangzi region and South China indicate that a typical subtropical and tropical vegetation extended further north than its present day limit, occupying all of South China and reaching beyond the Yangzi Basin (see Yu, et al., 1998; Yu, et al., 2000; Fuller & Qin, 2010; fig. 3-5 top). Scholars have argued that this was one important factor for the expansion of several Neolithic cultures both in North and South China between 6000-4000 BC (Fuller & Qin, 2010). Possibly, this also created favourable environmental conditions for the beginning of agriculture in its core areas, along the Yangzi Basin for rice, and in North China for millet (Fuller & Qin, 2010; Stevens & Fuller, 2017; see also Chapter 2).

This poses the question as to where and what kind of ecological barriers would the agricultural spread to Southwest China have encountered, if any? Recent archaeological and archaeobotanical work in Sichuan, and especially on the Tibetan Plateau, has shown how crops or cropping systems needed to adapt and change in order to be able to move to such higher, colder and drier conditions. It is argued that only with the arrival of wheat and barley, already better suited to the harsher conditions of the Tibetan environment,

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[5] On the basis of sediment analyses from the Lake Erhai, some authors push back anthropogenic environment change to as early as c. 5500 BC, possibly even c. 7000 BC (Dearing et al., 2008). However, no archaeological evidence in support of this hypothesis has been uncovered yet.

could human occupation expand to those areas (e.g. Liu, et al., 2019; D'Alpoim Guedes, 2016; Liu et al., 2016; Chen, et al., 2015; D'Alpoim Guedes & Butler, 2014).

Around the 5th millennium BC much of the Yangzi Basin, and both the area right north and south of it, were occupied by a subtropical forest, with Yunnan Province mostly occupied by tropical forests (fig. 3-5 top). With the cooling of the climate, the subtropical forest gradually retreated to its current limits in north Yunnan (and more broadly in South China), and the fully tropical vegetation became confined in the southernmost strip of land along the modern Chinese border (fig. 3-5 bottom).

On the territory adjacent to Yunnan, western Sichuan presents a similarly rugged and high elevation territory as northern Yunnan (see fig. 3-1 above). Studies on the reconstruction of the natural vegetation cover have proposed that on the northern section of western Sichuan, a montane coniferous forest composed of by *Picea likiangensis* var. *purpurea*, *Abies faxoniana* with secondary strands of *Betula* and *Populus* species was present above 2500m (Wang, 1961:55).

On the southern section of western Sichuan (closer to the Yunnan border) *Abies fabri*, *Picea brachytyla* constituted the main forest components, with presence of *Tsuga* sp, *Betula* sp, *Acer* sp and other broadleaved trees in disturbed area (Wang, 1961:55).

A montane coniferous forest of this type was also found in in remote and high elevation areas of northwest Yunnan (Wang 1961). Here, however, the main forest species possibly were *Abies delayavi, Picea likiangensis, P. brachytyla,* and *P. complanate (*Wang, 1961: 56).

Finally, above 3000m, pure *Abies* forest was present (Wang, 1961: 113). This montane coniferous forest is associated with long winters, and a very short and low temperature growing season. In this area today there are about 140 frost free days; the mean annual temperature is 3.8°C degrees (January average temperature is -4°C; July average temperature is 12.6°C); annual average precipitation varies between 1900-1700mm, of which more than 50% falls between July and August (Wang, 1961: 38, 56).

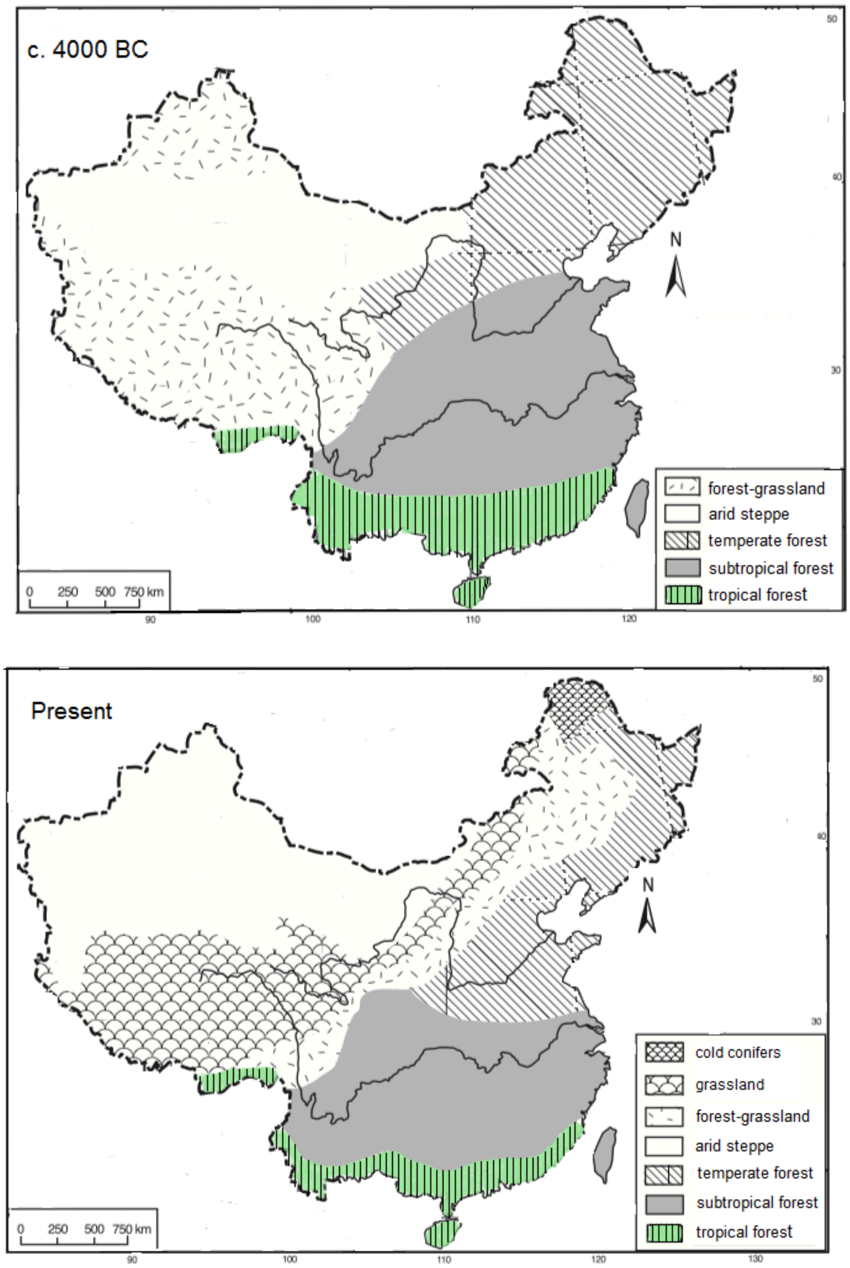


Fig. 3-5: Map showing a reconstruction of Chinese vegetation, dating to c. 4000 BC (top), and today vegetation zones (bottom). Redrawn from Li & Chen 2012 fig. 2.4 at page 31 (after Wrinkler & Wang, 1993).

Following along the Yangzi River Valley, both in its upper and lower reaches, Wang (1961) proposed that the original vegetation cover would have been composed by a mixed mesophytic forest. Remnants of this are still present both in western and eastern Sichuan, at Oubian and Chengkou respectively (Wang, 1961). The whole Yangzi Basin was therefore covered by a very diversified forest, with many tree species present, but none of which dominant (Wang, 1961: 95).

Between 1300-1600m we would have found a mixed deciduous forest composed by *Castanopsis platyacantha; Cinnamomum wilsonii; Machilus bracteate; Castanea hernyi*. Between 1600-2200m, an evegreen oak and *Schima* forest (*Schima superba; Castanopsis platyacantha; Pasania* spp., *Quercus* spp., *Fagus* spp., *Betula* spp.).

Finally, between 2200-2500m, an evegreen oak and hardwood forest was found (*Castanopsis platyachanta, Lithocarpus cleistocarpa, Betula insignis, Acanthopanax evodiaefolius, Acer flabellatum*; Wang, 1961).

Further to the East, in eastern Sichuan up to 1200m of elevation remnants of *Metasequoia* have been found, along with *Cunninghamia, Taiwania,* and *Ginkgo* species, which might have been the main components of the original vegetation *(*Wang 1961: 108). Now we find monstly *Lithocarpus, Fagus, Quercus, Schima, Populus* and other tree species. Between 1200-1600m *Pasania* and *Quercus* species are instead the dominant components of the mesophytic forest. This then extends in the lower Yangzi Valley showing mixture of typically upper Yangzi species such as *Davidia*, *Rhoiptelea*, *Tetracentron* species (Wang, 1961:112). Between 1600-2400m, the forest is composed by *Fagus, Euptelea,* and *Davidia* species (Wang, 1961).

General climatic conditions of this broad area are characterized by a quite lengthy growing season (frost-free) of between 230-280 days, mild temperatures, and between 1000-1500mm of annual average precipitation recorded (Wang, 1961: 96).

Finally, the Sichuan Basin occupies an area of 8000km and has an average elevation of about 500m; it is considered the "largest fertile area of Southwest China" (Zhao, 1994), and centuries of intensive agricultural practices have hindered the reconstruction of its original forest cover (Wang, 1961:113).

3.6. Reviewing records of slash and burn agriculture in Yunnan

Due to its mountainous nature, Yunnan is rich in mineral resources, but poor in arable land resources (Zhao, 1986), and only the 6% of basins and valleys would have been originally suitable for agriculture (Walker, 1986). According to the National Bureau of Statistics of China (NBS), in 2017 the total "sown area of crops" (sic) was 6,790,800 hectares (67,908 km^2; NBS, 2019). This equates to about 17% of the total land of the province. However, according to the definition provided by the NBS, this includes both "the land being cultivated, and non-cultivated, either because transplanted with crops or re-sown due to natural disasters" (NBS, 2019).

Before the introduction of modern mechanization in agricultural production in Yunnan, intensive irrigated agriculture was only practiced in the lower valleys, whereas for most part of the province, "slash and burn" (also referred to as "swidden" or "shifting") agriculture was the most widespread form of agricultural production (Yin, 2001). Slash and burn agriculture refers to a specific agricultural regime that involves the removal of the vegetation cover (usually from a patch of forested hilly land) through burning; the nutrient rich ashes fertilise the soil and the created fields are usually planted with dryland crops, such as rainfed rice. After the crops are harvested, another patch of land is chosen and the previous left to fallow, over a 8-10 year rotating cycle (Yin, 2001).

Ethnographic studies in the 1980s reported slash and burn agriculture was widely practiced along the western and southern limit of Yunnan province (Yin, 2001, fig. 3-6 right). According to Yin (2001), slash and burn agricultural practices were still quite developed, although they had progressively declined since the 1950s, possibly due to the increasing mechanization of agriculture and general push for industrial development of the province following the establishment of the PRC in 1949 (fig. 3-8 left).

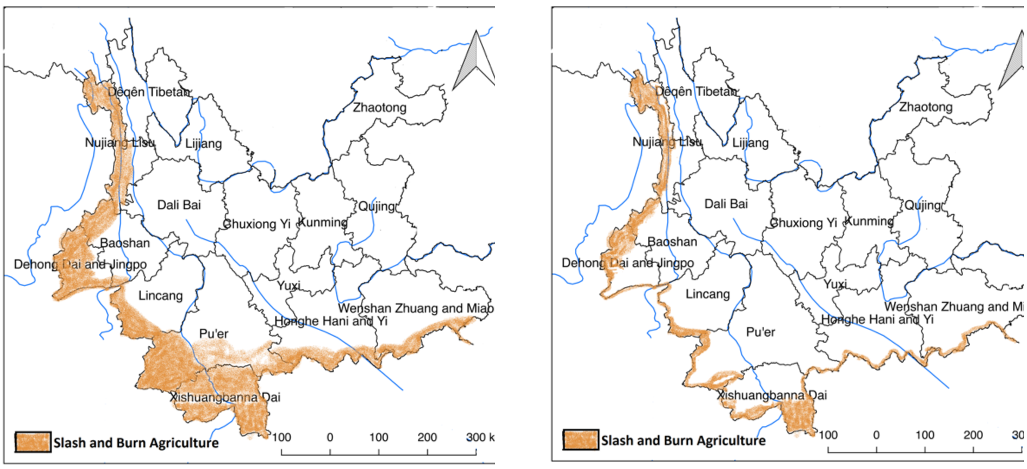


Fig. 3-6: Maps showing the comparison of the extent of slash and burn agricultural practices in Yunnan from the 1950s (left) to the 1980s (right). Maps redrawn from Yin, 2001:86-87.

In Chinese historical sources two terms have been traditionally used to indicate this type of agriculture:

- *shetian* 畲田 (literal translation "field cultivated by first setting fire to it"); old, used only in historical sources until c. Song Dynasty 960- 1297 AD, then uncommon;
- *daogeng huozhong* 刀耕火种 (literal translation "tilled with knife planted with fire"; Yin, 2001).

According to the *Shiji* (Records of the Grand Historian, by Sima Qian, dating to 95 BC), "South of the Yangzi they till with fire and weed with water (*huogeng shuonou* 火耕水耨)" (Bray 1984:99). Bray (1984:99) believes that this description refers to the "practice of burning the rice stubble after harvest to fertilize the fields with the ashes" (before ploughing them), rather than to slash and burn agriculture. This fertilizing technique was still practiced in parts of Southeast Asia at the time of Bray's writing, and ethnographically has been reported as linked with wetland rice cultivation rather than with slash and burn practices (Bray, 1984: 504). The author agrees with this interpretation and, therefore, this is not considered the earliest historical record for slash and burn agricultural practices in Southwest China. Instead, the first unambiguous reference to slash and burn agriculture in Southwest China is found in *Nan Man* (南蠻西南夷列傳 Treatise on the Nanman, Southwestern Barbarians, from the Hou Han Shu 后汉书 Book of the later Han), dating to the Later Han Dynasty (2nd century AD; see table 3-1). Later occurrences date to the Jin (4th century AD) and Song Dynasties (11th century AD), but most of the records date to the more recent Ming and Qing Dynasties (14th century AD and later, see table 3-1).

In the 1970s and 1980s, following studies on the Yangshao settlements patterns, K.C. Chang proposed that the earlier stages of millet agriculture in North China were based on slash and burn cultivation practices, as indicated by the thickness of the cultural deposits at the sites, which was interpreted to suggest a cyclical, discontinued, but recurrent, occupation (e.g. Chang, 1970; Chang, 1968; see also Li, 1983). Ho, instead, argued that "the highly dissected land forms (of the Yellow River and Loess Plateau) were hardly conducive to the practice of the classical type of 'slash and burn', 'swidden', or 'shifting' agriculture characteristic of the tropics", as loess soil is "self-fertilising", and would not require a long fallow period (Ho, 1975: 49). Ho further proposed that

Yangshao millet agriculture relied on a short fallow period to maintain soil moisture level, rather than to re-establish depleted nutrients (Ho, 1975).

One way to explore this issue is by looking at the macro-botanical weedy flora associated with crops. Experiments have shown that short fallow periods would not allow for the woodland vegetation to become re-established, as it would instead happen in shifting cultivation practices (Bogaard, 2002). Moreover, low population densities have also been taken as associated with possible slash and burn practices, as this type of agricultural regime would not support larger populations (Kingwell-Banham & Fuller, 2012). Finally, slash and burn agriculture has also been associated with a sort of "escape" from the State, in contraposition to permanent (rice) fields that would instead support the development of urbanism and the formation of a centralised State, and this has been historically attested for populations living along the border of modern Myanmar and China (Scott, 2009).

Given the very rugged landscape of Yunnan, it seems plausible that the earliest agricultural systems in the region relied in some part to periodically burning of the vegetation, or at least to initial clearing of the forest through fire to claim new lands for agricultural fields. However, to date there is no archaeological evidence nor study specifically undertaken to understand the beginning and development of slash and burn practices in the area. On the basis of paleo-environmental reconstruction such as those outlined above, some signs of possible slash and burn practices can be individuated in the increase of *Pinus* sp. from at least the 3rd millennium BC (Dearing, et al., 2008), however, further studies are needed in order to understand the origin, extent and nature of early slash and burn agriculture in Yunnan. What role did slash and burn practices have in relation to the establishment of more permanent agricultural fields in Neolithic Yunnan? Was there any regional difference in importance of slash and burn practices within early Yunnan? Was the historical dynamic of "State escape" through slash and burn practices attested in mainland Southeast Asia also relevant to early Yunnan populations living in what has been historically defined as "Zomia", especially after the Han conquest (Scott, 2009)? These questions need to be addressed with future studies.

Table 3-1. List of occurrences of slash and burn agriculture in Chinese historical documents, in chronological order from earliest to most recent. Translations of all quotes are from Yin 2001.

Ethnic group/ location	Date of historical record	Historical reference	Quote	Crops recorded	Reference
Miao Northeast-southeast Yunnan	Han dyn. 1st-2nd centuries AD	*Hou Han Shu* (Book of the Later Han Dynasty), chapter *Nan Man Zhuang* (Treatise on the Nanman, Southwestern Barbarians)	"...live in distant perilous land...practice swidden agriculture".	n/d	Yin 2001:71-72
	Qing dyn. 1885 AD	*Dayao Xian Zhi* (Gazeteer of Dayao County)	"They clear the hills for growing grains [刀辟山地种粮]"		
		Minguo Qiubei Xian Zhi (Republican era Gazeteer of Qiubei County)	"Miao people prefer living in the mountain valley forests, which they burn and plant their crops in [烧火山种植]. When the forests are destroyed, they move on"		
Zhangke prefecture (modern NW Yunnan and SW Guizhou)	Jin dyn. 4th century AD	*Huayang Guozhi-Nanzhong Zhi* (Annals of the Land of Huayang)	"In the Zhangke prefecture...They swidden their hills to make fields, and do not have silkworms or mulberry trees [畲山为天，无蚕桑]"	n/d	Yin 2001: 31
Yi (muji) Western Yunnan	Tang dyn. 8th century AD	unclear	"Cultivate the slopes of the towering moutains [耕于巍山之麓]"	Buckwheat	Yin 2001: 37
	Qing dyn. Yongzheng reign 1678-1735 AD	*Lin'An fu zhi* (Gazeteer of Lin'An Prefecture) Ch. 7;	"The *muji* support themselves by *swidden agriculture* [刀耕火种为食]"		
		Ami Zhou Zhi (Gazeteer of the Ami Division)	"They till the mountains and eat buckwheat [耕山食荞]; when they have free time, they shoot and hunt"		

Table 3-1. List of occurrences of slash and burn agriculture in Chinese historical documents, in chronological order from earliest to most recent. Translations of all quotes are from Yin 2001.

Ethnic group/ location	Date of historical record	Historical reference	Quote	Crops recorded	Reference
Dongxie Southeastern Guizhou	Song dyn. c. 1007-1072	*Xin Tang Shu- Nan Man Zhuan Xia* (The New Book of Tang- Descriptions of the Man Barbarians) by Xiu Ouyang	"Five grains, grow them in swidden fields [畬田], which they rotate every year"	n/d	Yin 2001: 75
Li	Ming dyn. 14th-17th centuries AD	*Haicha Yu Lu* (Odd Notes on the Sea Raft) by Gu Jie	"The Li...they gather to cut the trees of the hills large and small, which fall on each other. They wait for five to seven days, and then they set a great fire. They proceed form higher towards lower ground. and burn everything large and small so that it turns into ashes, it is not just the tree trunks or tree roots that are obliterated, even the soil is burned through and through for a chi or more down! Then they go over the ground with hoes, turning the soil, then they plant cotton, and also dry rice, which is called mountain grain. The grains are large, tasty, and fragrant. After three or four harvests the soil is worn out and it is left fallow. Another plot is chosen, and they start over again, using the same methods"	Dry rice, cotton	Yin 2001: 75-76
Achang Upper Mekong River Basin	Ming dyn. 14th-17th centuries AD	*Bai Yi Zhuang* (description of the hundreds barbarians)	"They live on top of the hills, and grow buckwheat [荞] for food".	Buckwheat?	Yin 2001 p 54-56;

Table 3-1. List of occurrences of slash and burn agriculture in Chinese historical documents, in chronological order from earliest to most recent. Translations of all quotes are from Yin 2001.

Ethnic group/ location	Date of historical record	Historical reference	Quote	Crops recorded	Reference
		Dian Lue (Chronichles of the Dian) *Xinan Yi Fengtu Ji* (Notes on the Costumes and Habits of the Barbarians of the Southwest)	"They like living high up in the mountains and engage in swidden agriculture [刀耕火种]" "The Achang live in the mountains. They dwell in the mountains valleys so that they can engage in swidden agriculture [刀耕火种]"		
Wa / West of the Mekong River	Ming dyn. 1455 AD	Zheng yong et al (1455) *Yunnan Tujing Zhishu* (illustrated description of Yunnan)	"They nest in the mountains and practice swidden agriculture [刀耕火种], and for most part they grow hill rice [旱谷]"	Dry rice	Yin 2001: 65
Bulang Along the Mekong River	Ming dyn. 1455 AD	Zheng yong et al (1455) *Yunnan Tujing Zhishu* (illustrated description of Yunnan)	They live high up on tall mountains and clear the mountains to make agricultural fields [垦山为田]. They grow buckwheat, and barnyard millet [种荞稗]. They do not invest on irrigation and move their fields around every year"	Buckwheat, barnyard millet	Yin 2001: 67
Kucong	Qing dyn, Kangxi reign 1714 AD	*Yuanjiang fu zhi* (Gazeteer of Yuanjiang Prefecture)	They practice swidden agriculture [刀耕火种] and often eat buckwheat [荞麦]	buckwheat, barnyard millet	Yin 2001:49
Zhuang (laxi)	Qing dyn. Qianlong reign 1758 AD	*Kaihua Fu Zhi* (Gazeeter of Kaihua Prefecture)	"The laxi live deep into the mountains, they weed with fire and till with knifes [火种刀耕]"	n/d	Yin 2001: 75
Pumi Northwest Yunnan	Qing dyn. Qianlong reign 1765 AD	*Yongbei Fu Zhi* (Gazeteer of Yongbei Prefecture)	"The *xifan* (pumi) ...They have swidden agriculture, and rely on buckwheat and wheat...They live on cold mountains and chilly valleys where they gather together in groups and settle down...They practice	Barnyard millet, buckwheat	Yin 2001: 58

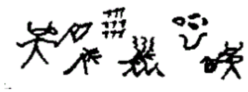
Table 3-1. List of occurrences of slash and burn agriculture in Chinese historical documents, in chronological order from earliest to most recent. Translations of all quotes are from Yin 2001.

Ethnic group/ location	Date of historical record	Historical reference	Quote	Crops recorded	Reference
			swidden agriculture [刀耕火种], and rely on barnyard millet [稗] and buckwheat [荞]"		
Lisu Salween (*Nujiang)* & Mekong(*Lancang*) valleys	Qing dyn. 1785 AD	*Weixi Jianwenlu* (Weixi Travelogue) *Yongchang Fu zhi* (Gazeteer of Yongchang Prefecture) *Yongbei zhili ting zhi* (Gazeteer of the Direct Administrated Division of Yongbei) vol. 7	"They clear the hills for cultivation [垦山而种] . When the earth is exhausted they move on, and thus never settle permanently" "They practice swidden agriculture [刀耕火种] and gather firewood, for their livelihood" "Each year by the end of fall they cut down the trees and burn them with fire [刀耕火种] then they plant miscellaneous grains in the soil"	Broomcorn millet, panicled millet, barnyard millet, buckwheat	Yin 2001:45-46
Yao	Qing dyn. Daoguang reign 1821-1850 AD	*Talang Ting Zhi* (Gazeteer of the Division of Talang)	"The Yao people…enter deep mountain forests and open up fields for swidden agriculture [开垦耕种], when the fields are somewhat ripe, they move again to a new place where they clear the land as they did before"	n/d	Yin 2001: 73
Jingpo	Qing dyn. Early 1900s	*Danbian Yeren Fengtu* (Notes on the Costumes and Habits of the Wild People of Yunnan Borderlands)	"Agriculture is their only occupation, every winter they go about felling the trees in the forest. In late spring when the weather is dry they burn the fields. after they have let the fields cool down they use bamboo sticks to make holes in which they sown the seeds"	dry rice, barnyard millet, xiaomi millet, sesame, taro, maize,	Yin 2001: 54

Table 3-1. List of occurrences of slash and burn agriculture in Chinese historical documents, in chronological order from earliest to most recent. Translations of all quotes are from Yin 2001.

Ethnic group/ location	Date of historical record	Historical reference	Quote	Crops recorded	Reference
		Dian-mian beiduan jiewu diaocha baogao (Report on the Investigations of the Issues Concerning the Northern Section of the Dian-Mian -*Yunnan-Myanmar*- border)	"They live for most part high up in the mountains and are always on the move…They grow many kinds of miscellaneous starch crops: dry rice [旱谷], barnyard millet [稗子], xiaomi millet [小米], sesame [芝麻], taro [芋薯], maize [苞谷], buckwheat [荞], beans [豆] and so on. They do not have plows or hoes; they only use their knifes to cut the trees, which are dried, set on fire, and burned. Then the seeds are sown, after which the crops are left to grow and mature on their own. This is called swidden agriculture [刀耕火种]"	buckwheat, beans	
Dulong (drung) Daxueshan Mt.	Qing dyn. 1908 AD	*Nu-Qiu bian'ai Xiangqing* (Detailed Report on the Nu-qiu Frontier Pass)	"At the Mangku crossing nothing is grown except buckwheat [麦], sorghum [膏粱], xiaomi millet [小米], barnyard millet [稗], maize [苞谷] and such crops. Downstream from here, however, dry rice [旱谷] is grown. When they cultivate their fields, all they have is their knifes, which they use to fell the trees. They then set fire and burn the clearing. They use bamboo sticks to bore holes in the ground, and point-sow maize [苞谷] into them. When they grow wheat and millet or other such grains they broadcast the seeds instead and spread them around and mix them with bamboo rakes after which they leave the crop to grow and mature on their own. This is called swidden	Buckwheat, sorghum, maize, barnyard millet, dry rice	Yin 2001: 61-62

Table 3-1. List of occurrences of slash and burn agriculture in Chinese historical documents, in chronological order from earliest to most recent. Translations of all quotes are from Yin 2001.

Ethnic group/ location	Date of historical record	Historical reference	Quote	Crops recorded	Reference
			agriculture [刀耕火种]. There are no crops that are not grown during this regime. During one year grows a particular crop, the next year another. Rotating every year amongst the various fields to the left and right, or behind and in front of one's above, which is then abandoned for a new site… The fields that have already been cultivated for ten or eight years after which one may return and clear them for cultivation again, provided that the vegetation and the trees now once again flourish on the site"		
Naxi Northwest Yunnan	Qing dyn. (17th-20th centuries AD)	*Jingdong fu zhi* (Gazeteer of Jingdong Prefercture)	"Men and women engage in swidden agriculture [刀耕火种], which is painstaking hard work. When they till the land they use two oxen… On level land they grow beans [豆] and wheat [麦], and on the hills they grow buckwheat[荞] and barnyard millet [稗], after which they abandon the land and grow turnips [蔓菁] on it"	Beans, buckwheat, wheat, barnyard millet, turnips	Yin 2001: 50-51
		Fang GY (ed) 1985. Dictionary of Naxi Pictograph. Kuning, Yunnan People Press. Pp 143, 163, 523	"…cut down the three in nine patches of forest, when I had cut them I set fire to the mountain; when the burning was done I planted the seeds; after the planting was done, I harvested it all" 		

CHAPTER 4. Methodology

4.1. Introduction

For the aims of this research (see section 1.1 in Chapter 1), three sites which span chronologically between the 3rd and 1st millennia BC, have been chosen as the focus of further, systematic archaeobotanical analysis: Baiyangcun, Haimenkou, and Dayingzhuang. The term archaeobotany is used here in the traditional sense, as "the study of past plant-human interactions, as evident from the archaeological record" (Ford, 1979). Ancient plant macro-remains from these three sites, and additionally, phytoliths remains from Dayingzhuang constitute the core of this research (table 4-1). The first two sites are located along the Jinsha river basin and the latter close to Kunming. The sites present generally good preservation conditions, especially Baiyangcun and Haimenkou, and although for Dayingzhuang preservation conditions are lower than the previous two (see Chapter 7), the site is one of the few Dian settlements with systematic archaeobotanical material available, and for this reason it has been selected for this study. Phytoliths from this site have been additionally studied to investigate the issue of rice irrigation during the Dian, which is a debated topic in the Archaeology of the Dian, as historical records indicated that rice irrigation might have been practiced during the Dian, but archaeobotanical evidence to evaluate this are still largely lacking (Yao, et al. 2015).

Although both Baiyangcun and Haimenkou have undergone multiple excavation campaigns (see below), no systematic environmental investigation was carried out at Baiyangcun, therefore the results presented here are based on new, systematic archaeobotanical data, and can provide a more detailed picture of the subsistence strategy of the 3rd millennium BC in Yunnan. Similarly, earlier archaeobotanical work at

Haimenkou has failed to provide detailed morphological and morphometric analyses on the archaeobotanical remains, and therefore unstudied samples have been selected to be included in this thesis in order to investigate the pivotal time of introduction of western domesticates into Yunnan.

Table 4-1. Outline of materials analysed for the purpose of this dissertation and their respective provenance.

Site	Macro	Phytoliths	Provenance
Baiyangcun	√		Collected in 2013 by Dr. Gao Yu, provided by Prof. Qin Ling (Peking University) and Prof. Dorian Q Fuller (UCL)
Haimenkou	√		Collected in 2008 by Prof. Cui Jianfeng, provided by Prof. Qin Ling (Peking University).
Dayingzhuang	√	√	Collected in 2017 by Li Xiaorui, provided by Li Xiaorui (Yunnan Province Institute of Cultural Relics and Archaeology).

This chapter provides a brief summary of the sites' excavation history (see table 4-2), and it includes the description of sampling strategies and laboratory analyses carried out for each of the materials analysed, as well as a general overview of archaeobotanical remains preservation, recovery, and biases and constraints linked with the study of each type of archaeobotanical remain as relevant for the research outlined in this dissertation.

4.2. Macro-Botanical Remains

4.2.1. Preservation, Recovery and Constraints

Macro-botanical remains indicate plant seeds, nutshells, fruit pips, and other food fragments, which can be preserved in archaeological sites either through charring, mineralisation, waterlogging, or desiccation (Pearsall, 2000). Charring occurs after a burning event, such as that produced by cooking, or by the disposal of waste through fire. Mineralisation occurs with high levels of calcium phosphate (CaO4P) in the soil, such as in sewage areas and alike. Waterlogging indicates plant materials that are preserved in anaerobic conditions generated by the continuous presence of water. Finally, desiccation occurs in extremely dry conditions, opposite to those of waterlogging (Pearsall, 2000). At the sites analysed for this dissertation, plant remains were preserved mostly by charring, and occasionally by mineralisation.

In archaeobotany, charred macro-botanical remains are usually recovered through means of water flotation. Flotation can be carried out manually with buckets, or with the aid of a flotation machine. After the float is collected directly from the soil without any sieving, it is slowly poured into a bucket of water/flotation machine. Gentle stirring movements are either manually applied to the soil, now deposited at the bottom of the bucket, or reproduced by the means of the flotation machine. Due to differences in density, this allows for the lighter fractions, containing various organic material such as wood charcoal, plant remains, food fragments, to detach from the inorganic material (the soil) and float to the surface. There, they can be collected either through scooping or through pouring the first layer of water into a screen of various mesh sizes, preferably of at least 0.3mm so to collect also the smaller remains, such as rice spikelet bases and small weeds (Pearsall, 2000). The screen can be made of nylon or cloth and is then labelled by sample and hanged in the shade to dry naturally.

In China, the collection of environmental samples, including archaeobotanical (macro-remains, phytoliths and pollen), is regulated by a clear and specific protocol outlined in *Tianye Kaogu Caozuo Guicheng* (田野考古操作规程 *Operational Guidelines for Field Archaeology*, Guojia, 2009: 21-25*)*[6]*.* The procedures set out in the Guidelines are modeled after standard UK environmental samples collection procedures. For flotation samples, recommended bulk soil volumes for flotation are 20L (but can be as little as 5L, and in 5L increase in high preservation conditions), mesh size for the collection of the sample during flotation is suggested at 0.3mm.

This protocol was followed by the people involved in the excavation and samples collection at the sites investigated for this dissertation. Mesh size for the collection of archaeobotanical material after flotation was between 0.2-0.3mm at all three sites. Thus, although there may still be some difference in the level of sorting based on care and experience of different workers, the results are broadly comparable.

[6] Published in 2009 by the Chinese Government, the guidelines for the sampling of environmental materials follow indications taken from Murphy & Wiltshire (1994) *A guide to sampling archaeological deposits for environmental analysis*. Museum of London Archaeology Service, Archaeological Site Manual, 3rd Ed.

4.2.2. Site Specific Excavation and Sampling Strategy

4.2.2.1. Baiyangcun

The site of Baiyangcun was discovered in 1972, and excavated a first time from November 1973 to January 1974, and more recently between 2013-2014. During the first excavation campaign 9 trenches of a total area of 290m^2 were excavated (fig. 4-1). In this occasion, 8 so-called "cultural layers" (or cultural deposits, see fig. 4-2) reaching a depth of 4.35m were individuated.

In 2013-14, a further 100m^2 divided in 2 trenches were excavated. A total of 24 cultural layers were distinguished, reaching a depth of 4.8m. The new excavation area was located northwest from the area dug during the first excavation season. Although the deposits from the most recent excavation had been divided in a more detailed way, according to the excavation director (Min Rui, personal comment 2016), they were stratigraphically aligned with the original 8 layers individuated during the first excavation campaign. Surveys following the last excavation seasons have revealed that the extent of the site might have been much larger than previously thought, with an estimated size of between 100- 200,000m^2 (Min Rui, personal comment 2018).

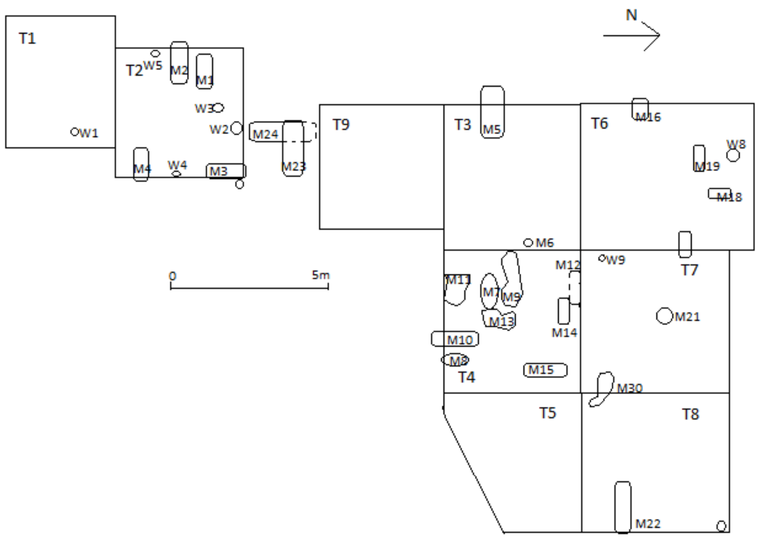


Fig. 4-1: Site plan showing graves excavated during first excavation season at Baiyangcun. Redrawn from Yunnan, 1981.

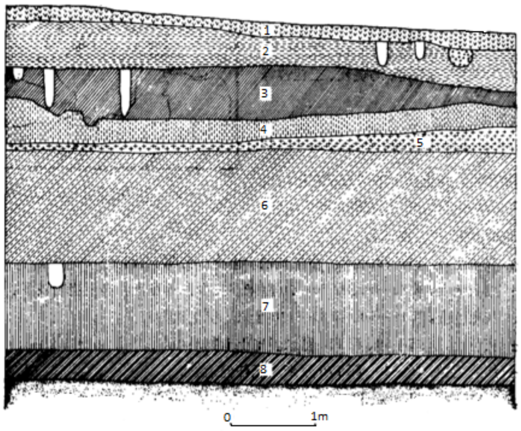


Fig. 4-2: Northern limit of T7, south facing profile section, showing the division in 8 layers, including topsoil (layer 1), and bedrock under layer 8. Redrawn from Yunnan, 1981.

Trial flotation tests from 3 rubbish pits were carried out during the initial phases of the 2013-14 excavation at Baiyangcun, so to establish a coherent sampling strategy, in line with the preservation conditions present at the site. Bulk soil samples of 35L of volume were taken from each of these trial deposits, and floated in 5L, 10L, 20L divisions. These tests revealed that extremely good preservation conditions were present, and it was established that a bulk soil volume of between 5-10L was enough to provide a sufficient collection of macro-botanical remains, as well as being more feasible with the total collection design and excavation area size (Chris Stevens, personal comment 2016). Given the importance of the site as one of the possible earliest prehistoric settlement of the area, a total sampling strategy ("blanket sampling") was adopted, and flotation samples were collected from each individual feature, and each cultural layer. For cultural layers, when reaching a new stratum, this was excavated for 5cm in depth in an attempt to prevent any intrusion from the layer above it, and a 1*1m of soil was collected for flotation. Multiple samples from the same cultural layer were collected and labelled S1, S2, S3, S4, and S5 (S standing for "sample"). By doing so, when all of S1 to S5 were collected, soil sampled accounted for about 5%- 10% of the total soil excavated for that cultural layer.

At Baiyangcun, more than 300 flotation samples were collected. Samples were floated through manual bucket flotation, and floats were collected using a 0.3mm mesh (fig. 4-3 left). The archaeobotanical material was then gathered on a cotton cloth bag and hanged in the shade to dry naturally (fig. 4-3 right).

Fig. 4-3: Manual bucket flotation and archaeobotanical samples drying in the shade at the site of Baiyangcun. Photos by Min Rui (Yunnan Provincial Institute of Archaeology), used with permission.

Given the large number of samples collected during excavation, and the impracticality of sorting their totality for the purposes of this research, some decisions were made to reach a representative selection of samples to be analysed. A complete sequence top to bottom from layer 3 to layer 24 was selected from each excavation trench. An attempt was made to sort all samples coming from house contexts. Other features, mostly ash pits, were randomly selected, trying to reach a similar number of contexts analysed per each period of occupation. Multiple samples coming from the same context, originally labelled as S1-5 as outlined above, have been combined before performing quantitative analysis, and Appendix 2 lists samples by context after the merging of these multiple samples. For the purposed of this analysis, the cultural layers from trench 1 and trench 2 have been considered jointly as their stratigraphic division was consistent between the two trenches, and layers could be link directly (Min Rui, personal comment 2016), therefore making the division redundant.

4.2.2.2. Haimenkou

The site of Haimenkou was discovered in 1957, and excavated three times in:

- January-March 1957 (Yunnan, 1958);
- April 1978 (Xiao 1991; Xiao, 1995);
- January-May 2008 (Xue, 2010).

During the third excavation campaign, the site was divided in two main areas, labelled as JHD (the southern area), and JHA (the northern area) respectively (fig. 4-4 left). A total of 1350m^2 divided in 27 trenches of 5x10m size each was excavated. Throughout the trenches, 10 cultural layers were distinguished (fig. 4-4 right). The estimated site area is currently believed to be about 100,000km^2 (Min, 2013).

Haimenkou presents extremely good preservation conditions, including many waterlogged remains. Archaeobotanical samples were collected from each cultural layer and features; each sample had a bulk soil volume of 5L, and was floated with manual bucket flotation, using a 0.3mm gauze. Floats were then collected on cotton cloth bags, and hanged to naturally dry in the shade.

10 previously unstudied archaeobotanical samples from the site of Haimenkou were available to analyse for this dissertation. The samples, which contained only charred remains, came from both JHD and JHA excavation areas (see table 6-3 in Chapter 6).

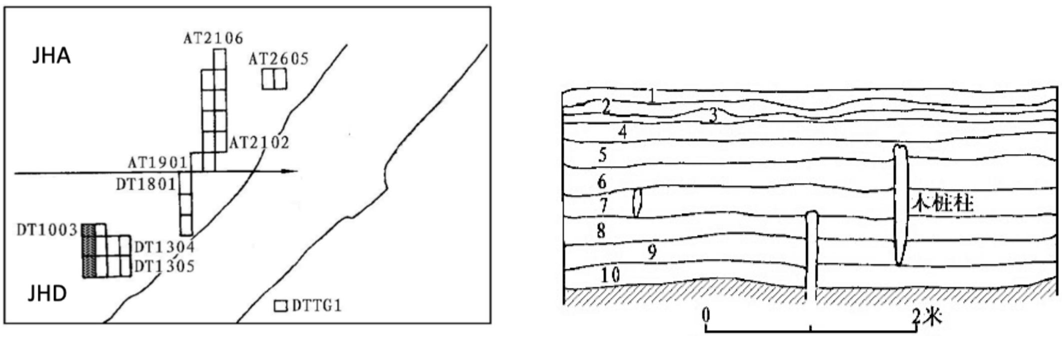


Fig. 4-4: Left: Plan showing excavation areas and trenches at Haimenkou. Redrawn from Xue, 2010. Right: South facing profile section of T1003. Redrawn from Yunnan, 2009.

4.2.2.3. Dayingzhuang

The site of Dayingzhuang was discovered in 2010, over the course of the “The Dian Heartland Archaeology Survey Project” (Yunnan et al., 2015; Yunnan, et al., 2014; Yao & Jiang, 2012). This was a three-year joint Chinese-American-Canadian archaeological survey of the western bank of the Lake Dian, led by the Yunnan Province Institute of Archaeology, Michigan University (USA), and the Anthropology Museum in Toronto (Canada). The survey aimed to investigate the distribution and settlements structure of archaeological sites belonging to the so-called Shizhaishan (now usually called Dian) Culture (Yunnan, et al., 2015; Yunnan, et al., 2014; Yao & Jiang, 2012). The survey also aimed to shed light on subsistence practices, material culture, relationships between each site in the area, and settlements development trajectories, especially those linked to human activities in relation to changes in the environment.

Dayingzhuang was excavated only for one season between the months of March and May 2017. The excavation area comprised of 4 trenches, each measuring 10x10m^2; and 5 further trenches, measuring respectively 2x30m^2, 2x14m^2 the first 2, and 2x2m^2 the other 3, for a total excavated area of 500m^2 (fig. 4-5). Cultural deposits were divided into 5 layers, which reached a maximum depth of 2.8m (fig 4-6). The total estimated size of the site is thought to be between 40,000-100,000m^2 (personal comment, Li Xiaorui 2018; Yunnan et al., 2015).

Fig. 4-5: Aerial view of the excavation at Dayingzhuang. Photo by Li Xiaorui (Yunnan Province Institute of Archaeology), used with permission.

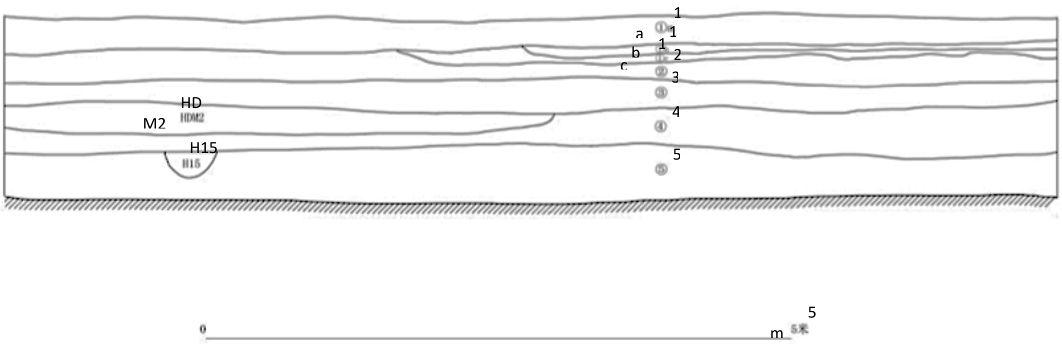


Fig. 4-6: Trench TN1E2 north wall profile section showing stratigraphy and cultural layers individuated at Dayingzhuang. Unpublished, used with permission (Li Xiaorui, excavation director, Yunnan Provincie Institute of Archaeology).

At the site of Dayingzhuang, samples for flotation were collected from each individual feature across all of the excavation trenches, and from cultural layers in trench TN2E2, located on the southwestern corner of the main excavation area, as well as from the point at the cross of the four trenches in the main excavation area. These are labelled as GJZ (*guanjianzhu* 关键住 meaning "control column"), followed by the layer number, in line with the stratigraphic division made through the trenches. A bulk soil volume of 20L was taken for each sample. This higher bulk soil volume of 20L aimed to maximise the collection of macro-botanical remains in light of the expected poor preservation, as attested at other similar shell-midden sites in Yunnan, where a 20L bulk soil volume proved necessary to increase the chance of recovery macro-botanical remains (Li Xiaorui, personal comment 2018). Similar higher bulk soil volume requirements are recommended at tropical sites in mainland Southeast Asia, where lower bulk soil volumes fail to recover macro-botanical remains (Cristina Castillo, personal comment 2019). In trench TN2E2, a total of 5 multiple samples for each layer were collected, indicated by S1-5, one at each corner of the trench (S1-4), and one (S5) in the middle, respectively. These have been merged before performing quantitative analyses.

At Dayingzhuang, over 130 archaeobotanical samples were collected. Samples were floated through manual bucket flotation, the archaeobotanical material was collected using a 0.3mm mesh and put into a cotton cloth bag to dry naturally in the shade.

All the samples were scanned by the author under a Leica low power binocular microscope at magnification up to X40 at the Yunnan Provincial Institute of Archaeology in Kunming in April 2018. This was done in order to select a number of representative samples to bring back to UCL to analyse fully. Originally, 32 samples were selected, covering a complete sequence top to bottom from layer 2 to layer 5, including two contexts linked with layer 2. However, AMS radiocarbon dating on remains from layer 2 showed it to be modern (see Chapter 7 for details on radiocarbon dating at the site of Dayingzhuang). Samples belonging to the 2nd layer have since been excluded.

Table 4-2. Summary of excavations at each of the sites analysed, including flotation method employed, samples bulk vol in L, and total samples analysed for this dissertation.

Site	Exc. history	Exc. area: size in m^2	Est. site size in ha^2	Flotation: bulk volume in L	Samples analysed
Baiyangcun	1973-74; 2013-2014	$290m^2$ $100m^2$	$20ha^2$	Manual bucket flotation: 5-10L	116
Haimenkou	1957; 1978; 2008	n/a n/a $1350m^2$	$10ha^2$	Manual bucket flotation: 5L	10
Dayingzhuang	2017	$500m^2$	$4\text{-}10ha^2$	Manual bucket flotation: 20L	30

4.2.3. Laboratory Methods

All samples analysed from the three sites were sieved to obtained fractions of 4mm, 2mm, 1mm, 0.5mm, 0.25mm, and >0.25mm. Fractions from 4mm to 0.5mm were fully sorted by the author under a LEICA S9D low power binocular microscope at magnification up to x40 at the UCL Institute of Archaeology, Archaeobotany Laboratory. Fraction 0.25mm was scanned for rice spikelet bases, and any not yet encountered larger species.

All identifications were recorded on an excel spreadsheet, following the Flora of China classification and numbering of species (efloras.org). Identifications were made consulting the UCL Institute of Archaeology-Archaeobotany Laboratory Reference Collection, which includes seeds and plant remains from many modern species, including some specific to East Asia. The reference collection also includes some archaeological plant remains from early sites in China, which were also consulted.

Furthermore, a number of written and online references were also employed to aid with identification, and these are listed below.

Written resources

- Fuller, D.Q. (unpublished). *Seeds for the Archaeologist. Identification primers and student's workbook for Old World Archaeology* (Handouts from the "Archaeobotanical Analysis in Practice" short course at UCL Institute of Archaeology run by Prof. Dorian Q Fuller).

- Liu, C., G. Jin & Z. Kong. 2008. *Archaeobotany-Research on seeds and fruits.* Beijing, Science Press (in Chinese).
- Zhang C. & Q. Guo (eds) 1995. *Illustrated Atlas of field weed seeds: Vol 1.* Beijing, Chinese Agricultural Press (in Chinese).
- Zhao, Z. 2010. *Paleoethnobotany: Theories, Methods and Practice.* Bejing, Science Press (in Chinese).
- Nakayama, S., M. Inokuchi, & T. Minamitani. 2000. *Seeds of Wild Plants in Japan*. Sendai, Tohoku University Press.
- Neef, R., R.T.J. Cappers & R.M. Bekker. 2009. *Digital Atlas of Economic Plants.* Gronigen, Barkhuis.
- Zohary, D., M. Hopf & E. Heiss. 2012. Domestication of plants in the Old World: The Origin and Spread of domesticated plants in Southwest Asia, Europe and the Mediterranean Basin. 4th ed. Oxford, Oxford University Press.
- Guo Q. (ed) 2009. *The Illustrated Seeds of Chinese Medicinal Plants.* Beijing, Chinese Agricultural Press (in Chinese).

Online resources

- Flora of China: www.efloras.org
- The Plant List: http://www.theplantlist.org
- The Digital Seed Atlas of the Netherlands: http://dzn.eldoc.ub.rug.nl
- Naturalised plants in Japan- Seed Image Database: http://www.rib.okayama-u.ac.jp/wild/okayama_kika_v2/okayama_kika-EN.html

After sorting, well preserved specimen from each species were photographed using the Leica imaging software.

4.2.4. Quantitative Analyses

A variety of quantitative analyses were systematically performed on the remains recovered from each of the sites. These include simple, non-multivariate analyses, as outlined below. Analyses performed include species ubiquity index (also referred in archaeobotanical reports as presence/absence), frequency index (also referred to as ratio, or abundance), and morphometric measurements on main species.

Counts

Total counts presented throughout this dissertation were obtained taking into consideration the minimum countable unit of each individual species: a whole caryopsis for crops, 2 cotyledons for pulses, and whole seeds/stones for other species. Given the high numbers of small rice fragments recovered, in order not to overestimate its frequency, it was decided to weigh them against their whole grain equivalent and record them as such. This was made in an attempt to standardise the data, as well as to reduce its possible distortion (Miller, 1988), and avoid the common overestimation of charred rice remains. The equation *1ml=50 whole grains* was applied to all rice fragments. This is indicated in Appendix 1 by the phrase "rice fragments as equivalent to whole grains=n", under the rice fragment tab of each analysed sample.

For other species, such as *Euryale ferox*, following Lymann (2008) an equivalent to the commonly used in zooarchaeology NISP (number of identified species) was adopted throughout this analysis, so to emphasise taxonomic presence.

Ubiquity & frequency

The ubiquity index informs on "the number of samples in which specific taxa appears within a group of samples" (Popper, 1988). This was used to evaluate which species are used more frequently, and therefore present in more samples. The term "presence" is also used to refer to the ubiquity of the remains.

The frequency indicates how much of the assemblage is constituted by a specific taxon, in relation to the total number of identified remains. It provides information regarding the composition of the assemblage (Miller, 1988). The term "abundance" is also used to refer to the frequency of the remains.

Percentages are used for ubiquity and frequency in order to standardise the data across the different sites and allow for comparisons. To reconstruct the subsistence system present at each site, ubiquity and frequency were calculated first for the overall archaeobotanical assemblage, and secondly chronologically by period of occupation. This allowed to assess assemblage compositional differences across the sites, as well as explore plant use changes through time. Ubiquity and frequency percentages across the text are systematically shown in relation to the overall archaeobotanical assemblage, either of the whole site, or of the period of occupation shown. Histograms and pie charts created using Microsoft Excel software have been used to visually present the results of these analyses.

Both ubiquity and frequency, together with qualitative data on each species (referring to morphological characteristics qualifying remains as wild vs. domesticated - see also below *A note on the categorisation of the remains*) are taken into account when inferring primary vs. secondary roles for each species recovered and thus reconstructing the economy of a site. A species with ubiquity values of 50%, and frequency values of at least 20-30% within the overall archaeobotanical assemblage is inferred to have had a more prominent role in the overall agricultural system of the site, and possibly reflect a primary resource in the subsistence regime of that site. Domesticated cereals are classified as crops, other economic species include any other non-cereal edible species, finally common field weed species are classified as weeds, in line with information gathered from Southwest China local floras.

Density

The density of items per litre floated results from the division of the total number of identified remains per the total number of litres of soil floated at each site. Density index allow us to discuss any differences deposition and preservation conditions across the sites (Miller 1988). Density has also been used in past archaeological studies to infer the intensity of the occupation at a specific site (Pearsall, 1983). In this thesis density is taken into account to compare the preservation condition of crop species at each site.

Morphometrics

The Leica imaging software was used to photograph specimens and undertake morphometric measurements. Species measured include rice, millets (both foxtail and broomcorn millet), wheat, barley, buckwheat, soybean, *Cajanus, Cannabis,* and *Chenopodium*. Only complete and well preserved, clean (with no husk) specimens, which would show clear morphological characteristics, as well as the embryo/ hilum, were selected for measuring. Measurements taken include length, width and thickness for each specimen, as shown in fig. 4-7 (see also Appendix 4 for a complete list of the measurements for each species from each site).

The measurements obtained were then plotted by species against already published morphometric data from other regions, especially Central China and the Lower Yangzi region, but also Southeast Asia when available, allowing us to discuss domestication trajectories of these species (Chapter 8).

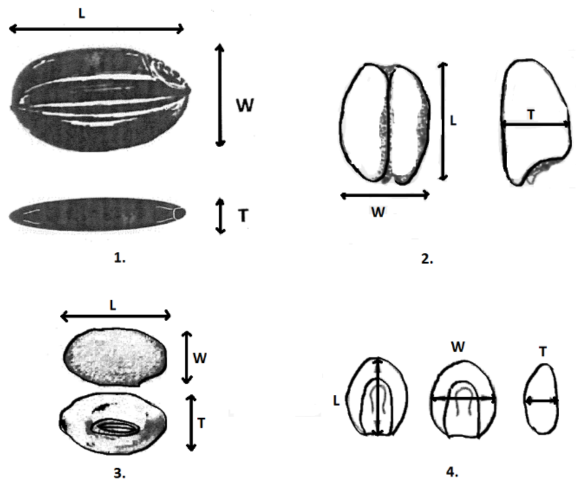


Fig. 4-7. Indications of measurements taken throughout this dissertation: L=length; W=width; T=thickness. Examples of main species measured: 1, rice; 2. wheat, 3. soybean, 4. millets.

Crop processing

At the site of Baiyangcun, the great quantity of weed seeds and other so-called crop processing by-products (or waste, undesired material that get incorporated through crop harvesting) has allowed for some further analyses on the crops to be undertaken. These analyses have been based on models derived by ethnographic studies on crop processing practices as documented in non-mechanized agricultural systems, with the inference that a similar set of practices might have been undertaken in the past, before the mechanization of agriculture (e.g. Hillman 1981; 1984; Reddy, 1994; 2003; Thompson, 1996). These studies have highlighted how each stage of these practices would produce specific waste from the crop plant, such as culm, chaff, straw parts, as well as unwanted infesting cultivation weeds. Therefore, by studying the presence of these by-products, one can infer which crop processing stage is represented in the archaeobotanical record. Generally speaking, for most cereal crops common crop processing stages include: harvesting, threshing, winnowing, storing, milling, pounding (dehusking) and cooking (Reddy, 1994; Thompson, 1996). The amount of non-grain by-products that get incorporated into the assemblage depends greatly on the harvesting method chosen. Harvesting the crop at the base of panicle allows for less non-grain products to be incorporated into the assemblage, usually chaff remains (glumes, palea, lemma, and spikelets for rice), whereas harvesting lower at the base of the plant or uprooting it (for rice) in addition to chaff remains would allow for more weeds and straws to enter the assemblage. By threshing and winnowing, the majority of straws, chaff and light weed seeds get removed. According to experimental studies on foxtail millet undertaken by Song (2011, see also Song et al., 2013), immature millet grains get also removed mostly through winnowing. Through pounding, heavy weeds, husks and rice spikelets get removed (see fig. 4-10). This kind of analysis can shed light into past people behaviours as related to processing habits; the greater ratio of unwanted products in relation to the crops would evidence earlier stages of crop processing, whereas the greater ratio of crop grains in relation to their waste would attest later stages of crop processing.

Meta data analysis of archaeobotanical remains

Finally, in Chapter 8, a meta-data analysis of all known sites, including the additional sites studied in this thesis, with archaeobotanical remains (macro-botanical, phytoliths) from Yunnan, the surrounding Southwestern provinces and the neighbouring Southeast Asian countries has been undertaken. This has been carried out through the consultation of the available literature, mostly archaeobotanical reports and dissertations, detailing occupation dates for the sites considered, as well as providing lists of taxa and their abundance within the assemblage (see chapter 8 for detailed bibliography). The raw data provided in these publications, such as excel spreadsheet listing species recovered and their quantity, was used to compile a chronological overview of the regional changes in the archaeobotanical assemblages.

This constitutes a first of its kind meta-data analysis of all the available archaeobotanical evidence dating between the 3rd and 1st millennium BC from Southwest China and from mainland Southeast Asia, which allows the evaluation of past hypotheses and theories of cultural, social and economic development in the area, as well as providing a solid chronological and archaeological framework *for* the future study of the prehistoric cultural and agricultural development of the region.

A note on the categorisation of the remains

For the purposes of the quantitative analyses outlined above, archaeobotanical remains recovered from each of the sites were divided in the following main categories:

1. cereal crops;
2. other economic species;
3. seeds of field weeds species;
4. other.

The categorisation of the species found at each of the sites was made consulting botany manuals and plant atlas, such as Usher (1974) and the online Flora of China (eFloras), so to establish any edible species and known usage of minor species in the study area as attested by historical documents. Non-cereals, edible, or otherwise with known economic uses species in the area have been included in other economic species.

- "Crops" include cereal crops that show domesticated morphological features, regardless of ubiquity and/or frequency. Specifically, systematically included in this category are the following domesticated crop species found in the assemblages, due to their domesticated status: *Oryza sativa* -rice; *Setaria italica* -foxtail millet; *Panicum miliaceum* -broomcorn millet; *Triticum aestivum* -bread wheat; *Hordeum vulgare* -barley; *Fagopyrum* cf *esculentum* -buckwheat. These crops are then also considered primary constituents of the agricultural systems when showing a high ubiquity (at least 50%) and frequency (20-30%) in the overall archaeobotanical assemblage of the site.
- "Other economic species" is a broad category that include non-cereal economic species; such as pulses, fruits, and nuts. At times these include morphologically wild food remains. Their relevance as primary or secondary resources in the overall subsistence follows ubiquity and frequency cut-offs as outlined above.
- "Field weeds" include all those wild weed species that are usually associated with field cultivation and can inform us on the ecology regime under which a crop (especially rice) was grown.
- *Chenopodium* sp. has been considered separately from other categories, as its status (and therefore categorisation) as minor crop or weed is discussed in light of the specific circumstances of each site; it is considered a crop and not a weed

when it has a ubiquity of over 50%, and a frequency of over 20-30% in the overall archaeobotanical assemblage.

- Finally, under “other” are included any other plant remain that could not be included in the previous three categories, such as seeds of tree or weeds non-directly associated with agricultural cultivation, that indicate more general environmental conditions. These are not discussed in detail as not many of these remains are found, but when present they are included in the graphs.

4.3. Phytoliths

4.3.1. Preservation, recovery and constraints

Phytoliths are opal silica bodies deposited in the soil by plants with inflorescences, leaves, stems and roots (Pearsall, 2000). Plants metabolism and genetics are the main determining factors for the deposition of phytoliths; additionally, climate and chemical and physical soil conditions also affect the creation and preservation of phytoliths (Piperno, 2006). Under good preservation conditions, they retain diagnostic characteristics of shape and size of the taxa they belong to, which can enable their identification. Phytoliths, therefore, can inform us on vegetation and environmental conditions present at archaeological sites. (Piperno, 2006: 21). Phytoliths remains can be especially useful for assessing plant resources at sites with very low preservation of macro-botanical remains (Pearshall, 2000).

Phytolits samples are usually recovered through unprocessed soil collection during excavation. This can be either vertically from a profile, or horizontally, following the progression of the excavation (Piperno, 2006).

4.3.2. Site specific excavation and sampling strategies

4.3.2.1. Dayingzhuang

Phytoliths samples from the site of Dayingzhuang were collected vertically from the GJZ control column in the main excavation area (see above), without performing any sieving or other kind of processing. Soil samples were was taken every 10cm, put into bags and let dry in the shade. About 10g of soil per each sample was brought back to UCL.

Due to time constraints, only 12[7] individual samples were selected to be processed and analysed. Even numbers between samples #16 and #34 (excluding #28) were selected. Samples #3 and #10 were also selected to provide a modern vegetation baseline (table 4-3; fig. 4-8).

Fig. 4-8: Phytoliths slides, samples from Dayingzhuang.

[7] Originally, sample #12 (from layer 3) was also processed to be analysed, but after mounting to slide it revealed to be too badly mounted to be successfully analysed and was thus discarded.

Table 4-3. Summary of Dayingzhuang phytolith samples, with indication of their original sample number, laboratory sample ID and stratigraphic relation to cultural layers.

Original sample #	Lab. Phytolith ID	Corresponding stratigraphy
3	12	Modern topsoil
10	11	Layer 2 (modern)
12	10	Layer 3 (discarded)
16	9	Layer 3
18	8	Layer 4
20	7	Layer 4
22	6	Layer 4
24	5	Layer 4
26	4	Layer 5
30	3	Layer 5
32	2	Layer 5
34	1	Layer 5

4.3.3. Laboratory methods

Laboratory extraction was carried out at the UCL Institute of Archaeology-Phytoliths Laboratory following an adaptation of the A. M. Rosen (1999) protocol as outlined below.

Day 1:

1. Soil from each sample was ground using a marble pestle and mortar, and then sifted through a 0.25mm sieve.

   Pestle, mortar, and sieve were systematically cleaned with soapy warm water in between each sample to avoid contamination.

   About 1.2g of sieved soil was weighted and poured into a plastic tube.

   Tubes were labelled 1-12. Weights were recorded.
2. 15ml of 10% HCL were added to each sample and tubes were shacked gently in a fume cupboard.
3. About 40ml of deionised water were added to each tube to be balanced on scales in pair and put in the centrifuge.

   Tubes were centrifuged for 5 minutes at 2000rpm. The excess water was then poured off, and this whole step was repeated a total of 3 times.
4. About 5ml of distilled water were added to each sample, and they were let to sit overnight.

Day 2:

5. The excess water was pipetted out from each plastic tube.
6. About 20ml of 10% calgon solution was added, and each tube shaked.

   The content was then transferred to glass beakers, washing out the tubes with deionised water to transfer anything residue left in the tube.
7. Each beaker was filled up to 8cm height with deionised water and stirred gently, then let to sit first for 1hour and 10minutes.

   The top layer of water was then poured off and more water was added up to the 8cm mark. After stirring again, the samples were let to sit for 1 hour exactly, and the whole process was repeated until the water was clear.
8. The top layer of clear suspense was poured off, and each sample was transferred into a crucible using a pipette.
9. Samples on crucibles were dried in the drying oven at 50 ºC overnight.

Day 3:

10. After taking the samples out of the oven, they were each broken up and put in the muffle furnace at 500°C for 2 hours.
11. At the end of the 2 hours, samples were taken out of the furnace and let to cool.
12. Each sample was scraped from the crucible and poured into a 15ml tube with the aid of a piece of shiny plastic paper.
13. 3ml of sodium polytungstate solution were added to each tube, which was then shaked.
14. About 12 ml of deionised water were added to the samples, which were balanced on scales in pairs, and then centrifuged for 10 minutes at 800rpm.
15. The suspense (containing the phytolith) was poured in a new 15ml tube, to which more deionised water was added.
16. The samples were centrifuged three times for 5 minutes at 2000 rpm, pouring away the suspense and re-adding deionised water in between as outlined in steps 14-15 above.

17. After the last centrifuge, the suspense was poured away, and the phytoliths (now at the bottom) were transferred to small glass beakers with a pipette. Weights were recorded.
18. The beakers were finally put in the drying over overnight.

Day 4:

19. Dry phytoliths and pot weights were recorded.
20. About 2.5mg of phytoliths from each sample was weighted and mounted on a glass slide using Entellan. After spreading Entellan on a premeasured square on the glass slide, a toothpick was used to spread the phytoliths evenly across the square. A thin glass square cover was then put over it, and the slides were put horizontally to dry.

    Each slide was labelled with sample ID and mounted phytoliths weight (see fig. 4-8).
21. The rest of the phytoliths were put in individual plastic tubes for storage.

4.3.4. Quantitative analyses

Each phytolith slide was examined with the use of a biological binocular microscope with magnifications up to x400. Phytoliths were counted to reach a minimum of 300 single cells and 150 multi-cells count respectively per each slide.

Phytoliths were classified according to the morphotype divisions outlined in Piperno (2006) and Madella et al. (2005).

Phytoliths analyses include the following three main foci of discussion:

- vegetation composition and forest cover at the time of occupation of the site;
-water availability in relation to crop cultivation;
-crop processing patterns as visible from the phytolith record.

Vegetation composition and forest cover

The D/P index was employed to reconstruct the extent of forest cover at the time of occupation of the site. This ratio is calculated by dividing all the woody dicotyledons morphotypes by the sum of the Poaceae-type phytoliths (short cells including bilobes, saddles, rondels, and fan shaped phytoliths). The D/P index has been successfully applied to determine intensity of past vegetation cover of areas in the African and Eurasian continents, with D/P values of <1 indicating woodlands/ grassland vegetation; D/P values between 4-7 indicating dense evergreen forests (Barboni, et al., 2007; Barboni, et al., 1999; Alexandre, et al., 1997).

In addition to calculating the D/P index, phytoliths were grouped into major plant taxa categories (genera of families as appropriate), and simple scatterplots have been used to show vegetation compositional changes through time (Biswas & al, 2016).

Ecology and water availability

Grass phytoliths were divided in "sensitive" and "fixed" morphotypes, as these are believed to be indicators of water availability at the time of deposition (Madella & al., 2009; Jenkins, et al., 2011; Weisskopf & al., 2015). The deposition of sensitive morphotypes is environmentally influenced by the level of water availability through the life cycle of the plant. Fixed morphotypes, instead, are genetically determined, and are deposited in the soil regardless of the water intake of the plant throughout its life cycle. The ratio of sensitive to fixed morphotypes, in association with the presence of crop phytoliths, can inform us about possible irrigation practices and general water availability. The presence of crop remains is necessary to ascertain that phytoliths and the signature they provide are directly correlated with crop waste, and not other plants that could have naturally occurred.

Crop processing

Crop processing activities were investigated through the ratio of leaf to husks phytoliths as outlined in Harvey & Fuller (2005; see fig. 4-9). This scheme applies models derived from macro-botanical crop processing studies to phytolith remains. Each specific stage of crop processing produces specific types of by-products, for instance, crop processing of rice would produce light, small seeded weeds and culms during the initial stages (such as threshing); whereas later stages of processing (such as pounding) produce waste comprised of husks and heavy, large seeded weeds (e.g. Harvey & Fuller, 2005; Hillman, 1973; Hillman, 1981; Stevens, 2003). Following the same principles, during the initial stages of crop processing leaf phytoliths are deposited, while during the later stages husk phytoliths will be present in higher quantities. Therefore, leaf: husk phytolith ratio, when associated to crop remains from the same context, can inform us about specific crop processing activities, including if different areas of a site were used for different crop processing stages.

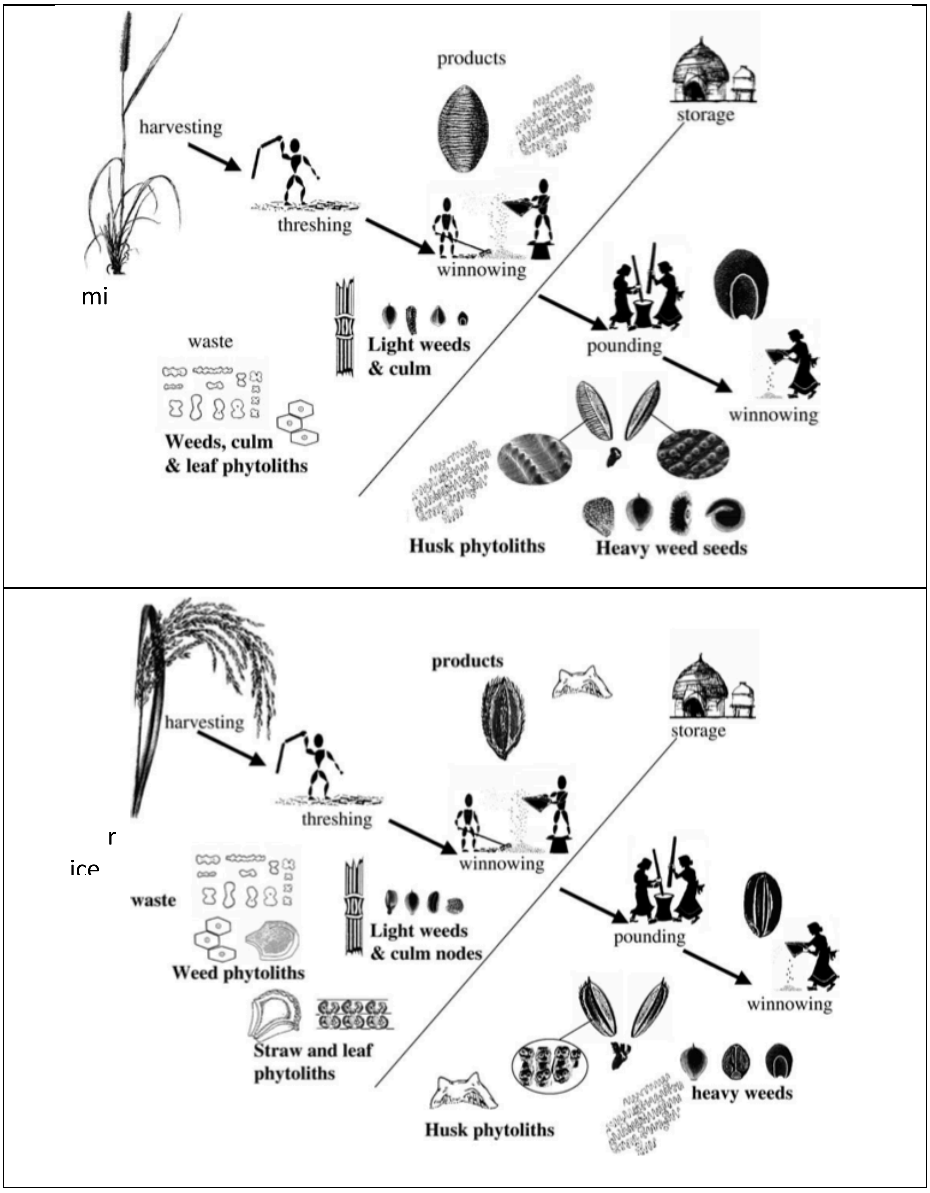


Fig. 4-9: Scheme for millet (top), and rice (bottom) crop main processing stages and respective macro and micro-botanical remains produced. From Harvey & Fuller, 2005.

CHAPTER 5. The site of Baiyangcun

5.1. Introduction

The site of Baiyangcun is located in the middle Jinsha River Valley, in Binchuan County, north-western Yunnan. The site is at about 50km East of the city of Dali, and only 3 km away in a north-eastern direction from the banks of the Binju River, an offshoot of the Jinsha River, which is itself a tributary of the Yangzi River (fig. 5-1).

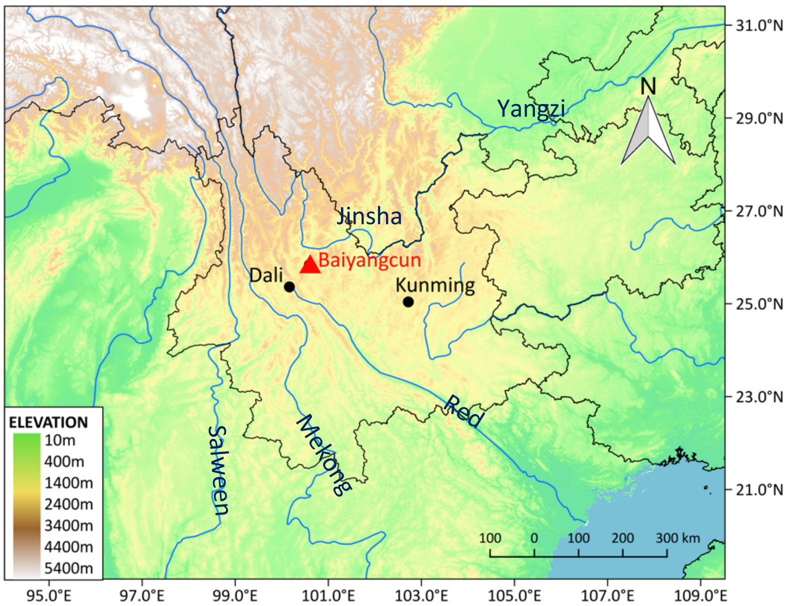


Fig. 5-1: Map showing geographical location, major rivers, and relative position of the site of Baiyangcun to the cities of Dali and Kunming.

Fig. 5-2: Modern day surrounding environment at Baiyangcun. Clockwise from top left corner: standing on top of the mound, facing North, informative stone panel indicating location of the site visible in the distance; standing on top of the mound, facing South, informative stone panel indicating location of the site visible in the foreground on the right; standing on top of the mound, facing West showing intensive modern agriculture and harvest being practiced in August 2016; facing East, showing river now used for irrigation. High mountains visible in the far, hazy background of each photo. Photos by the author.

The site is surrounded by high mountains (fig. 5-2), which reach an altitude of 2300m asl. The subtropical monsoons active in the region create separate dry and wet seasons. Annual average precipitation at Binchuan is about 578mm, and 1069mm at the nearby city of Dali (Yunnan, 1986). Most of the precipitation occurs between the months of May and October, and only 6.9% of the total annual precipitation occurs during the rest of the year. Annual average temperature is attested between 15°C to 18°C (Yunnan, 1986; Li & Walker, 1986). Temperatures for the coldest month (January) average to 7-10°C, and 20-21°C for the hottest month (July). Temperatures rarely reach below 0°C, therefore frost almost never occur in this area of Yunnan. The annual relative humidity rate is 63%, with an attested water evaporation of about 2477mm per year. No fog generally occurs in this part of Yunnan (Yunnan, 1986).

Modern agriculture is heavily practiced all around the city of Dali and at Binchuan County. This deteriorated the original vegetation composition; modern forests are almost solely composed of *Pinus* spp, which is a strong indicator of human intervention (see Chapter 3).

During the 3rd millennium BC, the Binchuan Basin had environmental conditions slightly hotter and more humid than those of present day (Li & Walker, 1986; see Chapter 3).

5.2. Site description and material culture

5.2.1. Features

During the first excavation season numerous archaeological features were found, including: 11 houses, 14 hearths, 48 pits, and 34 graves (see fig. 4-1 in Chapter 4). According to the excavation report, the 5th layer demarcates two different occupational periods, and features are divided accordingly (Yunnan, 1981, fig. 4-2 in Chapter 4). Of the 11 houses unearthed during the first excavation season, F7 to F11 belong to an early phase, F1 to F6 belong to a later phase. All houses are of the wattle and daub structure type, with differences across the two periods.

The earlier houses are rectangular in perimeter, with an average area of 5x2/3m. The perimeter is characterized by a groove 25-35cm wide and 30-40cm deep dug from the floor level. Postholes are found within the groove, usually clustered at the four corners. The postholes diameter varies between 30-50cm wide, and they reach a depth of up to 70cm in the ground. Remains of the wooden posts were recovered from some of the postholes, and they showed signs of unpolished burnt clay and straw plaster material. The opening of the house was usually located on the long side of the perimeter, although no information is provided on the direction houses' entrance faced. The floor had a general thickness of between 2-5cm (Yunnan, 1981).

Later period houses are also all of the wattle and daub type, however, there is no sign of the earlier groove along the perimeter. Houses of this period can be divided in two subgroups according to differences in foundations building technique. No precise number is provided in regards of these two subgroups. For some, posts were dug straight into the ground at the floor lever. Other houses presented a mixture of stone planks and posts as foundation structure for the walls.

Pot sherds, stone implements, and animal bones were often found scattered on the floor of the houses.

Of the 14 fire hearths excavated, 7 belong to the earlier period, and 7 to the later period. Presumably some of those hearts represent houses' fireplaces, but the perimeter could not be distinguished during excavation (Yunnan, 1981).

The pits from the first excavation campaign are divided typologically according to their overall shape and the characteristic of their opening: rounded (25, only found in the later phase of occupation), oval (6), rectangular (9), and irregular (6). Their size varies, but no extensive description is provided in the report. Although no floor plan of the houses nor the pits was included in the report, the excavators state that the majority of the pits are located around the houses. In some of them (such as H1; H2) "white ashes" identified as possible rice remains, together with animal bones and a few pot sherds were found.

Two types of graves were found during the first excavation: simple rectangular cut inhumation/shaft pit (24), and urn inhumation (10). Amongst the rectangular cut inhumation, 8 are primary burials, 6 are secondary burials, and the remnant 10 are treated separately in the report as the buried skeletons lacked the skull. In single primary burials, the deceased is placed in either extended or flexed supine position. Burials presenting no skull contained both adult and children skeletons, singular and multiple inhumations. Finally, urn inhumations, apart from one instance where an infant was found, were all reserved for new-borns and toddlers. Funerary objects (small pottery vessels) were present only in a few graves, and the majority of graves had no funerary objects at all (Yunnan, 1981).

From the most recent excavation campaign, the following features were unearthed: 11 houses, 11 fire places, 248 pits, and 23 graves. Because no excavation report has been published yet, no details are available on the characteristics of the features unearthed during the second excavation campaign at Baiyangcun. However, the stratigraphy of the 2013/14 campaign closely correlates to the first excavation campaign (Min Rui, personal comment 2016), therefore, it can be safely assumed that a certain degree of similarity must exist with the features as described in the 1981 report.

Baiyangcun is currently estimated to be around 10ha in size, but more recent surveys hypothesised that the site might be as big as 20ha (Min Rui, personal comment 2018).

Population estimates from Early Neolithic China propose a ratio of between 50-53.5 persons/hectare (Sun, 2013: 563; Liu, 2004: 79). This has been based on calculations on buildings number and floor space from the site of Hemudu (c. 5000-4000 BC, see Chapter 2), in the Lower Yangzi, and on burial numbers from the site of Jiangzhai, an Early Yangshao site located in the Yellow Basin. There are no current available population estimates for Neolithic sites in Yunnan, and based on Early Neolithic China approximations, population at Baiyangcun might have been c. 500, or even around 1000 people for a 20ha site for calculations based on rice only production. This population estimate would be much lower for sites based on millet farming (around half of that of wetland rice production; Carlstein, 1980).

5.2.2. Ceramics

The ceramics unearthed at Baiyangcun are characterized by a coarse and quite thick temper, mostly reddish or greyish in colour, and decorated with the so-called "incised/impressed pottery style" (see Rispoli, 2007, see fig. 5-3). The decoration is usually found on the shoulders or the upper half of the vessel. The vessels are all handmade through the coil technique, with no evident sign of the use of the slow wheel (Yunnan, 1981).

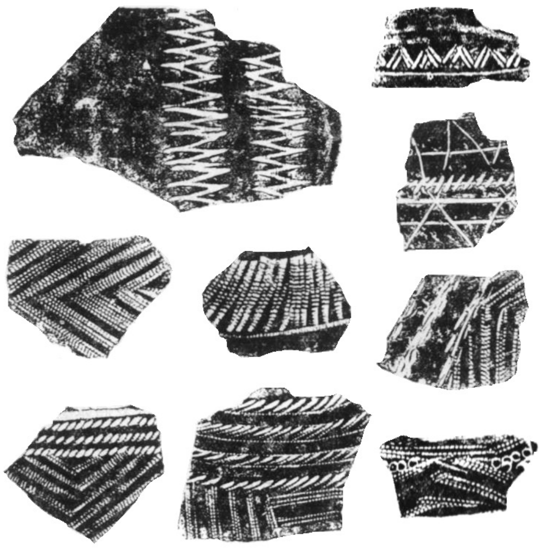


Fig. 5-3: Baiyangcun pot sherd showing typical "incised/impressed" ceramic decoration style. Redrawn from Yunnan 1981.

The ceramic vessel assemblage is characterized by the heavy presence of vessels suitable for cooking liquid substances (*guan* vessel type, see fig. 5-4: 1, 2, 3) and big storing vessels (*gang* vessel type, see fig. 5-4: 4, 5) followed by bowls and basins/plates (fig. 5-5; Yunnan, 1981). *Guan* jars are characterized by an ovoid body, with an outward protruding lip, presenting a diameter of between 10-20 cm. *Guan* jars occasionally present double handles, usually have flat bases, and are between 15-22cm high. Round bases and bigger body sized *guan* jars appear during the late phase (i.e. fig. 5-4: 2), reaching a height of 30cm. *Gang* jars refer to an unrestricted vessel, with either an ellipsoid or a cylindrical body, a height of about 20-40 cm, and about 30-40cm of diameter (measured at the opening). During the later period of occupation, pouring and drinking vessels increase, and spouts start appearing at the opening of many vessels (i.e. fig. 5-4: 3). Finally, the *ye* vessel type, characterized by a round base, shallow body and a wide spout on a side, becomes increasingly present during the later period of occupation (fig. 5-4: 6; Yunnan, 1981). Finally, two elongated and pointy ceramic vessel "foot" remains (*qizu* 器足) have been recovered from the early period of occupation at Baiyangvcun. These are made of coarse reddish temper, between 3-6.8cm high, with undecorated surface (Yunnan, 1981).

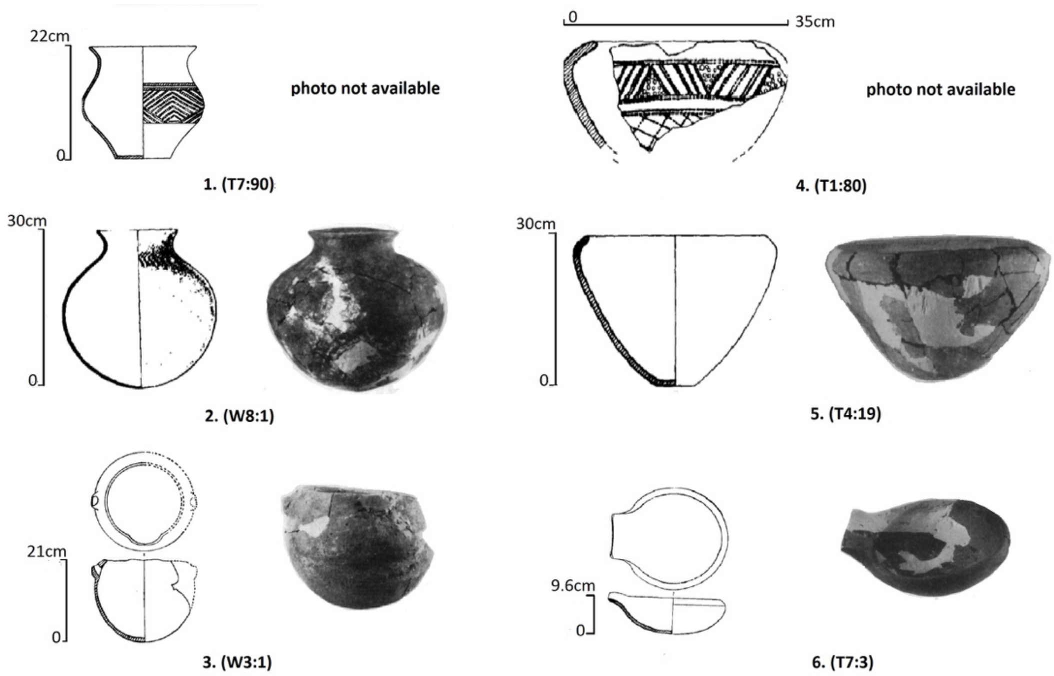


Fig. 5-4: Baiyangcun ceramics. 1-3. *guan* vessel type (early to late); 4-5. *gang* vessel type (early); 6. *ye* vessel type (late). Redrawn from Yunnan, 1981.

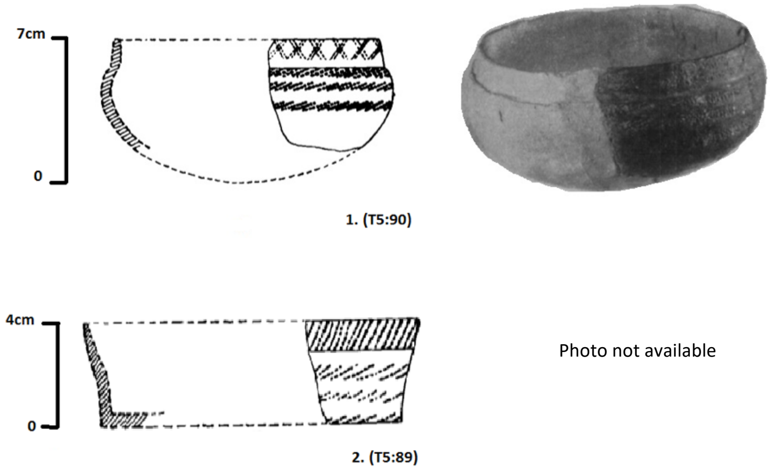


Fig. 5-5: Baiyangcun ceramics. Examples of *bo* bowl (1); *pen* basin/plate (2). Redrawn from Yunnan 1981.

5.2.3. Stone implements

Stone tools recovered at Baiyangcun are polished. The raw materials used are: quartzite, sandstone, flint, and porphyry (Yunnan, 1981). Although no comprehensive study on Baiyangcun lithics has been undertaken yet, preliminary analysis suggests that these raw materials were sourced in the Binchuan Basin (Yunnan, 1981). The most commonly found stone tools are (numbers in brackets refer to the first excavation season, see fig. 5-6 for examples of most common tools): axes (109; fig. 5-6:1-3), adzes (49; fig. 5-6:4), knifes (86), chisels (30; fig. 5-6:7), arrowheads (33; fig. 5-6:8), scrapers (16; fig. 5-6:9), bores (6), harvesting knifes (or sickles) (2; fig. 5-6: 5-6, 10), and blades (2). The 2013-14 excavation campaign unearthed a similar set of stone tools, and, proportionally more harvesting knifes were found (Min Rui, personal comment 2018). Harvesting knifes recovered at Baiyangcun are either rectangular or half-moon shaped, and usually present a sharp edge (i.e. fig. 5-6: 5, 6). However, the new excavation revealed many had a serrated cutting edge (i.e. fig.5-6: 10, Min Rui personal comment 2018). This peculiar characteristic led some archaeologists from the area to hypothesise that these tools might have actually been used to impress the typical decoration on the ceramics from the site (Min Rui, personal comment 2018), but this hypothesis has no other supporting evidence. Harvesting knifes are usually associated with the harvesting of rice at the panicle base, and sickles are associated with the harvesting of the rice lower than the panicle base, collecting part of the straw together with the panicle ear

(Bray, 1984: 323-331; Thompson, 1996). Different types of harvesting knife and sickle might have been involved in different harvesting techniques, that would each suit specific needs. For instance, the straw collected when using a serrated sickle could have been used as construction material, or as animal fodder. However, until more detailed info is available on the ratio of each type of knife, and more importantly, use-wear analysis on these tools is undertaken, these hypotheses cannot be confirmed.

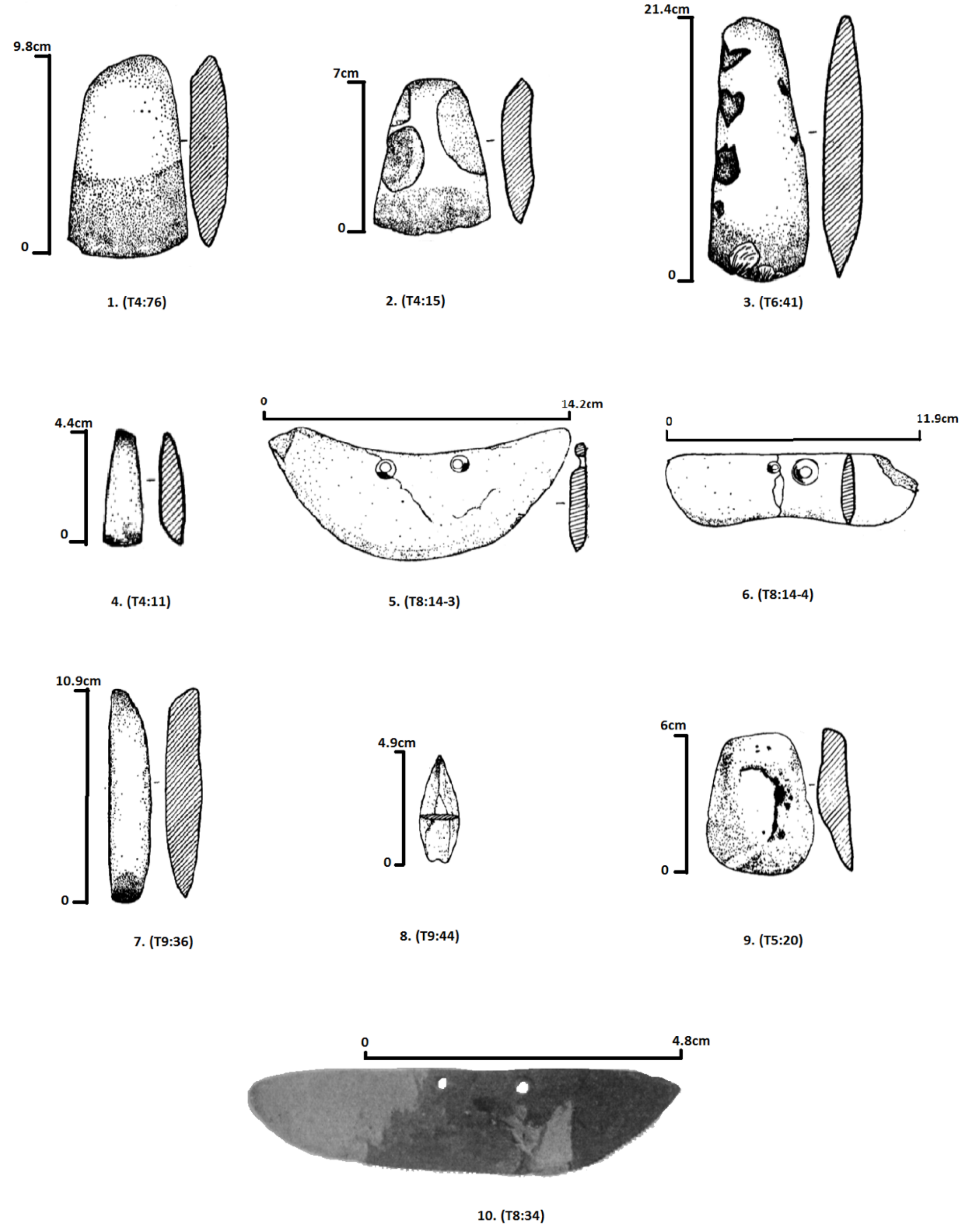


Fig. 5-6: Baiyangcun stone tool assemblage: 1-3. axes; 4. adze; 5-6. sickles/knifes; 7. chisel; 8. arrowhead; 9. scrape; 10. serrated harvesting knife. Redrawn from Yunnan, 1981.

5.2.4. Faunal remains

According to the preliminary excavation report from the first excavation campaign (Yunnan, 1981), many bone tools found at Baiyangcun were made from deer bones. The report also states the presence of dog, pig, cattle, deer/stag, boar, squirrel, and Asian black bear (*Ursus thibetanus*) bone remains. However, no further information is provided, the specific proportion of each animal in the overall bone assemblage and the possible domestication status of each species is unknown. This makes it difficult for us to make a meaningful analysis of the faunal assemblage and its role in the overall economy of the site.

5.3. Site chronology

Radiocarbon dates for the Baiyangcun site are available from both excavation seasons. From the first campaign, charred wood samples retrieved from house F3 postholes were submitted for C14 radiocarbon dating shortly after the end of the excavation to the Institute of Archaeology at the Chinese Academy of Social Science in Beijing. Baiyangcun was determined to have been occupied between 2296-1860 cal. BC (ZK-0220, 3660±85 BP) /2190-1690 cal. BC (ZK-0330, 3570±85 BP; Yunnan, 1981; Zhang & Hung, 2010). According to the typological analysis of the ceramic remains unearthed at the site, two periods of occupation were distinguished: an earlier period, between layers 8 and 6, and a later period, from layer 5 to layer 2. Earlier period houses cut straight into the bedrock, indicating that no previous human occupation occurred at the site, and later houses cut into earlier features, indicating a possible occupation hiatus between the two periods.

Most recently, new dates were obtained through the AMS radiocarbon dating of rice and millet grains recovered from the 2013-14 excavation archaeobotanical samples (table 5-1). AMS dating on short-lived plant remains, such as crop grains and legumes, has become increasingly practiced, as these kind of remains provide higher precision data than wood (Dal Martello et al., 2018). Grains were selected from both cultural layers and features contexts, covering a complete top to bottom stratigraphic sequence. The grains were submitted to the Oxford University Radiocarbon Acceleration Unit, to the Scottish University Environmental Research Centre AMS Facility, and to the Beta

Analytic Ltd. London BioScience Innovation Centre respectively for AMS radiocarbon dating (see table 5-1). A summary of the now available dates for Baiyangcun, including the first excavation season's dates, complete with lab code and context of origin, is provided below (table updated from Dal Martello et al., 2018). The Bayesian model derived from the newly obtained radiocarbon dates suggests an occupation of the site between c. 2500 BC, or possibly 2650 BC, to 1800/1700 BC (fig. 5-7). Furthermore, the model also suggests two main periods of occupation,

- Phase I: layers 24-26, dated to 2650 to 2450 BC;
- Phase II: layers 15-3, dated to 2200 to 1700 BC.

Ceramics remains showed striking differences in typology between layers 9/8 (Min Rui, personal comment 2016); this phase, therefore, has been subdivided in a first phase (henceforth "period 2") comprising layers 15 to 8, and a second phase (henceforth "period 3") comprising layers 7 to 3. Phase II occurred after a possible occupation hiatus of at least a century, possible c. 250 years (fig. 5-7).

The first two layers were modern topsoil. This chronological and stratigraphic division is consistent with the stratigraphy and material culture described from the first season of excavation.

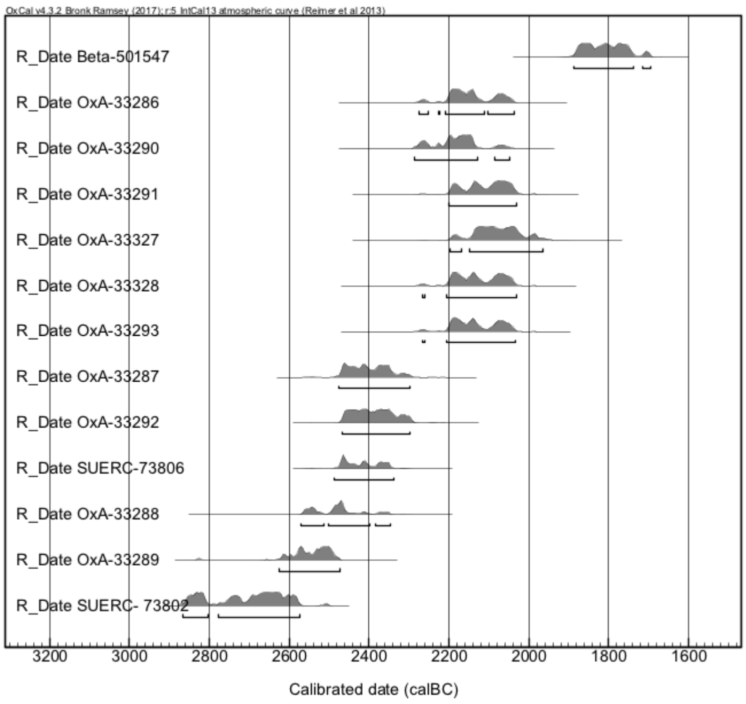


Fig. 5-7: Bayesian model of the calibrated radiocarbon dates from the site of Baiyangcun, updated from Dal Martello et al., 2018. Made with Oxcal, v.3.2 (Bronk Ramsey, 1995; Bronk Ramsey, 2001).

Table 5-1. Radiocarbon dates from Baiyangcun, with indication of samples context, material, and lab code. Updated from Dal Martello et al., 2018.

Context	Material	Lab Code	Cal. Date BP	95.40%	68.20%
1973 excavation:					
F3 posthole 2	Wood charcoal (bulk)	ZK-0220	3660±85	2190-1920 cal. BC	1196-1860 cal. BC
Unnumbered posthole from trench 7	Wood charcoal (bulk)	ZK-0330	3570±85	2030-1770 cal. BC	2190-1690 cal. BC
2013 excavation:					
Layer 5	Rice grain	Beta-501547	3480±30	1890-1690 cal. BC	1880-1750 cal. BC
Layer 8	Rice grain	OxA-33286	3743±29	2280-2030 cal. BC	2210-2060 cal. BC
Layer 8	Rice grain	OxA-33290	3764±28	2290-2040 cal. BC	2280-2130 cal. BC
Layer 9	Rice grain	OxA-33291	3718±29	2210-2030 cal. BC	2200-2040 cal. BC
Layer 9	Rice grain	OxA-33327	3689±35	2200-1960 cal. BC	2140-2030 cal. BC
H118 （sealed by layer 15）	Rice grain	OxA-33328	3731±30	2270-2030 cal. BC	2200-2040 cal. BC
H118 （sealed by layer 15）	Rice grain	OxA-33293	3735±29	2270-2030 cal. BC	2200-2050 cal. BC
Layer 17	Rice grain	OxA-33287	3916±29	2480-2290 cal. BC	2470-2340 cal. BC
Layer 17	Rice grain	OxA-33292	3898±29	2470-2290 cal. BC	2470-2340 cal. BC
Layer 20	Millet grains (n=3)	SUERC-73806	3929±23	2490-2330 cal. BC	2480-2340 cal. BC
Layer 21	Rice grain	OxA-33288	3958±30	2570-2340 cal. BC	2570-2410 cal. BC
Layer 21	Rice grain	OxA-33289	4035±28	2630-2470 cal. BC	2580-2490 cal. BC
Layer 24	Millet grains (n=3)	SUERC-73802	4110±34	2870-2570 ca. BC	2860-2580 cal. BC

5.4. Archaeobotanical results

5.4.1. Samples size and diversity

116 samples[8] from those collected during the last season of excavation at Baiyangcun were analysed at the UCL Institute of Archaeology-Archaeobotany Laboratory for this dissertation, and their results are discussed below. A description of the methods of recovery and analysis has been provided in Chapter 4 (see also Dal Martello et al., 2018).

Table 5-2 summarises the archaeobotanical dataset for Baiyangcun, namely, the number of samples analysed per each period and their context type, the total litres floated, density indexes, and the total number of identified plant remains per period and context types.

Table 5-2. Summary of Baiyangcun samples, indicating total number of contexts analysed for each period of occupation, including a breakdown of context type per each period; litres floated; total number of identified (ID) remains, and density of item per litre.

Period of occupation	No. of contexts analysed		Total litres floated	Total ID remains (NISP)	Density (mean)
Period 1	Layers	10	106	3679	34.70
	Houses	10	100	2822	28.22
	Pits	18	180	1446	8.03
	Burials	1	10	1	n/a
	Total	**39**	**396**	**7948**	**20.07**
Period 2	Layers	12	132	2450	18.56
	Houses	5	50	1214	24.28
	Pits	22	220	3796	17.25
	Burials	0	n/a	n/a	n/a
	Total	**39**	**402**	**7460**	**18.55**
Period 3	Layers	6	61	575	9.42
	Houses	3	30	317	10.56
	Pits	26	260	1366	5.25
	Burials	3	20	59	2.95
	Total	**38**	**371**	**2317**	**6.24**
TOTAL		**116**	**1169**	**17,725**	**15.16**

The archaeobotanical samples from Baiyangcun were generally very rich in charred plant remains. A total number of 17,725 identified remains belonging to 22 families, and

[8] Originally, 117 of which 39 samples belonging to period 3 were sorted, including sample H44-1, which was sterile, and therefore it has been excluded from the analysis.

more than 40 different individual species were found (see fig. 5-8; table 5-2). The samples appear richer in the first period of occupation, with a total density (item per litre floated) of 20.07. This decreases slightly during the second period of occupation, with 18.55 items per litre, and finally decreases sharply during the last period of occupation, with a density of items per litre of only 6.24 (see table 5-2). Depositional processes seem to be the most likely reason for this decrease; intensive modern agriculture coupled with erosion activity from the nearby river might have disturbed and destroyed the upper layers. Biases in collection and recovery methods are ruled out as soil sampling and flotation was carried out by the same person during excavation, following national guidelines (see Chapter 4).

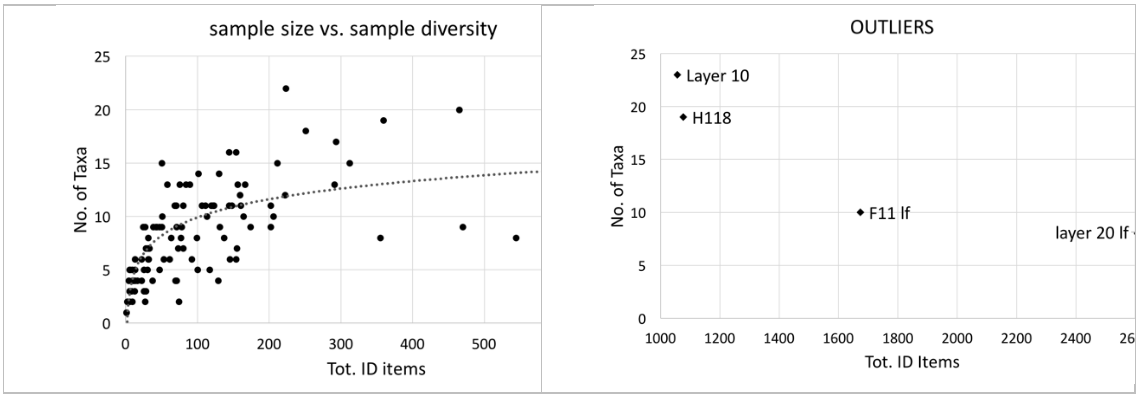


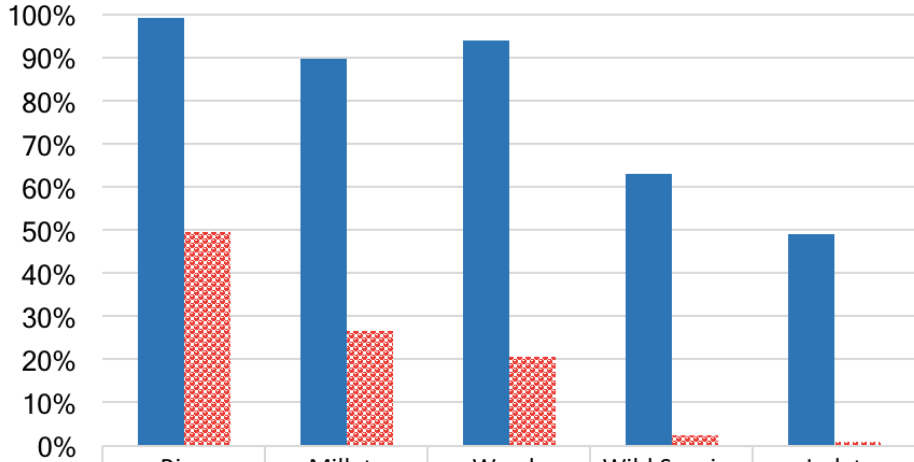
Fig. 5-8: Graph showing Baiyangcun sample size vs sample diversity (left). Outliers excluded are shown separately on the right: layer t2(20)lf; f11 lf, layer t1(10); h118.

5.4.2. Ubiquity and frequency

At Baiyangcun, cultivated cereals and field weeds are the two most ubiquitous categories recovered, as well as the two most abundant across the samples analysed. Crops and seeds of field weeds are recovered in more than 80% of the samples, and together they constitute c. 96% of the total identified remains (see fig. 5-9). Other economic species, including pulses, nuts, and fruits are found in 62% of the samples, but they constitute less than 3% of the total identified remains (see fig. 5-9). A detailed ubiquity and frequency index per each family, with main species highlighted, found at Baiyangcun is provided in table 5-3.

Table 5-3. Ubiquity and frequency index, including absolute counts, per each family and major species, identified in the samples analysed from Baiyangcun.

Main species and families	No. of samples (n=116)	Ubiquity index	Absolute counts (n=17,725)	Frequency index
Asteraceae	4	3.4%	4	0.02%
Brassicaceae	14	12%	23	0.13%
Chenopodiaceae: *Chenopodium* sp.	70	60.3%	405	2.28%
Convolvulaceae	1	0.8%	1	0.005%
Cucurbitaceae	4	3.4%	4	0.02%
Cyperaceae-various	40	34.4%	150	0.85%
Euphorbiaceae: *Euphorbia* sp.	2	1.7%	2	0.011%
Fabaceae: *Glycine* sp.; *Vigna* sp.; *Cajanus* sp.	45	38.79%	149	0.84%
Fabaceae- various wild	26	22.4%	45	0.25%
Juncaceae	3	2.6%	5	0.03%
Junglandaceae (acorns and nutshells)	33	28.4%	106	0.6%
Lamiaceae	8	6.9%	38	0.21%
Malvaceae	3	2.6%	3	0.01%
Meliaceae: *Melia azedarach*	1	0.8%	1	0.005%
Nymphaceae: *Euryale ferox*	41	35%	156	0.88%
Poaceae –various	101	87%	3284	18.53%
Poaceae: *Oryza sativa*	115	99%	8785	49.56%
Poaceae: *Panicum miliaceum*	63	54.3%	429	2.42%
Poaceae: *Setaria italica*	99	85.3%	3898	21.99%
Polygonaceae: *Polygonum* spp.	9	7.7%	29	0.17%
Portulacae: *Portulaca* sp.	2	1.7%	2	0.01%
Rosaceae- various	3	2.5%	12	0.07%
Solonaceae: cf *Lycium*	3	2.5%	4	0.02%
Urticaceae: *Urtica* sp.	2	1.7%	2	0.01%
Verbanaceae: *Verbena* sp.	2	1.7%	18	0.1%
Vitaceae: *Vitis* sp.	1	0.8%	1	0.005%
Indet.	57	49.13%	169	0.95%
TOTAL	N/A	N/A	17,725	100%

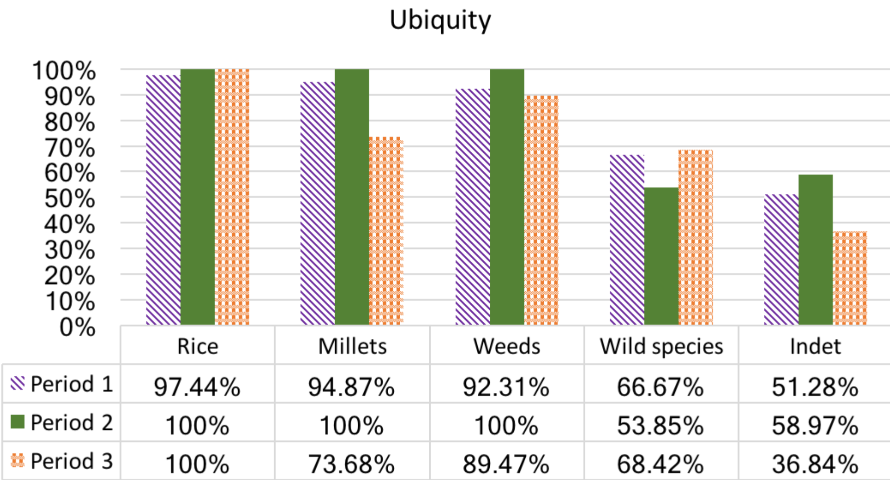


	Rice	Millets	Weeds	Wild Species	Indet
Ubiquity	99.14%	89.66%	93.97%	62.93%	49.14%
Frequency	49.56%	26.50%	20.60%	2.38%	0.95%

Fig. 5-9: Ubiquity and frequency for main macro-remains categories at Baiyangcun.

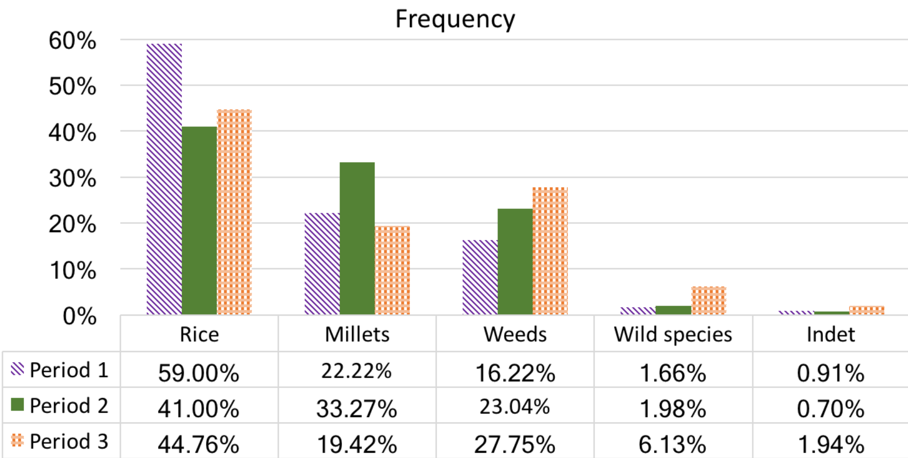
When comparing ubiquity and frequency index of the categories across the three periods of the site (see fig. 5-10 and 5-11 respectively), the following patterns can be seen:

- Taxa at Baiyangcun have rather homogeneous ubiquities across the three periods, with only some noticeable changes for millets and indet. remains, which are recovered in comparatively fewer samples during the last period.
- Crop remains have higher frequency throughout the whole occupation of the site, with rice predominant over millets.
- Rice is present in higher quantities over millet remains throughout the whole occupation of the site; however, during the second period there is a sharp decrease in rice remains, accompanied by an increase of millets (see fig. 5-12). Millet remains then decrease sharply in both ubiquity and frequency during the last period of occupation of the site.
- During the second and third periods of occupation there is an increase of field weeds remains, due in particular to a higher quantity of *Chenopodium* remains.
- Finally, at the end of the occupation of the site wild species increase considerably, this is due to an increase in pulses remains, especially the *Cajanus* sp. (see below).



	Rice	Millets	Weeds	Wild species	Indet
Period 1	97.44%	94.87%	92.31%	66.67%	51.28%
Period 2	100%	100%	100%	53.85%	58.97%
Period 3	100%	73.68%	89.47%	68.42%	36.84%

Fig. 5-10: Ubiquity index of main macro remains categories at Baiyangcun, divided by periods.



	Rice	Millets	Weeds	Wild species	Indet
Period 1	59.00%	22.22%	16.22%	1.66%	0.91%
Period 2	41.00%	33.27%	23.04%	1.98%	0.70%
Period 3	44.76%	19.42%	27.75%	6.13%	1.94%

Fig. 5-11: Frequency index of main macro remains categories at Baiyangcun, divided by periods.

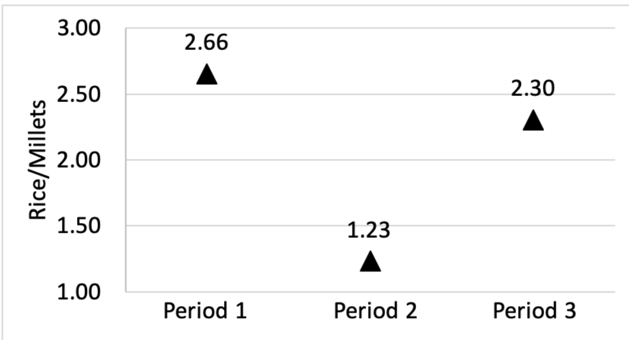


Fig. 5-12: Rice/millet ratio over the three periods of occupation at Baiyangcun.

5.4.3. Cereal crops

Three main crop species were recovered from the Baiyangcun samples: *Oryza sativa*(rice), *Setaria italica* (foxtail millet), and *Panicum miliaceum* (broomcorn millet). Rice and millet remains from Baiyangcun take up 74% of the total identified remains. Furthermore, 371 millet grains were too badly preserved to allow identification to the genus level, therefore, they have been categorised as "indet. millets". These are included in the Poaceae-various category in table 5-2, as well are in the overall millets category in the ubiquity and frequency charts above, but are not discussed further in the analysis here.

5.4.3.1. Rice

Rice was found in all but one of the samples analysed, and it accounted for c. 50% of the total identified remains. Rice density per litre is 7.5 items/L. Rice remains are both the most ubiquitous and abundant plant remains throughout the whole occupation of Baiyangcun. Rice remains recovered at Baiyangcun include: whole grains, grain fragments, detached embryos, and spikelet bases. Husks, mostly in silicified form, have been recovered from at least 11 samples (see table 5-4).

Table 5-4. Rice remains at Baiyangcun with absolute counts.

Remain type	Total	Ubiquity (no. of samples)
Rice caryopsis (whole with embryo)	3689	94
Caryopsis fragment[9]	2252	112
Detached embryo	283	58
Immature caryopsis (whole with embryo)	209	39
Immature caryopsis fragment[7]	216	39
Spikelet bases- domesticated type 1	1364	68
Spikelet bases- domesticated type 2 (wild-like)	350	30
Spikelet bases- immature	163	29
Spikelet bases- wild	89	13
Spikelet base- indeterminate	131	18
Husk	11	11
Amorphous charred food remains	4	1
TOTAL	**8785**	**115**

[9] Rice fragments count is approximated to whole grain equivalent through ml weighting approximation, following 1ml=50 grains (see Chapter 4).

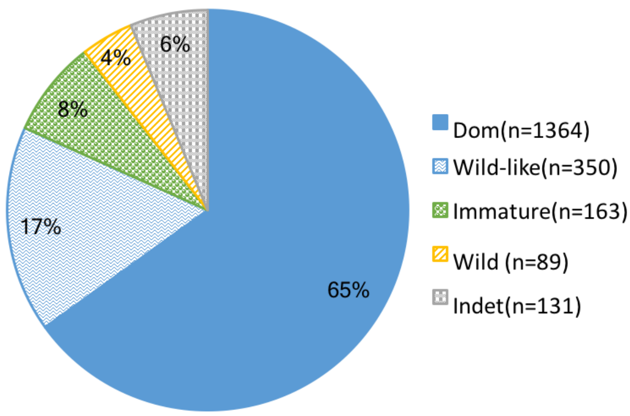


Fig. 5-13: Spikelet bases composition at Baiyangcun.

Morphologically, no wild rice grains have been recovered from the samples analysed at UCL. However, some wild type spikelet bases were found in 13 samples, with a total count of 89 out of the 2097 total recovered spikelet bases (table 5-4; fig. 5-13). In the past decade, numerous studies have shown the importance of the analysis of rice spikelet bases to determine the domestication status of rice (e.g. Fuller et al. 2009, Fuller & Allaby 2009; Fuller et al. 2014; Deng et al 2015; Castillo et al. 2016). Given the extremely low number of morphologically wild spikelet bases recovered, it's safe to assume that rice at Baiyangcun was fully domesticated (fig. 5-13).

Within the domesticated spikelet bases category, there are 350 spikelet bases that have been separately sub-classified as "wild-like". The abscission scar present on these spikelet bases is semi-ripped, meaning that they differentiate from the domesticated type, whose abscission scar is completely ripped, but at the same time they are also morphologically different from wild spikelet bases, which scar is completely smooth. Fig. 5-14 illustrate the three different morphology. The reasons for this phenomenon is unclear, and further studies are needed to understand the factors influencing this differentiation.

Fig. 5-14: Pictures showing different types of spikelet bases recovered at the site of Baiyangcun: 1: domesticated type; 2: wild-like type; 3: wild type. Photos by author.

4 fragments of what appeared to be masses of fragmented grains lumped together were recovered from context layer 18. In one of these fragments, the remnant of a pounded rice grain is clearly visible embedded in an amorphous mass (fig. 5-15 top). The long size of the grain, its overall shape and especially the small size of the aleurone cells (<15um) indicates that this is a rice grain, and the same characteristics are visible on the

other remains, suggesting that they all are products of fragmented rice grains lumped together (fig. 5-15; Lara Gonzalés Carretero personal communication, 2019; Winton & Winton, 1937).

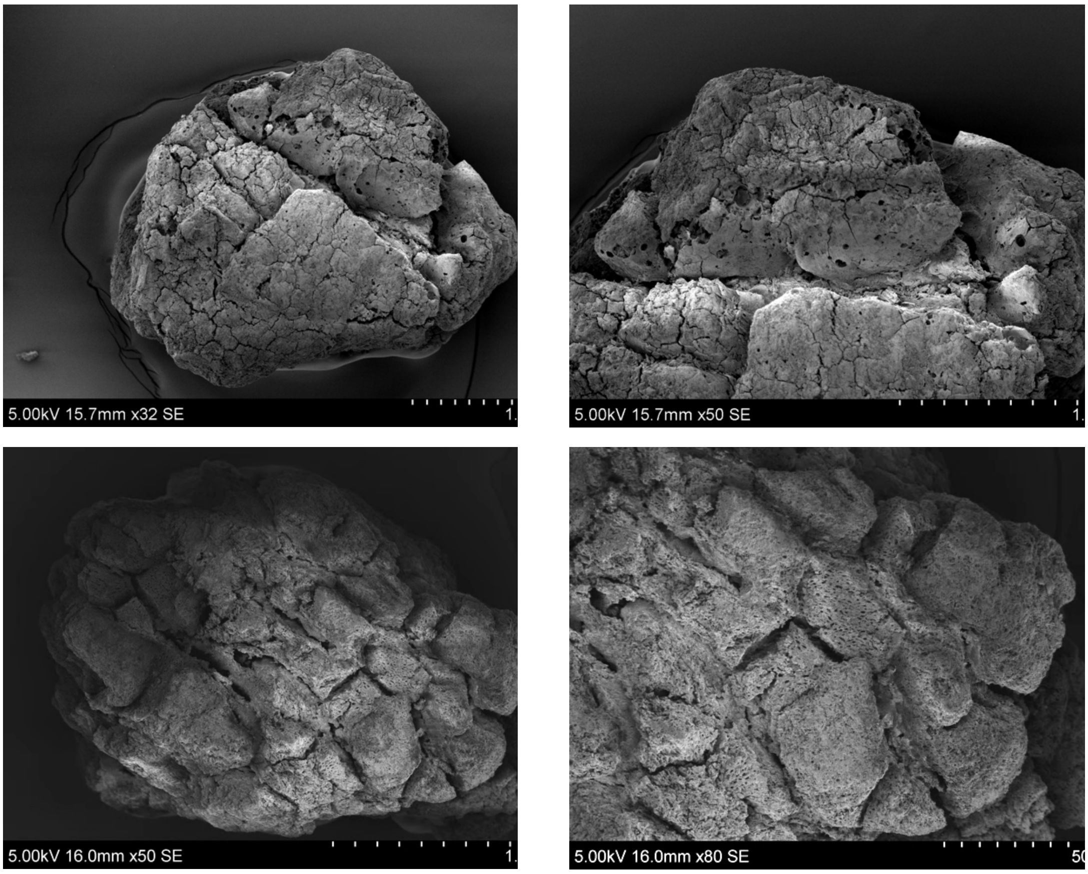


Fig. 5-15: SEM pictures of partially processed rice grains lumps from context layer 18. Photos on the right show close up of respective left picture. Photos by author.

The possibility of rice grains being cracked as part of pre-cooking processing at Baiyangcun seems to be supported by finds of large quantities of cracked grains in contexts directly related to cooking activities, such as floors (*huodongmian* 活动面, literal translation “living floor” indicating activities surfaces; fig. 15-16). In these contexts, cracked rice grains correspond to about 1/3 of the total rice remains. Upon close examination of the fracture side of the grain, this appears glossy, with some degree of vitrification (shiny in picture) and partial bulging and cracks on some grains (fig. 5-17). Experimental works on rice charring have shown how these characteristics are proportionally more prevalent in grains that are broken before charring, rather than after charring (Lian, 2015). This kind of cracked grains are present in those samples where lumped cracked rice grains such as those pictured in fig. 5-15 were recovered. This suggests that the Baiyangcun people were pounding and cracking rice grains in preparation of cooking; however, with the lack of a detail report on the last excavation season tools, it is unclear what kinds of tool were used to perform this rice processing; similarly, further experiments are needed to individuate what types of food cracked rice grains were used for.

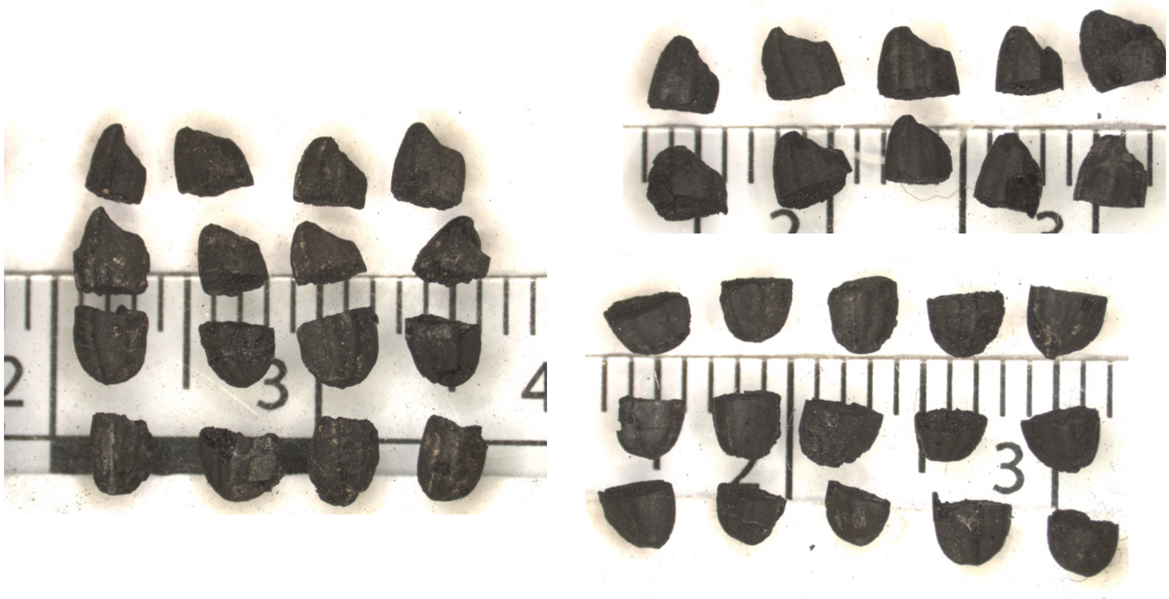


Fig. 5-16. Cracked grains at Baiyangcun, from contexts F11 (left) and Layer 20 (right) floors.

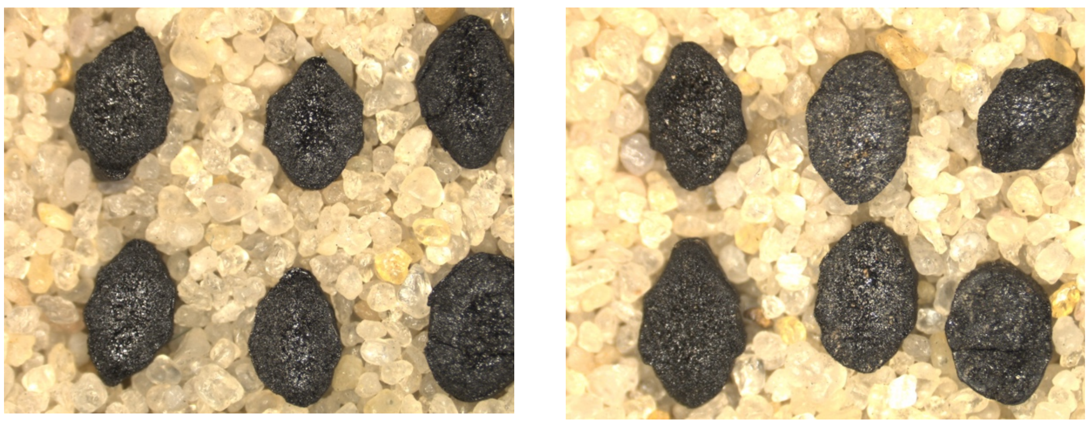


Fig. 5-17. Cracked rice grains from Baiyangcun, showing broken side, from contexts F11 (left), and layer 20 (right).

As part of her PhD at UCL, Dr. Cristina Castillo conducted charring experiments to study preservation patterns of several cereals and pulses that could bias the archaeobotanical assemblage composition (Castillo, 2013). Her experiments aimed to replicate the way cereals and other plant remains get archaeologically preserved through charring by fire, and are then recovered during archaeological excavation employing common archaeobotanical procedures, such as flotation and sorting under a binocular microscope. Her experiments revealed that there exists a bias toward the preservation of rice over millet remains, and especially rice husks were recovered 25:2 than millet husk remains. Castillo suggested that a possible way to overcome the overestimation of rice remains in an assemblage is to look at the smaller fractions when sorting under the microscope: 0.50mm, and 0.25mm, where most of the small millets and seeds of weed species are usually found. This was systematically undertaken during the sorting of all the samples from Baiyangcun, therefore, the overestimation of rice, although could still be present, has been possibly kept to a minimum (see Chapter 4).

Morphometrics

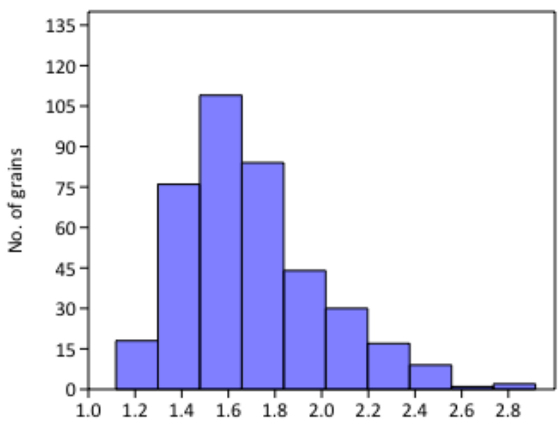


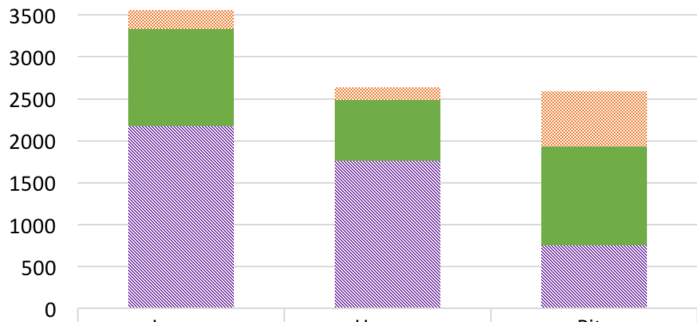
Fig. 5-18: Histogram plot of rice L/W measurements from Baiyangcun. Made with Past.

Length, width, and thickness of 429 complete and well-preserved rice grains were measured (Appendix 4). The average L/W ratio was 1.74mm, with a standard deviation of 0.3mm (fig. 5-18). L/W was also taken into consideration to determine possible populations differences in rice remains (Fuller et al., 2007; Harvey, 2006; Castillo et al., 2015). L/W <2mm was considered to be *japonica* type, L/W >2.2mm *indica* type. At Baiyangcun, only 27 grains measured >2.2mm; 358 measured <2mm; 44 grains measured between 2-2.2mm, which is regarded as an overlapping range for both categories (Fuller et al., 2007; Harvey, 2006; Castillo et al., 2015). The majority of rice grains measured from Baiyangcun are within the *japonica* type range, therefore, rice at Baiyangcun has been identified as *Oryza sativa* subsp*. japonica.*

Rice grains L/W at Baiyangcun shows a slight increase over time, with L/W for period 1 of 1.65mm (stdev 0.28mm); 1.72mm (stdev 0.30mm) for period 2; 1.92mm (stdev 0.40mm) for period 3.

Contexts analysis

Overall, rice remains at Baiyangcun are present in higher quantities in cultural layers than in houses or pits (fig. 5-19). Chronologically, however, from period 2, rice remains are found proportionally in higher quantities in pit contexts (fig. 5-19). Moreover, the very high presence of rice remains from house contexts in period 1 is due to an extremely well preserved deposit (T2(20)lf -layer 20 floor), which contained more than 2000 whole charred rice caryopses. This context has been identified as being either a hearth-like deposit on a house floor, which limits could not be distinguished, or a hearth/cooking facility. The decrease of rice remains from house contexts in period 2 and 3 could also be due to the fact that, comparatively, fewer house contexts were sampled from these periods: 10 from period 1; 5 from period 2; and only 3 from period 3 (see table 5-2).



	Layers	Houses	Pits
Period 3	226	151	660
Period 2	1154	724	1181
Period 1	2177	1762	750

Fig. 5-19: Baiyangcun rice remains context analysis, with indication of absolute count for each period.

5.4.3.2. Millets

Foxtail (*Setaria italica*) and broomcorn (*Panicum miliaceum*) millet remains were both found in the Baiyangcun samples, with broomcorn millet secondary over foxtail. Millets account for c. 26% of the total identified remains, and have been overall found in c. 90% of the analysed samples (fig. 5-9). Part of the millet grains recovered (accounting 2% of the total identified remains at Baiyangcun) were too badly preserved to be identified to the genus level, and have therefore grouped in a "indet. millet" category (fig. 5-20).

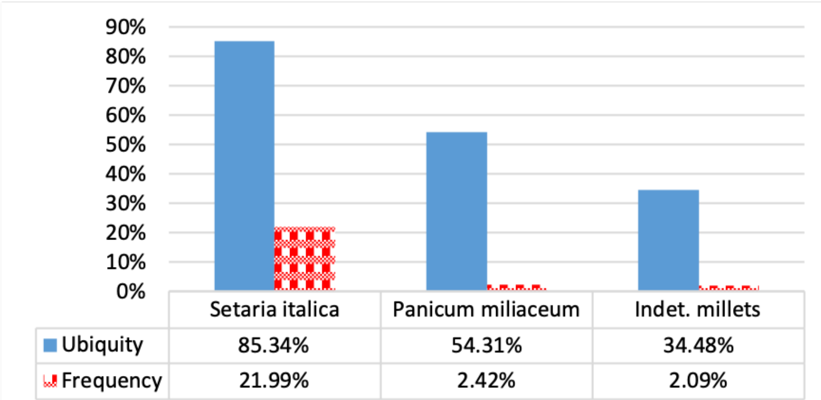


Fig. 5-20: Ubiquity and frequency of millets at Baiyangcun.

Foxtail millet

Foxtail millet (*Setaria* italica) was found in 85% of the total samples analysed, and it accounted for c. 22% of the total identified remains (fig. 5-20). Foxtail millet remains density is 3.33items/L. Remains of foxtail millet include whole caryopsis, mostly cleaned with no husk, immature grains, some badly preserved *Setaria* cf. grains, and some possible amorphous food by-product remains (table 5-5). The SEM analysis of this particular type of remain, as shown in the example pictured in fig. 5-21, reveals a partially processed millet grain embedded into an amorphous charred organic agglomerate. Similarly to rice, this type of remain needs to be investigated with further experimental studies in order to be able to determine what kind of food product it represents. Immature foxtail millet grains have been identified following baselines set in Song et al. (2013). These are usually smaller and flatter than fully mature grains, with a flattened embryo (Appendix 3).

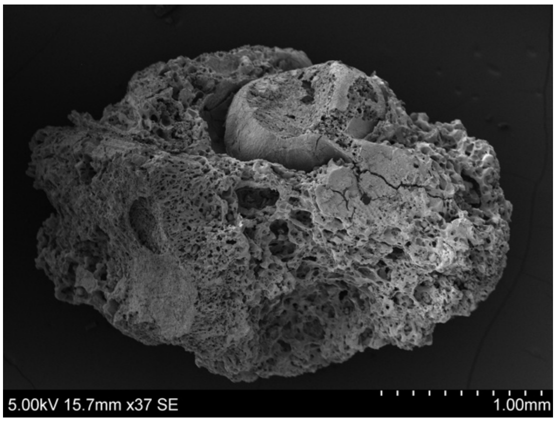


Fig. 5-21: SEM picture of *Setaria italica* amorphous food by-product remain. Photo by the author.

Although millet remains are secondary to rice throughout the whole occupation of the site, during period 2 there is a sharp increase of both ubiquity and frequency of millets, accompanied by a decrease of rice remains (see figs. 5-10, 5-11). This could be due to an increase of millet cultivation, with new land being brought under cultivation, and/or less yields of rice harvest during that period.

Table 5-5. Foxtail millet remains at Baiyangcun with absolute counts.

Remain type	Total	Ubiquity (no. of samples)
Foxtail millet caryopsis	3228	92
Immature caryopsis	528	68
Setaria cf.	120	9
Amorphous charred fragments	3	1
TOTAL	**3898**	**99**

Morphometrics

228 grains of *Setaria italica* were measured. They were on average 1.28mm in length, 1.20mm in width, and 1.09mm in thickness (see Appendix 4). Average L/W ratio was 1.06mm, with a standard deviation of 0.12mm (fig. 5-22). *Setaria italica* grains at Baiyangcun appeared extremely round, and often puffed, as it is typical of the crop when undergoing charring.

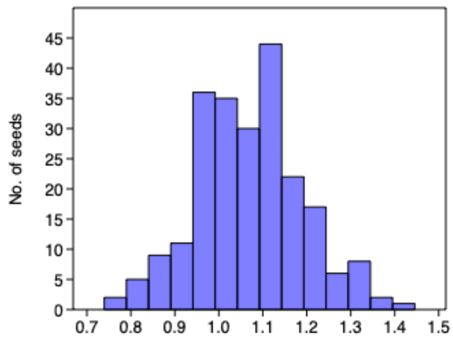


Fig. 5-22: Histogram plot of L/W measurements of *Setaria italica* grains from Baiyangcun. Made with Past.

Context analysis

Setaria italica remains have been found primarily in pit contexts, followed by layers, and houses (fig. 5-23). During period 1, foxtail millet finds come mostly from layers, but from period 2 to period 3 foxtail millet remains are predominantly found in pits (fig. 5-23). As highlighted for rice remains, this difference could be due to the fact that there are proportionally more pit contexts during period 2 and 3, but it could also indicate chronological changes to land use, with new land being dedicated to millet cultivation during time of low rice yield.

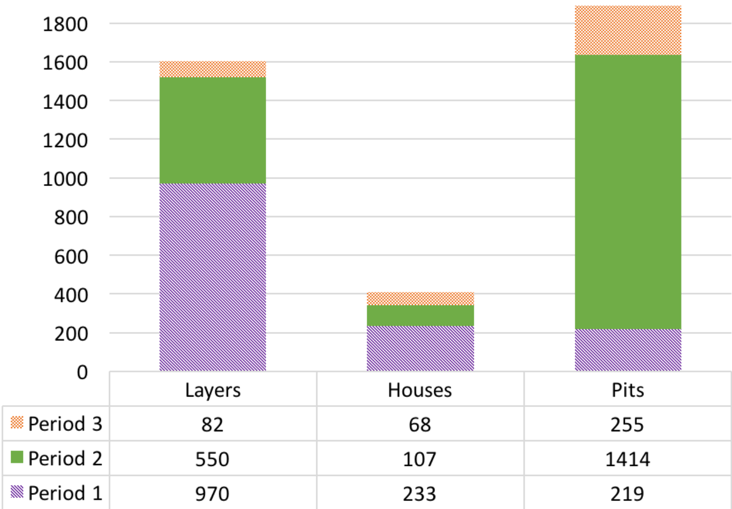


Fig. 5-23: Baiyangcun *Setaria italica* contexts analysis, with indication of absolute count for each period.

Broomcorn millet

Broomcorn millet (*Panicum* miliaceum) was found in 54% of the samples analysed, but it accounted only for slightly more than 2% of the identified remains (fig. 5-20), and density of items per litre is only about 0.36items/L. Broomcorn millet remains comprise of whole grains, some immature grains, and wild *Panicum* sp. (see table 5-6).

Table 5-6. Panicum miliaceum remains with absolute counts.

Remain type	Total	Ubiquity (no. of samples)
Broomcorn millet caryopsis	334	47
Immature caryopsis	27	12
Panicum sp. (wild)	68	23
TOTAL	429	63

Morphometrics

85 grains of *Panicum miliaceum* were measured. They were on average 1.74mm in length, 1.71mm in width, and 1.47mm in thickness (Appendix 4). L/W was 1.02mm, with a standard deviation of 0.1mm (fig. 5-24).

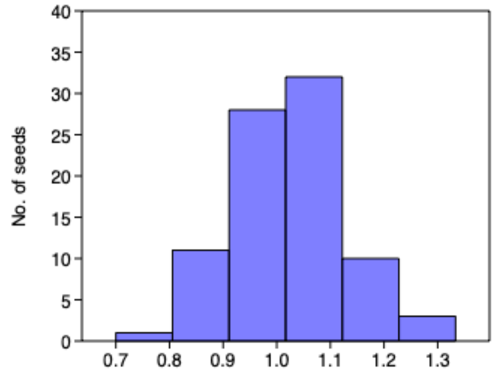
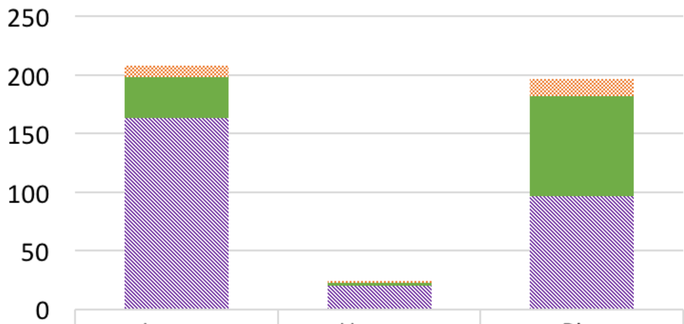


Fig. 5-24: Histogram plot of *Panicum miliaceum* grains L/W measurements. Made with Past.

Context analysis

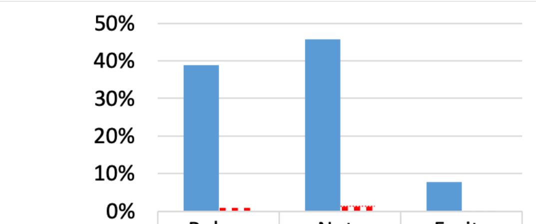
Broomcorn millet remains have been recovered respectively in higher quantities in layer contexts from period 1, and from pits in periods 2 and 3 (fig. 5-25), in a trend similar to that of foxtail millet remains. Moreover, *Panicum* remains are found mostly in pit contexts rather than houses throughout the three periods of occupation, and overall finds from pits and layers show negligible differences (fig. 5-25). This seems to indicate that *Panicum* was weeded out during post-harvest processing activities.



	Layers	Houses	Pits
Period 3	10	1	15
Period 2	35	3	85
Period 1	163	20	97

Fig. 5-25: *Panicum miliaceum* remains context analysis, with indication of absolute count for each period.

5.4.4. Other economic species

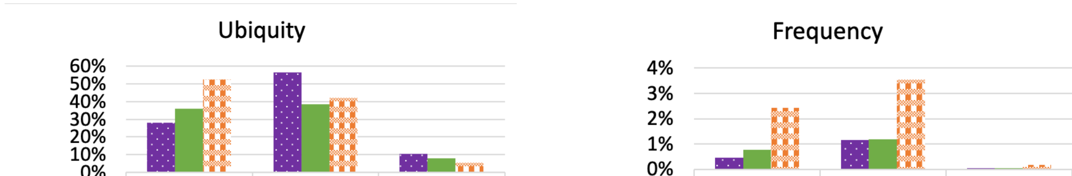


	Pulses	Nuts	Fruits
Ubiquity	38.79%	45.69%	7.76%
Frequency	0.84%	1.48%	0.06%

Fig. 5-26: Ubiquity and frequency of pulses, nuts, and fruits in the overall Baiyangcun assemblage.

Several examples of pulses, nuts and fruits were recovered at Baiyangcun. Upon close examination of the remains' morphology as well as through morphometric data, their status has been determined as non-domesticated. Moreover, they have been found in less than half of the samples analysed and are present in very low quantities (fig. 5-26).

Chronologically, pulses increase both in ubiquity and frequency over time; nuts and fruits instead increase in frequency but decrease in ubiquity (fig. 5-27).



Ubiquity:

	Pulses	Nuts	Fruits
Period 1	28.21%	56.41%	10.26%
Period 2	35.90%	38.46%	7.69%
Period 3	52.63%	42.11%	5.26%

Frequency:

	Pulses	Nuts	Fruits
Period 1	0.45%	1.16%	0.05%
Period 2	0.76%	1.18%	0.04%
Period 3	2.42%	3.54%	0.17%

Fig. 5-27: Ubiquity (left) and frequency (right) of pulses, nuts, and fruits at Baiyangcun, divided by period of occupation.

5.4.4.1. Pulses

Three species of pulses were found at Baiyangcun: *Glycine soja* (wild soybean), a wild variety of a small, round, and thin pulse, which has been identified as *Cajanus* sp., and *Vigna* sp. Soybean and *Cajanus* remains were usually found as whole seeds; *Vigna* remains were more often found as split cotyledons. Totals in the table below (table 5-7) refer to whole pulses, for which, when only 1 cotyledon was found, it counted 0.5 towards the total, as outlined in Chapter 4. Pulse remains at Baiyangcun constitute less than 1% of the total identified remains, but altogether have an ubiquity index of slightly less than 40% (fig. 5-26).

Table 5-7. Pulses species at Baiyangcun.

Species	Total	Ubiquity (no. of samples)
Glycine soja	70	22
Cajanus sp.	66	29
Vigna sp.	13	12
TOTAL	149	45

Wild *Cajanus* is the most ubiquitous pulse at Baiyangcun, found in 25% of the samples analysed, followed by soybean (c. 19%), and lastly *Vigna* (c. 10%; see fig. 5-27). *Cajanus* sp. and soybean also constitute most of the pulse remains recovered at Baiyangcun, with only 13 specimens of *Vigna* (see table 5-7, fig. 5-28).

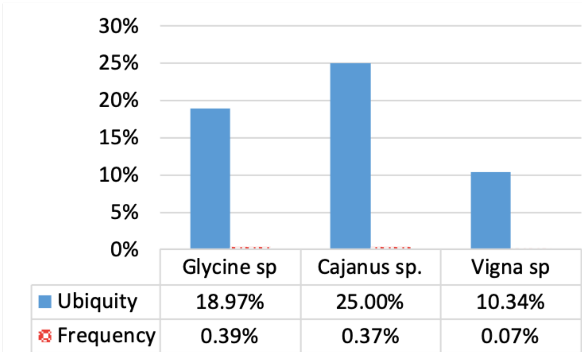


Fig. 5-28: Pulses remains ubiquity and frequency index at Baiyangcun.

Chronologically, during the initial period of occupation at Baiyangcun, soybean is found in comparatively more samples than the other two pulses; however, during period 2 and 3 *Cajanus* increase both in terms of ubiquity and frequency (fig. 5-29).

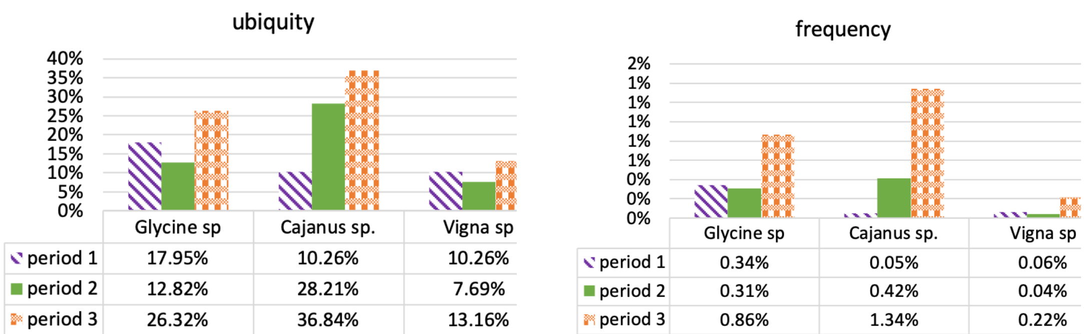
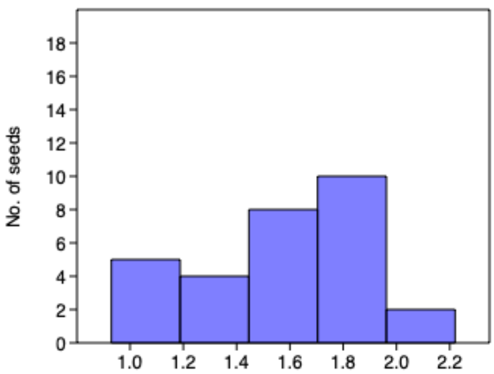


Fig. 5-29: Ubiquity (left), and frequency (right) index of pulses species through the three periods of occupation at Baiyangcun.

Morphometrics

29 grains of soybean were measured (see Appendix 4). Width is often taken as main discriminant measurement to determine domestication status of the species (Lee et al., 2011; Fuller, et al., 2014). At Baiyangcun soybean grains are rather small, with an average width of 1.56mm (standard deviation of 0.33mm; fig. 5-30 left). This falls within the wild size range, as compared with measurements on soybean from other sites in China (Fuller et al., 2014; see Chapter 8: fig. 8-15 this thesis). This suggests that the soybean recovered at Baiyangcun had not yet reached full domestication; this could imply that either soybean was brought into Yunnan before it could reach domestication, or that a local variety of soybean had been brought under cultivation. A wild pocket of soybean has in fact been attested in Southwestern China (Dong et al., 2001), and this indicates that wild soybean was locally present at the time of occupation of Baiyangcun.

Moreover, 25 seeds of *Cajanus* were measured. Their average L/W is 0.94mm, with a standard deviation of 0.13mm (see Appendix 4; fig. 5-30 right). This is within the wild range of most of the *Cajanus* sp. varieties known across South Asia (Fuller et al., 2019).



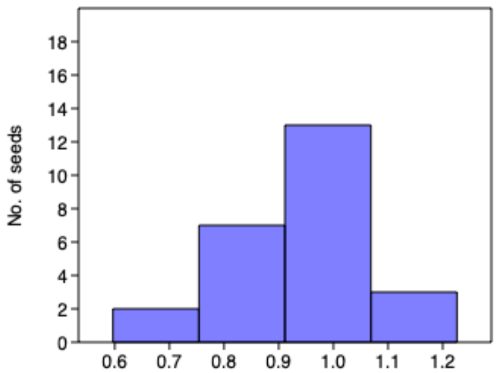


Fig. 5-30: Histogram plots of W measurements of soybean (left), and L/W measurements of *Cajanus* (right) from Baiyangcun. Made with Past.

Context analysis

Overall, pulse remains are mostly found in pit contexts (fig. 5-31). Moreover, pulses are very often associated with millet remains. Legumes are known to adjust the nitrogen levels of the soil, and therefore fix soil fertility depletion (Zohary et al., 2012: 75). The recurrent association of pulses with millets could indicate that pulses were possibly employed as a sort of “green manure” in the cultivation of millets.

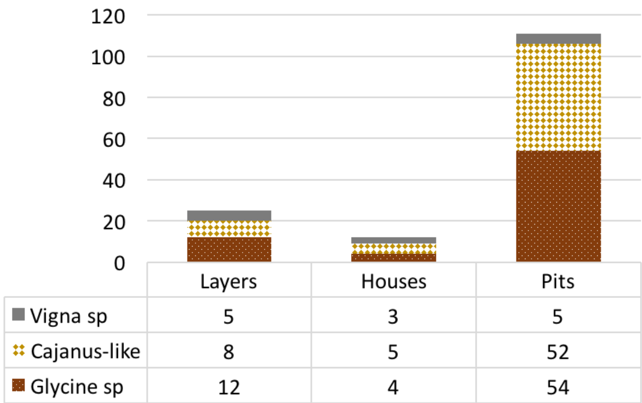


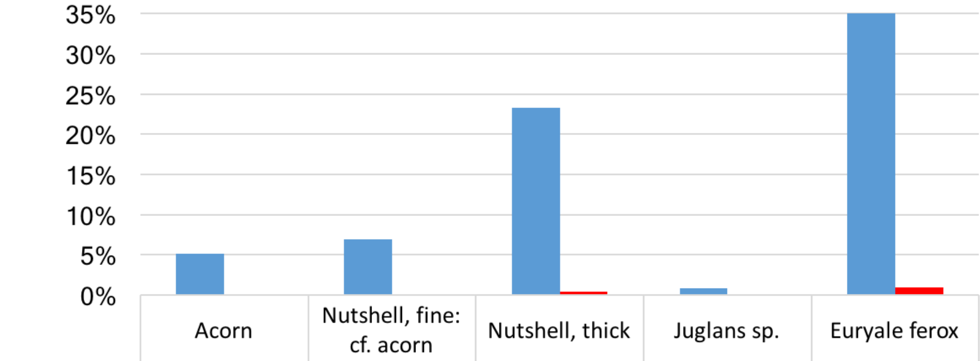
Fig. 5-31: Pulses context analysis at Baiyangcun, with indication of absolute counts for each period.

5.4.4.2. Nuts

Edible nut remains found at Baiyangcun include *Euryale ferox* (foxnut), acorns of at least two different unidentified types, nutshells of unidentified species (categorised in thick, or thin), and 1 remain of *Junglans* sp. (walnut; see table 5-8). Foxnut remains were always found in the form of small broken fragments, whereas *Junglans* and acorns were found mostly complete (Appendix 3). Overall, ubiquity and frequency index of nuts are closely associated. Foxnut is both the most ubiquitous and abundant nut species found at Baiyangcun, followed by fragments of thick nutshell (fig. fig 5-32).

Table 5-8. Nut remains at Baiyangcun, showing absolute counts.

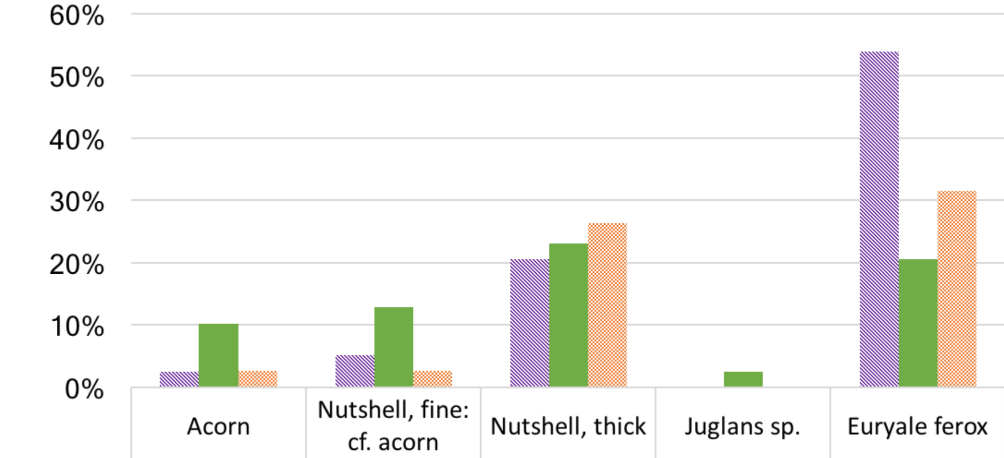
Remain type	Total	Ubiquity (no. of samples)
Acorn	22	6
Nutshell, thin	13	8
Nutshell, thick	70	27
Junglans sp.	1	1
Euryale ferox	156	41
TOTAL	**262**	**53**



	Acorn	Nutshell, fine: cf. acorn	Nutshell, thick	Juglans sp.	Euryale ferox
Ubiquity	5.17%	6.90%	23.28%	0.86%	35.34%
Frequency	0.12%	0.07%	0.39%	0.01%	0.88%

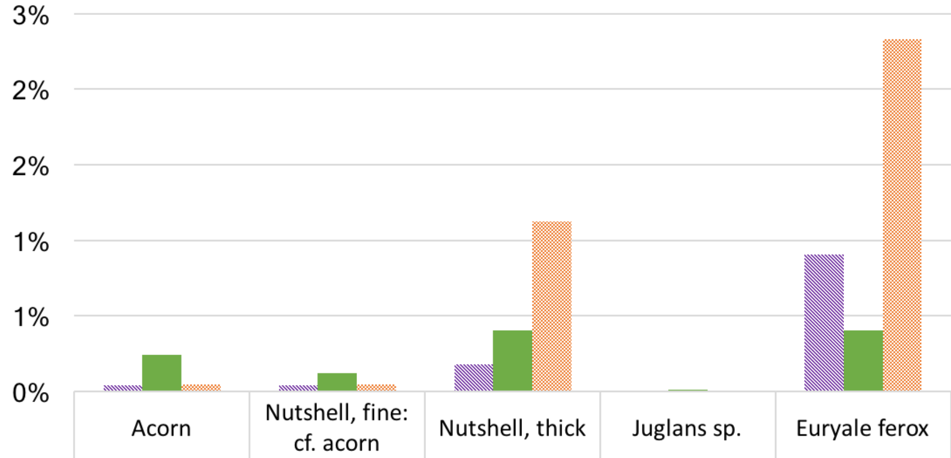
Fig. 5-32: Ubiquity and frequency indexes for nut remains at Baiyangcun.

Chronologically, ubiquity and frequency index are also tightly associated (fig. 5-33; 5-34). Acorns increase during period 2, and then decrease again in period 3. Thick nutshell remains, instead, show a steady increase pattern through the three periods of occupation. Finally, foxnut, although present in comparatively more samples during period 1, had the highest frequency during the last period of occupation (fig. 5-34).



	Acorn	Nutshell, fine: cf. acorn	Nutshell, thick	Juglans sp.	Euryale ferox
period 1	2.56%	5.13%	20.51%	0.00%	53.85%
period 2	10.26%	12.82%	23.08%	2.56%	20.51%
period 3	2.63%	2.63%	26.32%	0.00%	31.58%

Fig. 5-33: Ubiquity index of nut remains at Baiyangcun through the three periods of occupation.

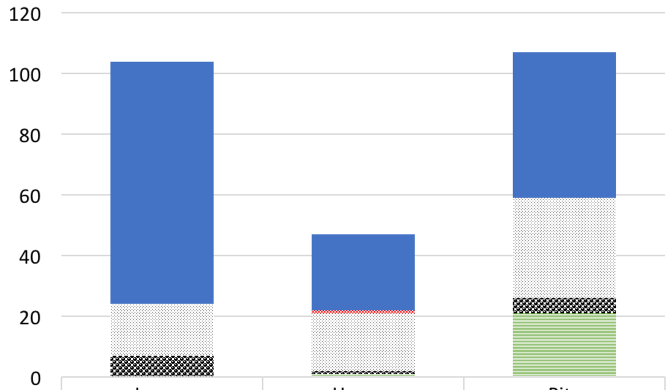


	Acorn	Nutshell, fine: cf. acorn	Nutshell, thick	Juglans sp.	Euryale ferox
period 1	0.04%	0.04%	0.18%	0.00%	0.91%
period 2	0.24%	0.12%	0.40%	0.01%	0.40%
period 3	0.04%	0.04%	1.12%	0.00%	2.33%

Fig. 5-34: frequency index of nut remains at Baiyangcun through the three periods of occupation.

Context analysis

Overall, nut remains are found almost equally in layer and pit contexts (fig. 5-35). Foxnut is found almost twice as much from layer contexts than from pit contexts. Fragments of thick nutshell are instead found most often in pit contexts than in layer contexts. Finally, acorns are almost only found in pits, the majority of them from pit contexts belonging to period 2. These pits also always contain *Echinochloa*, and *Chenopodium* remains. Not having precise information on the size and shape of the pit makes it difficult to determine whether it was a simple refuse pit, or a storage pit. However, the increase of acorns finds from period 2 coincides with the increase of millets, as seen above. This seems to further suggest that during this time there was a slight change in the subsistence regime, with secondary food resources exploited more than during the previous periods of occupation.



	Layers	Houses	Pits
Euryale ferox	80	25	48
Juglans sp.	0	1	0
Nutshell, thick	17	19	33
Nutshell, fine: cf. acorn	7	1	5
Acorn	0	1	21

Fig. 5-35: Baiyangcun nut remains context analysis, with indication of absolute counts.

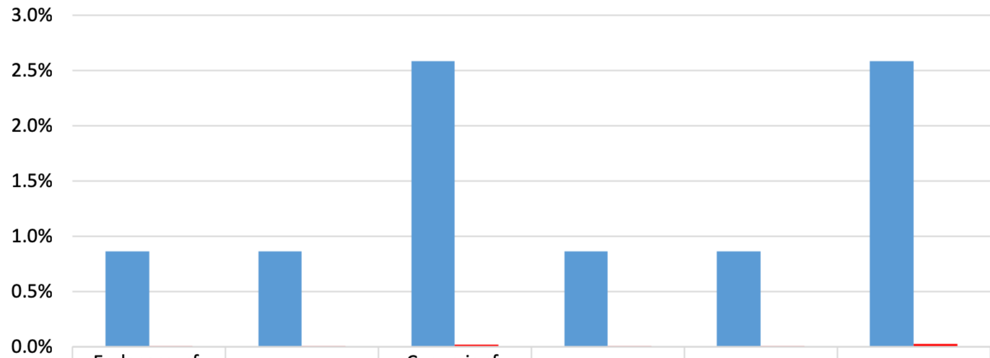
5.4.4.3. Fruits

Only a few species of fruits were found in the samples analysed: endorcarp fragments of *Melia azerdach* (chinaberry); few fragments of *Cucumis* cf *melo,* possibly melon seeds, and other indet. cucurbitaceae seed fragments; seeds of *Lycium* cf (goji berry); one seed of a wild variety of *Vitis* sp. (grape); and one seed of *Crataegus* sp. (hawthorn; table 5-9).

Table 5-9. Fruit species at Baiyangcun showing absolute counts and no. of samples in which they are found.

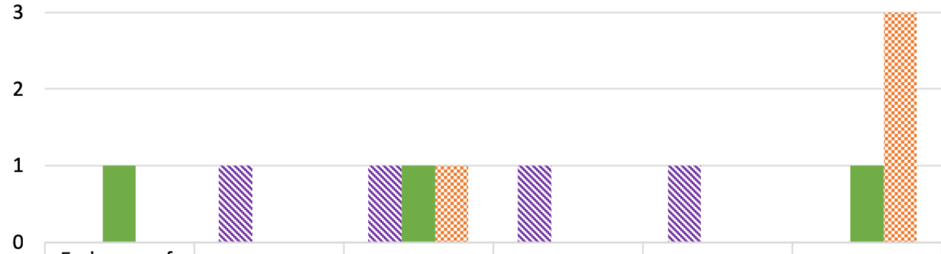
Species	Total	Ubiquity= no. of samples
Melia cf *azerdach*	1	1
Cucurbitaceae indet.	1	1
Cucumis cf *melo*	3	3
Vitis sp.	1	1
Crataegus sp.	1	1
Lycium cf	4	3
TOTAL	11	9

Lycium cf and *Cucumis melo* are the two most abundant fruit found at Baiyangcun, as well as the most ubiquituous (fig. 5-36); other fruit remains are found in very low numbers and only in a couple of samples (table 5-9; fig. 5-36). Chronologically, however, melon is the only fruit present through all the three periods of occupation; grape and hawthorn are found only in period 1, chinaberry only in period 2, and *Lycium* cf in period 2 and 3 (fig. 5-37).



	Endocarp, cf. Melia azedarach	Cucurbitaceae cf	Cucumis cf. melo	Vitis sp. (wild)	Crataegus sp.	Lycium cf
Ubiquity	0.86%	0.86%	2.59%	0.86%	0.86%	2.59%
Frequency	0.01%	0.01%	0.02%	0.01%	0.01%	0.02%

Fig. 5-36: Baiyangcun fruit remains ubiquity and frequency index.



	Endocarp, cf. Melia azedarach	Cucurbitaceae cf	Cucumis cf. melo	Vitis sp. (wild)	Crataegus sp.	Lycium cf
period 1	0	1	1	1	1	0
period 2	1	0	1	0	0	1
period 3	0	0	1	0	0	3

Fig. 5-37: Baiyangcun fruit remains presence showing absolute counts through periods of occupation.

The seed of *Cucumis* cf *melo* from period 1 came from context layer 23 (sample T2(23)S2). This context is at the very bottom of the site mound, second to last before the bedrock, therefore representing the very beginning of the occupation of the site (Dal Martello et al., 2018). Most of the remains from this context were found in mineralised form. Mineralisation of organic remains occurs with high calcium phosphate presence, such as in contexts associated with faecal matter or urine. The preservation state of the archaeobotanical remains from context T2(23)S2 seems to suggest they come from either sewage build-up or animal dung (Dal Martello et a., 2018).

5.4.5. Echinochloa

1762 grains of *Echinochloa* sp. have been recovered from the 116 samples analysed. Of these, 285 are of smaller size, with some possibly immature grains (table 5-10). Although this corresponds to only about 10% of the total identified plant remains at Baiyangcun, *Echinochloa* is the third most ubiquitous species, after rice and foxtail millet (fig. 5-38, compare with fig. 5-9).

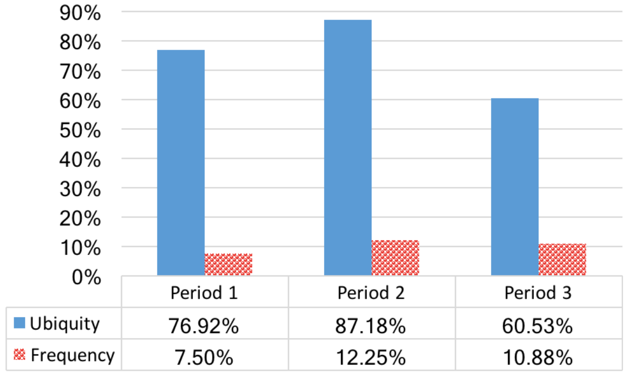


Fig. 5-38: *Echinochloa* sp. remains ubiquity and frequency at Baiyangcun through the three periods of occupation at Baiyangcun.

Table 5-10. breakdown of *Echinochloa* sp. remains at Baiyangcun.

Remain type	Tot	Ubiquity (no. of samples)
Echinochloa caryopsis	1477	84
Caryopsis, smaller size	101	10
Immature caryopsis	184	29
TOTAL	1762	87

Chronologically, we see an increase of *Echinochloa* remains, both in ubiquity and frequency, during period 2 (fig. 5-38). *Echinochloa* remains are most often found in houses, especially for period 1 (255 grains of *Echinochloa* have been recovered from house context F11, see Appendix 2), followed by finds in pit contexts, and lastly in layers (fig. 5-39).

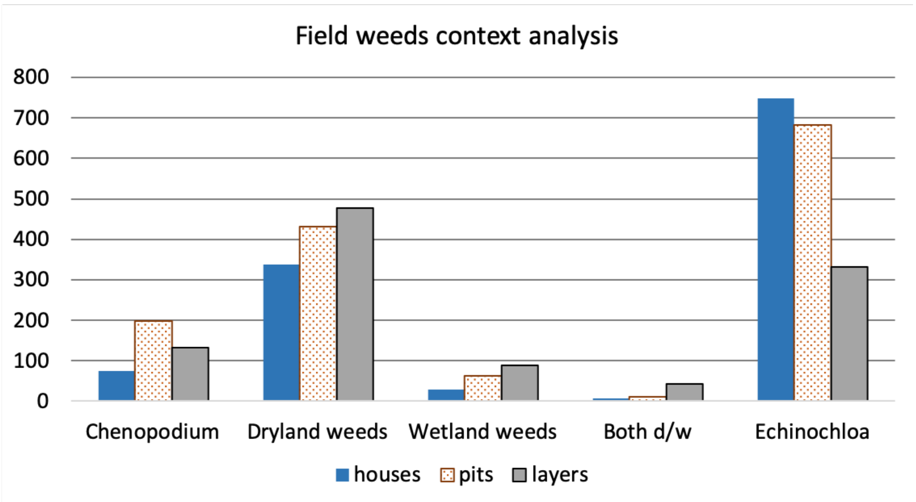


Fig. 5-39: Comparison of provenance of seeds of weeds and *Echinochloa* remains.

The status of *Echinochloa* as a weed or as a minor crop at Baiyangcun is unclear.

Today, two species of *Echinochloa* are cultivated worldwide both as minor crop and animal fodder: *E. frumentacea* (Indian sawa millet), and *E. esculenta* (Japanese barnyard millet), which derive from *E. colona* and *E. crus-galli* respectively (see Chapter 2). In Yunnan, *E. frumentacea* is cultivated and used in the production of a local alcoholic beverage (Dorian Fuller, personal comment 2017). Other 7 species of *Echinochloa* weedy forms are also found in the province (table 5-11, Wu et al., 2013 www.efloras.org; Chen & Philipps, 2006). These weedy species inhabit wet ecologies and usually infest irrigated fields, especially rice fields, of which they have adapted to resemble the habit (Chen and Phillips 2006). Only one of the modern-day varieties present in the province, *E. crusgalli* var. *praticola*, thrives in a dry habitat.

Table 5-11. Echinochloa species present in modern day Yunnan, with Chinese nomenclature, indication of status and ecology; Wu et al., 2013; www.efloras.org, Chen & Philipps, 2006)

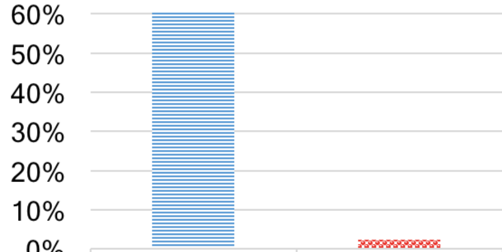
Latin name	Chinese name	Status	Ecology	Notes
Echinochloa frumentacea	湖南稗子 *Hu Nan Bai Zi*	Cultivated	Wet	Derivative of *E. colona* (India?)
Echinochloa esculenta	紫穗稗 *Zi Sui Bai*	Cultivated	Wet	Derivative of *E. crusgalli* (China/East Asia?)
Echinochloa oyzoides	水田稗 *Shui Tian Bai*	Field weed of rice	Wet	Infests irrigated rice fields, particularly aggressive
Echinochloa colona	光头稗 *Guang Tou Bai*	Field weed	Wet	Infests irrigated fields
Echinochloa crus-galli	小旱稗 *Xiao Han Bai*	Field weed	Wet	Infests rice fields, also found in streamsides
Echinochloa glabrescens	硬稃稗 *Ying Fu Bai*	Environmental weed	Wet	Extreme genetic variant of *E. crus-galli*, showing glossy, hard lower floret
Echinochloa caudata	长芒稗 *Chang Mang Bai*	Environmental weed	Wet	Segregate genetic variant of *E. crus-galli* with very dense, purple inflorescence presenting long awns
Echinochloa crusgalli var. *praticola*	细叶旱稗 *Xi Ye Han Bai*	Environmental weed	Dry	Dry variety of *E. crus-galli* found in roadsides and disturbed places

Echinochloa remains at Baiyangcun have been found in high ubiquity, and they are overall present in higher quantities in house and pit contexts (fig. 5-38; 5-39). This is in sharp contrast with the provenance of the other categories of weeds, which are instead prevalent in layers and pits (fig. 5-39) and could seem to suggest that *Echinochloa* was exploited as food resource. But given the aggressiveness of this species as a weed, and the difficulty of weeding it out in the early stages of cultivation, it is also likely possible that its high presence is due to the resilience of the weed and the inefficient weeding techniques and processing habits carried out at the site. If we are to consider *Echinochloa* as a weed rather than a minor crop, not being able to identify the to the species level makes it difficult to establish whether it was an indicator of dry or wetland habit.

5.4.6. Chenopodium

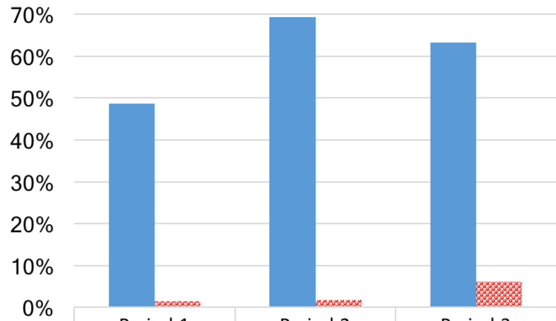
Chenopodium sp. is treated here separately as the species has been shown to be possibly exploited as food resources from other prehistoric sites in Yunnan (such as Haimenkou, and Dayingzhuang, see Chapters 6 and 7).

At Baiyangcun, *Chenopodium* is found in 70 out of the 116 samples analysed, with an absolute count of 405 grains (table 5-3). *Chenopodium* is the fourth most ubiquitous species found after rice, foxtail millet, and *Echinochloa* (fig. 5-40, compare with 5-4). Its presence shows an increasing pattern from period 1 to 3, with absolute counts of *Chenopodium* grains triplicating by period 3 (fig. 5-41). Moreover, *Chenopodium* is mostly found in pit contexts, especially for period 3 (fig. 5-42). *Chenopodium* is known to infests dryland fields, such as millet fields. Given its very low frequency in the overall archaeobotanical assemblage at Baiyangcun, as well as its small morphometric size, *Chenopodium* has been considered as a weed, and included in the total count of dryland weeds (see below).



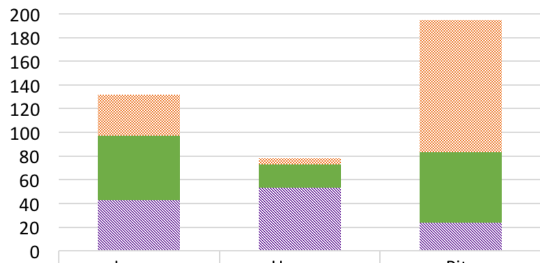
	Ubiquity	Frequency
Chenopodium	60.34%	2.28%

Fig. 5-42: Baiyangcun Chenopodium remains ubiquity and frequency index.



	Period 1	Period 2	Period 3
Ubiquity	48.72%	69.23%	63.16%
Frequency	1.51%	1.78%	6.09%

Fig. 5-41: Baiyangcun *Chenopodium* remains ubiquity and frequency index over time.



	Layers	Houses	Pits
Period 3	35	5	112
Period 2	54	20	59
Period 1	43	53	24

Fig. 5-40: Baiyangcun *Chenopodium* remains contexts analysis showing absolute counts through the three periods of occupation of the site.

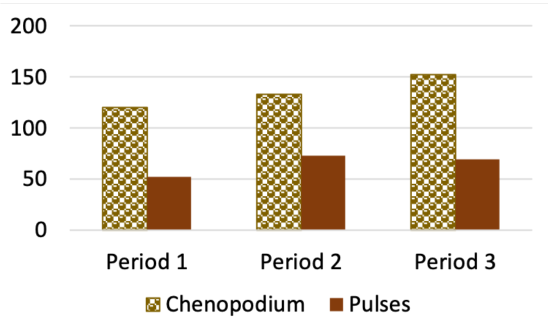


Fig. 5-43: Chenopodium vs. pulse remains at Baiyangcun divided by periods of occupation.

Chenopodium presence as a weed is considered an indication of good fertility in the soil, in contrast to leguminous weeds, which instead indicate loss of soil fertility (Song, 2011). At Baiyangcun, *Chenopodium* is always present in higher quantities than pulses (fig. 5-43), possibly indicating that the soil had a good level of fertility.

5.4.7. Seeds of field weed species

5.4.7.1. Weed ecology

Several field weed species belonging to the Poaceae, Cyperaceae, Polygonaceae, and Juncaceae families were found in the samples analysed. Because rice fields are not often individuated/excavated in archaeological investigations, the associated macro-botanical weedy flora is analysed to establish rice cultivation systems (Fuller et al., 2011). Each species was divided according to its specific ecology into dryland weed, wetland weed, and both dry/wetland weed (see table 5-12). This was done following information from available weed floras for the region of study (i.e. Wang, 1990; Li, 1998; Zhou & Zhang, 2006), as well as following divisions made in other published authorships from Southwest China (e.g. D'Alpoim, 2013; Jin, 2014).

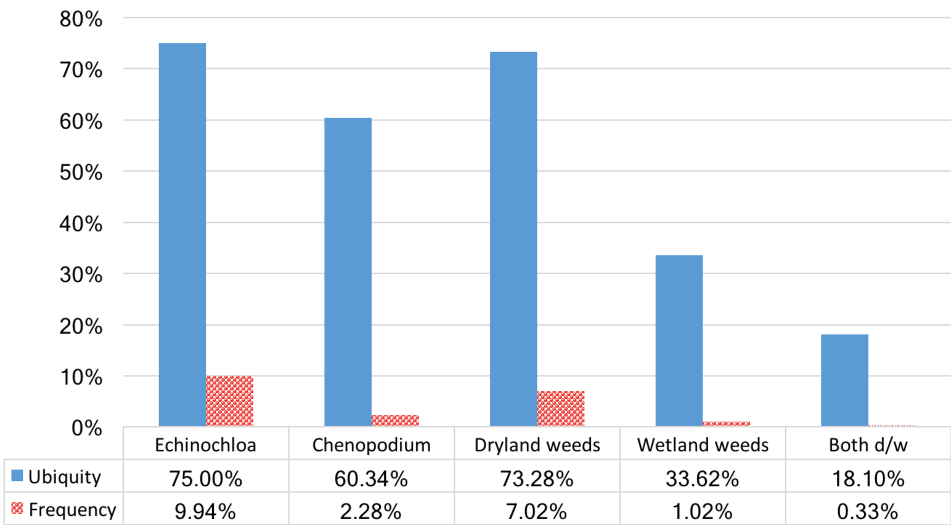


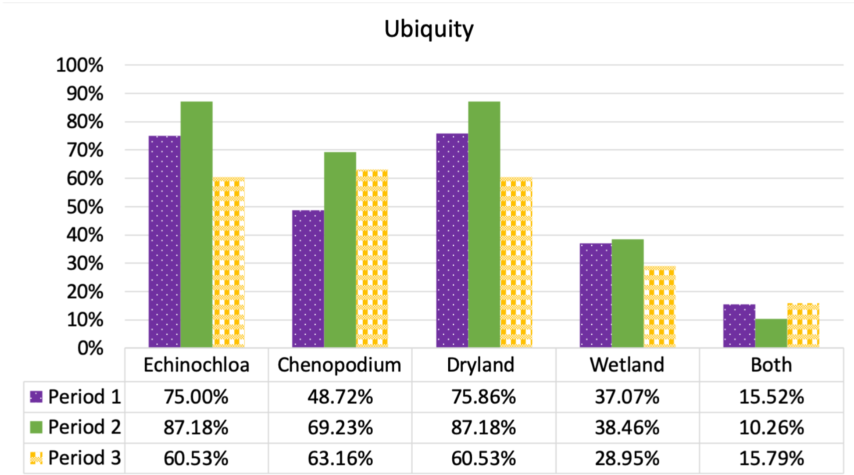
Fig. 5-44: Ubiquity and frequency index of main weed categories at Baiyangcun.

Table 5-12. Weed ecology relating to weed species found in the archaeobotanical assemblage at Baiyangcun.

Dryland- associated with millet	Wetland- associated with rice	Dry/wetland weeds
Brassica sp.	*Cyperaceae* indet.	Asteraceae indet.
Brassicaceae indet.	*Cyperus* sp.	*Carex* sp.
Digitaria sp.	*Eleocharis* sp.	*Echinochloa* sp.
Eragrostis sp.	*Fimbristylis* sp.	Lamiaceae indet.
Euphorbia sp.	*Girardinia diversifolia*	Malvaceae indet.
Fabaceae – various indet.	Juncaceae indet.	*Potentilla* sp.
Ipomea sp.	*Polygonum* sp.	*Stachys/Mosla* cf
Panicum ruderale	*Polygonum persicaria*	
Panicum sp.	*Schoenoplectus macronatus*	
Paspalum sp.	*Scirpus* sp.	
Pennisetum sp.		
Perilla sp.		
Poa sp.		
Poaceae (wild)		
Portulaca sp.		
Setaria verticillata		
Setaria viridis		
Setaria/ Echinochloa		
Urochloa sp.		
Verbena officinalis		

Weeds remains from Baiyangcun are quite ubiquituous. Within the different weed categories, seeds of *Echinochloa* are the most ubiquitous, followed by dryland weeds, *Chenopodium,* and wetland weeds (fig. 5-44). Similarly, the majority of the weed assemblage is composed of *Echinochloa,* followed by dryland weeds, and *Chenopodium* (fig. 5-44). Wetland weeds are present in slightly more than 30% of the samples analysed and account to only 1% of the total identified remains (fig.44).

However, a lower presence of seeds of wetland weeds is to be expected in weed assemblages, as these get weeded out in higher quantities during the earlier stages of cultivation (Thompson, 1996). Moreover, if associated with rice, harvesting of the crop at the panicle level with the aid of harvesting knifes, such as those found at Baiyangcun, would result in proportionally less weeds to be harvested along, and, therefore, become included in the assemblage (Bray, 1984; Thompson, 1996).



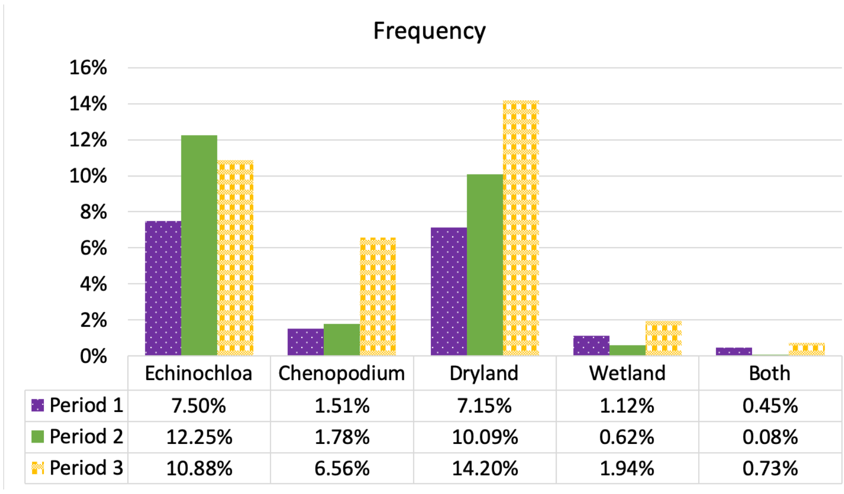


Fig. 5-45: Baiyangcun weeds assemblage showing ubiquity (top) and frequency (bottom) index of weeds categories through periods of occupation.

Weed remains show a general increase through time (fig. 5-45), especially *Chenopodium,* and dryland weeds show a steady increase, while wetland weeds decrease in period 2, and increase again in period 3 (fig. 4-45), following a similar trend to rice remains

Table 5-13: P-values of regression analyses on rice-millets remains and weed data; positive correlation for values below 0.1; negative correlation for values above 0.1.

	P-value
Rice vs. Wet	0.013
Rice vs. Dry	0.010
Millet vs. Wet	0.00016
Millet vs. Dry	0.814

Linear regression analysis on the weed assemblage in relation to rice and foxtail millet revels a stronger positive correlation between rice and wetland weed remains in comparison to dryland weeds (P-value 0.013; table 5-13). Even though rice and dryland weeds also show a positive correlation, the very strong correlation of millet and dryland weeds (P-value 0.00016) in conjunction with the rejection of correlation between millets and wetland weeds (P-value 0.8) suggest that dryland weeds are associated with millets, and wetland weeds with rice.

At the time of occupation, Baiyangcun presented slightly wetter conditions than present day (modern day range for annual precipitation at Binchuan is 587mm); however, even with a precipitation higher 20% than it is today (which would make it c. 704mm), it would not support the cultivation of rice in a dryland regime, which requires a minimum of 800-1000mm of precipitation (see Chapter 2). Given the climatic instability attested by lake sediments and pollen records in the Erhai region during the 3rd millennium BC (see Chapter 3), it is also difficult to determine the amount of precipitation that occurred at the time of occupation of the site. The close vicinity of the site to a body of water (the Binju River) under monsoonal influences would have possibly allowed for seasonal flooding. This suggests that rice at Baiyangcun was cultivated in a wetland cultivation regime, taking advantage of the seasonal submerging of the rice fields.

5.4.8. Crop processing

The analysis of weeds and other crop processing activities "by-products" can inform on past social organization and labour structures as linked to agricultural practices (e.g. Stevens, 2014; Stevens, 2003; Hillman, 1984; Hillman, 1981). Specifically, the presence of certain types of weed and crop by-product has been proved to be closely associated with specific crop processing activities, also referred to as stages of crop processing (fig. 4-10 in Chapter 4), therefore, their analysis can directly inform on post-harvesting habits.

For millets, past models have shown how the decline of the ratio of immature to mature millet grains vs. weed seeds to millet grains relates to the later stages of crop processing (e.g Song, 2011; Song et al. 2013; Reddy, 2003; 1997, see Chapter 4). In order to analyse crop processing practices through time at Baiyangcun, immature grains to mature grains of *Setaria italica,* vs. dryland weeds to *Setaria italica* grains have been plotted (fig. 5-46; 5-47). Immature *Setaria* grains are distinguished from mature grains by their flatter and smaller size in comparison to fully mature one (see Appendix 3). It has been decided to plot dryland weeds only against *Setaria* grain as the two show strong correlation in the samples at Baiyangcun (table 5-13).

Rice crop processing has not been as widely investigated as millet, and some models have been adapted from ethnographic studies on modern rice cultivation in Thailand (i.e. Thompson, 1996, see Harvey & Fuller, 2005; fig. 4-10 in Chapter 4 of this thesis), however, they have not been substantiated with archaeological experiments. Nevertheless, spikelet bases, husks, and weeds are considered to be crop processing by-product of rice, as those should be eliminated before preparing the rice for cooking. Because of the very little occurrence of chaff in the samples analysed for this dissertation, it has been decided to only plot the ratio of spikelet bases to grain vs. wetland weed seeds to rice grains has been plotted to explore crop processing patterns. Regression analysis has shown a slightly stronger correlation of wetland weeds to rice remains (table 5-13), thus it has been decided to only plot wetland weed seeds against rice grains (fig. 5-48; 5-49). Finally, the overall ration of crop remains vs. weed remains has been analysed, to investigate changes of overall land management through time.

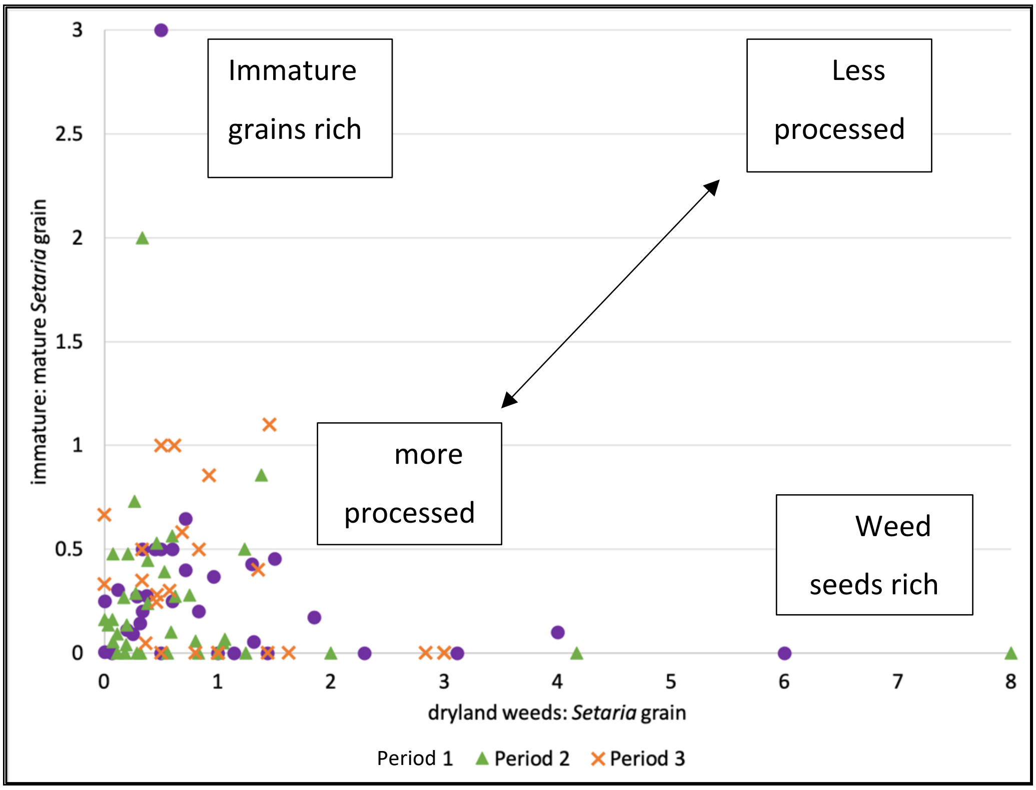


Fig. 5-46: Scatterplot of immature: mature *Setaria* grains ratio vs. dryland weed seed: *Setaria* grain ratio.

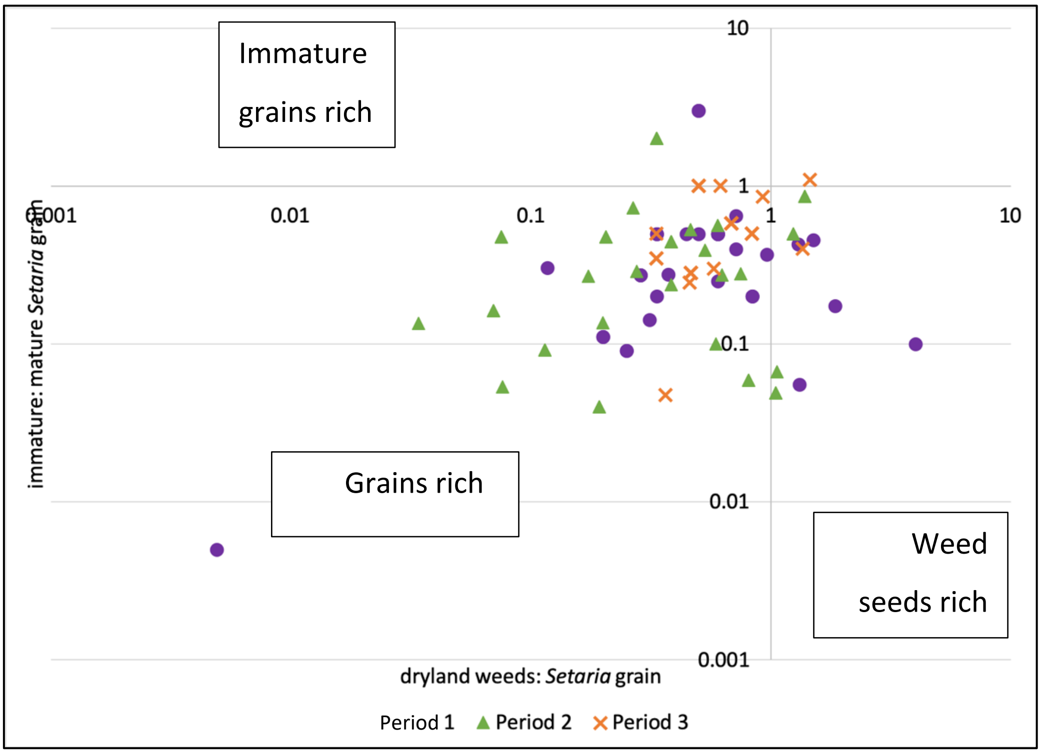


Fig. 5-47: Logscale scatterplot of immature: mature *Setaria* grains ratio vs. dryland weed seeds: *Setaria* grains ratio.

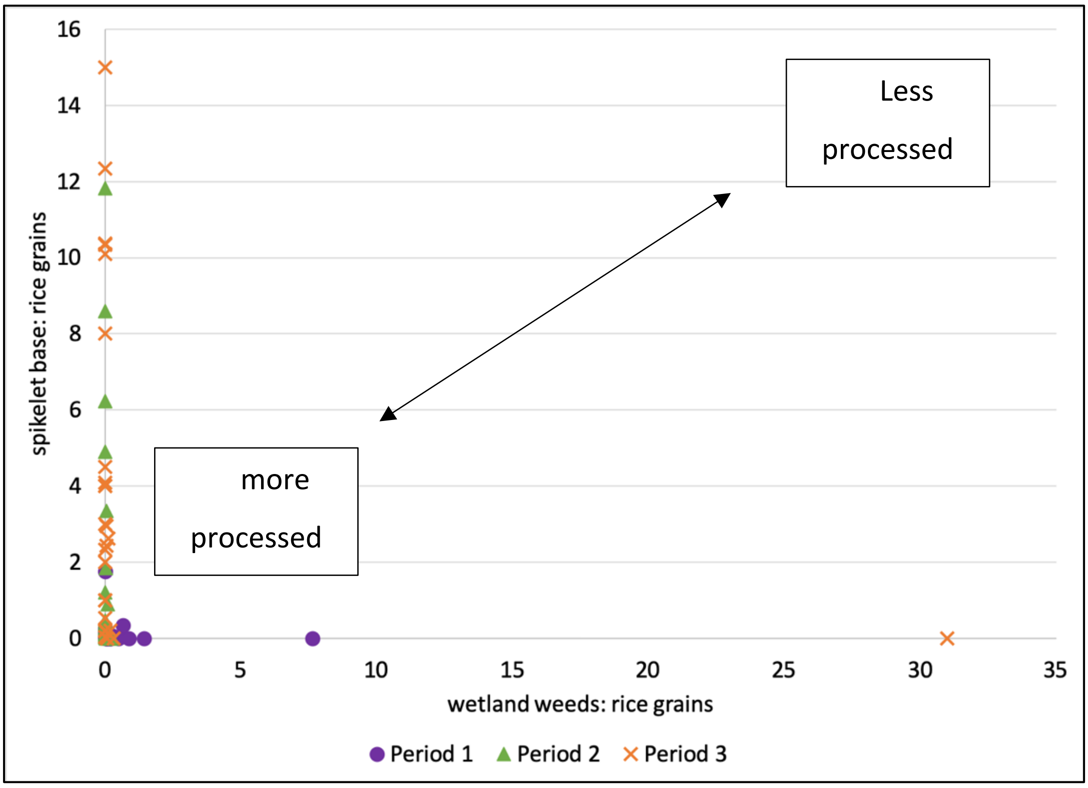


Fig. 5-48: Scatterplot of rice spikelet bases to rice grain ratio vs. wetland weed seeds to rice grain.

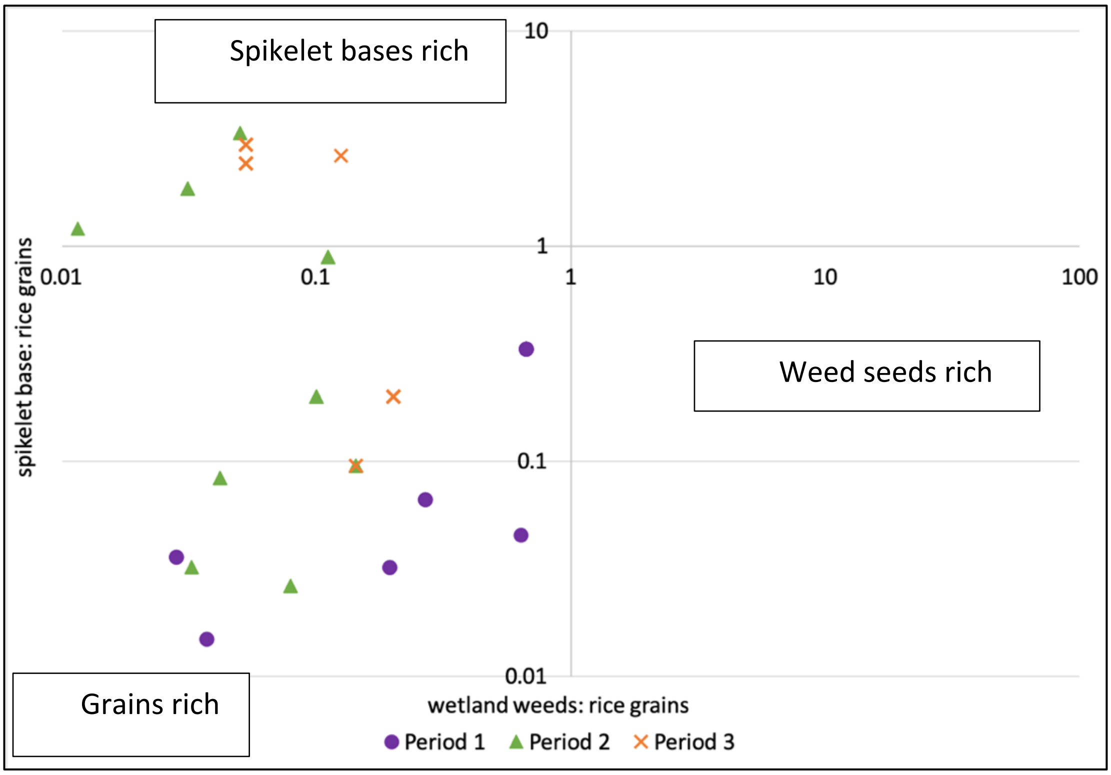


Fig. 5-49:Logscale scatterplot of spikelet bases to rice grains ratio vs. wetland weed seeds to rice grains.

For foxtail millet most of the samples plot close to the lower left corner of the plot, indicating that most of the samples are richer in mature grains and less rich in weed seeds and immature grains (fig. 5-45). Therefore, in order to see patterns more clearly, ratios have been replotted in a logscale scatterplot on base 10 (fig. 5-46). This shows more clearly that most of the samples plot on the lower left corner of the graph, with ratio values under 1. Samples from period 2 (green triangle) plot slightly more towards the lower left corner of the logscale, but overall there are no evident differences among the three periods, and the majority of the samples all plot on the lower left corner (fig. 5-47).

In contrast, the analysis for rice shows that most of the sample contexts cluster in the lower left corner and in the y-axis, indicating that all the samples are richer in grain with relatively few weed seeds (fig. 5-48). The logscale scatterplot for rice shows more clearly that the majority of the samples are distributed on the left half of the plot; with some clustering on the upper half and some on the lower half (fig. 5-49).

Chronologically, samples from period 1 (purple dots) only cluster on the lower left corner, while samples from period 2 (green triangles) and 3 (oranges crosses) are more widely distributed across both the left lower and upper corner. This indicates that samples from period 1 appear richer in grain, while those from period 2 and period 3 differentiate in those richer in grains and those richer in spikelet bases.

According to the analysis, most samples, both relating to foxtail millet and rice, are grain rich, throughout all of the occupation periods. There is generally not a lot of input from earlier crop processing stages, with only a few samples showing higher quantities of weeds in comparison to millet grains for period 1, and spikelet bases to rice grains for period 2 and 3.

This indicates that the later stages of crop processing (particularly de-husking) are more prevalent in the archaeobotanical records at Baiyangcun, and that the initial stages of crop processing, such as threshing and winnowing, were carried out off-site, probably in the fields, and that the waste from these stages are therefore absent from the settlement.

The very high percentage of clean grains, both millet and rice, throughout the samples would suggest that they became charred shortly after or during cooking preparations. Another hypothesis could be that the higher presence of de-husking waste indicate that crops were routinely stored as mostly as cleaned grain. However, the storage of grain requires greated input of labour within crop processing following harvest, which would in turn require a larger scale, more centrally organised labour, possibly suggesting that agricultural activities were not practiced at the household level, but at a more complex stratified social structure at the site (Fuller & Stevens, 2009).

However, it has also been noted especially millet husks does not preserve well archaeologically, especially when grains are preserved through charring by fire, as a high fire temperature more readily destroys the more fragile husk comparatively to grain (Castillo, 2013). Similarly, preservation by fire also inherently bias the archaeobotanical records towards the later stages of crop processing, as the earlier stages, if carried out in the fields, are less likely to become charred and hence incorporated into the archaeobotanical record (Harvey & Fuller, 2005).

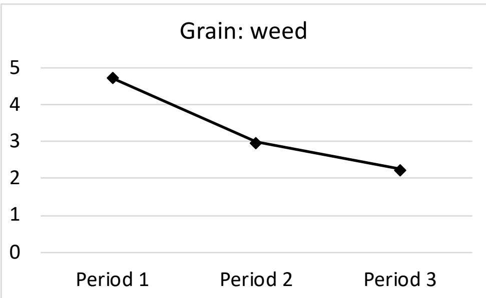


Fig. 5-51: Ratio of grains (including rice, and millets) to weeds (including dryland, wetland, and both categories) at Baiyangcun.

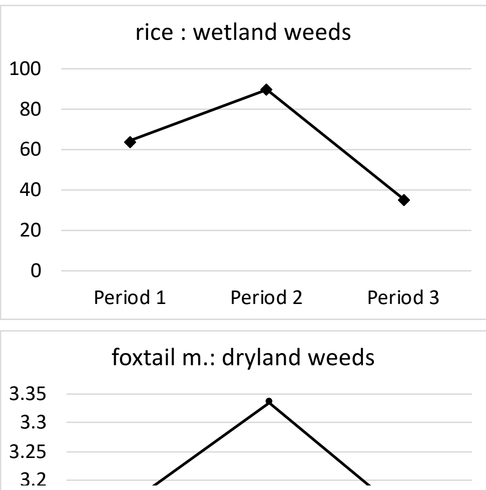


Fig. 5-50: Ratio or rice to wetland weed remains (top), and of *Setaria italica* to dryland weed remains (bottom) at Baiyangcun.

Overall, the ratio of grain to weed remains show a decreasing trend through time (fig. 5-50). This means that more weed remains are being incorporated in relation to crop remains through time. There are several reasons why more weed seeds can become incorporated in the archaeobotanical assemblage, people could be weeding less efficiently than previously, or it could also indicate prolonged use of fields, which would allow for more weeds to become established in the field and to build up a larger seedbank. It could also indicate a change in harvesting methods, for example by harvesting lower at the culm, rather than at the panicle level, or also in storage conditions, by storing the crops in a less processed state. If comparing ratio of rice to wetland weeds, and millet to dryland weeds (fig. 5-51), both crops and their associated weeds show a similar trend through time. The higher proportional presence of weed seeds in relation to grains is due to the fact in period 1 more contexts relate to direct cooking activities (i.e. 20lf), whereas in period 3 especially, more contexts seem to relate to storage units (i.e. H60-2). Therefore, the patterns seen in the analysis are likely to relate more to differences in context provenance, rather than being an indication of changes in behaviours. Given that similar crop processing studies are still lacking from other sites in Yunnan, due to either the lack of systematic archaeobotanical work or the insufficient quantity of remains retrieved, at present it is difficult to interpret further and future studies might help clarify this issue.

5.5. Baiyangcun: summary

The white ashes found in several pits at the Baiyangcun site during the first excavation season were most probably siliceous rice glumes. This was seen by the archaeologists of the time as evidence that the Baiyangcun people practiced a rice-based agriculture. Regardless of the fact that no archaeobotanical analyses had been carried out at the site to verify the actual presence and importance of rice in the overall subsistence regime, this find made the site well known amongst archaeologists and academics both in China and abroad. Yunnan Province was thought to be the centre for rice domestication in East Asia, and even until quite recently Baiyangcun and its alleged rice-based agriculture subsistence were taken as primary supporting evidence indicating that rice agriculture spread to Southeast Asia through Yunnan in the context of the Austroasiatic languages dispersal (e.g. Higham, 1996; Higham, 2002; see Chapter 2). The early date at which Baiyangcun was excavated precluded archaeobotanical investigations, as they were not a widespread practice in Chinese Archaeology at the time (see Chapter 1). The finds of white ashes from the first excavation season of Baiyangcun cannot in itself be considered a sufficient evidence to establish the presence of agriculture at the site, let alone discuss agricultural spread issues amongst regions.

The most recent excavation provided us with the hard evidence to finally discuss these topics. Although rice had indeed a substantial role in the overall subsistence of the site, systematic archaeobotanical analyses revealed that a mixed crop economy based on both rice and millets was practised throughout the occupation of the site. Moreover, even though the site was abandoned after period 1 and reoccupied after a period of a century or so, there is no substantial change in overall crop assemblage between the two periods. The reason why the site was abandoned is unclear.

The find of field weeds in the archaeobotanical samples allowed for the investigation of the crop ecology. The specific weeds associated with rice (i.e *Fimbristylis s*p. and *Scirpus* sp.) at Baiyangcun suggest that rice was most likely cultivated in a wet regime through seasonal floods, with rice fields possibly located close to the river, in the central area of the valley. Millet, instead, could have been grown in the outskirts of the site, on the surrounding hills, taking advantage of the peculiar vertical zonation of vegetation, which was already present at the time of occupation of the Baiyangcun site, and would have thus allowed for different ecological belts to exist within short distance.

The relative importance of the crops fluctuated through the three periods of occupation of the site, with rice declining, and millet increasing during period 2, after re-occupation of the site. However, rice and millet maintained their overall primacy over other food resources, indicating that they were the main staple food on which the Baiyangcun people relied. Additional food resources that implemented the diet include a variety of fruits and nuts, as well as legumes. The exploitation of these resources was undertaken during time of scarce crop (rice) yields, such as during period 2, when their overall frequency increases.

CHAPTER 6. The site of Haimenkou

6.1. Introduction

The site of Haimenkou is located in Jianchuan County, in the Jinsha River Basin, about 80km north of Baiyangcun and just 1km north of the modern day village of Haimenkou, from which it takes its name (N 26.43333 E 99.91667, fig 6-1). The site of Haimenkou is situated at 2190m asl (Min, 2013) at a slightly higher elevation than Baiyangcun. For this reason, climatic and environmental conditions are drier and colder than at Baiyangcun. At Haimenkou, modern average annual precipitation is about 730mm, and average annual temperature is 14.6˚C (Yunnan, 1999). Modern agriculture is heavily practiced in the area today, and it relies mostly on double wheat cropping (Zhao, 1986).

At the time of occupation, climatic conditions similar to modern day were present at Haimenkou. The site was in fact occupied right after a sharp climate decline event which brought the general environmental conditions very close to modern day range (see Chapter 3).

Short excavation reports have been published for each excavation season (Yunnan, et al., 2009; Xiao, 1995; Yunnan, 1958). Since the last excavation campaign, further studies of Haimenkou have been focusing mostly on establishing the chronology of the site, as well as investigating its metal working craftsmanship and technology (see Yunnan, et al., 2009; Lin & Min, 2014; Min, 2013). Currently, further excavations of the site are being led by Sichuan University, as part of its archaeological field school programme for undergraduate students.

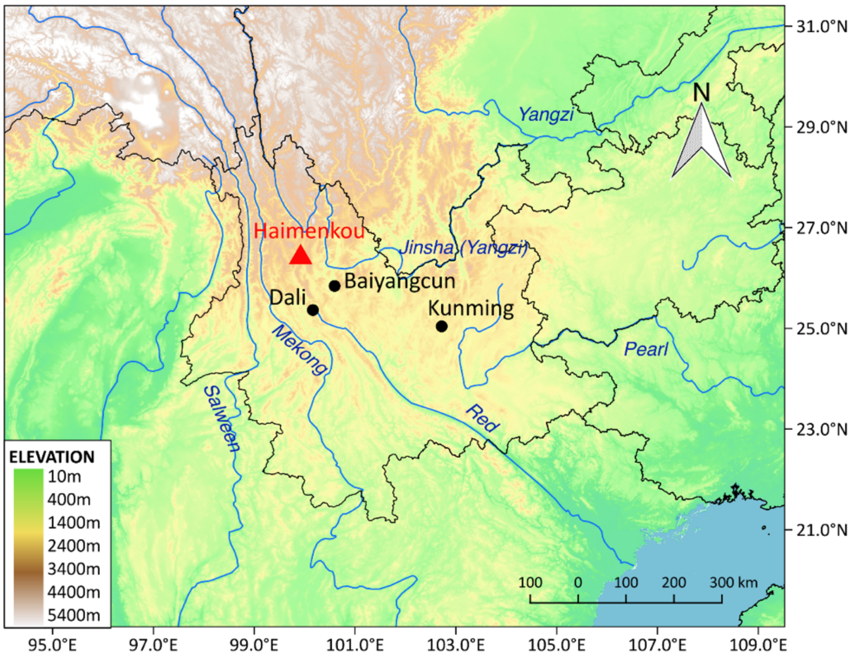


Fig. 6-1. Map showing the location of the site of Haimenkou, and its relative position to the cities of Kunming and Dali, and to the nearby site of Baiyangcun. Made with QGIS.

Thanks to the unparalleled degree of preservation of the site, which included large part that were waterlogged, the last excavation campaign of Haimenkou was one of the 2008 Chinese annual "10 Best Archaeological Discoveries".

6.2. Site description and material culture

Features

The waterlogged conditions of the site allowed for the recovery of many wooden remains, including thousands of wooden posts arranged in rectangular perimeters, and therefore interpreted as the vestiges of pile-dwellings (Yunnan, et al., 2009). These pile-dwellings vary in size between about 5-5.50m in length, and 2-2.2m in width. They were most likely wattle and daub structures which were built above the ground surface level, with the aid of wooden poles, and wooden flooring (Yunnan, et al., 2009).

This dwelling structure remains the same throughout the whole occupation of the site, and the number of wooden posts recovered increases sharply in the second and third phase (see below for a discussion of the radiocarbon dating of Haimenkou). This has been interpreted as a possible sign of increased population (Wang, 2018). Current estimates on the size of the site is around 10ha; this is close to site size estimates for the site of Baiyangcun, and according to population estimates for Early Neolithic China, it could indicate a population of c. 500 people, if based on rice production (Song, 2013; Liu, 2007).

Other features discovered at Haimenkou include some (human) bones in pits, and some hearths; although no precise number of these has been provided (Yunnan, et al., 2009).

6.2.1. Ceramics

Ceramic remains at Haimenkou have been recovered in very high quantities from each excavation season, however, these are mostly in the form of broken pottery sherds, rather than complete vessels. The ceramics at Haimenkou are characterised by incised/impressed simple geometric decoration motifs, such as triangles, zigzags, lozenges, etc (Xiao, 1995). These motifs show some similarities with the Northwestern (Gansu-Qinghai) late Neolithic ceramic cultures (Xiao 1995; Wang 2018).

The ceramic vessel assemblage varies through the three periods of occupation of the site, and as a whole is composed by *bo* bowls, *guan* and *gang* jars, *bei* glasses, *pen* basins, *ye* vessels, and *fu* cauldrons. Other ceramic objects recovered include spindle whorls, and fishnet weights (figs. 6-2; 6-3).

During the first period of occupation of Haimenkou, ceramics are mostly characterised by a coarse and black or greyish coloured temper, sometimes fine polished temper, which was fired at very high temperatures (Yunnan 2009). Vessels were handmade, with no evident signs for the use of the slow-wheel (Yunnan 2009). *Guan* jars are the most prevalent vessel type in the assemblage, followed by *bo* bowls, and *pen* basins (fig. 6-2). Only a couple of *guan* jars had handles. Moreover, some so-called "ring-foot" vessels (*zhizu* 支足; or *quanzuqi* 圈足器) were also found. This is a hollow, round pedestal type of ceramic remains used to elevate the base of the vessels, to which they were attached forming one container; some of these remains have carved out rings, hence the name "ring-foot". This type of ceramic remain is found only from deposits associated with the first period of occupation, and disappears during the later periods (Yunnan, et al., 2009). Ceramic foot remains similar to those found at Haimenkou have been reported also from the site of Dadunzi (Yunnan, 1977).

The ceramic vessels of this period are rather small. Most of the *guan* jars are characterised by an almost straight body and a virtually unrestricted outward protruding opening, measuring about 16-20cm in diameter (fig. 6-2: 1; 6-2:3). A minority of *guan* jars show instead a restricted opening, with a profound and round body, shoulders that lead to a much narrower neck, measuring also about 20cm (fig. 6-2:2). Not many bottoms were recovered, and most of the vessels remains are constituted by the upper part of the vessels, so it's difficult to know whether most vessels had a flat or round base, and how tall they were.

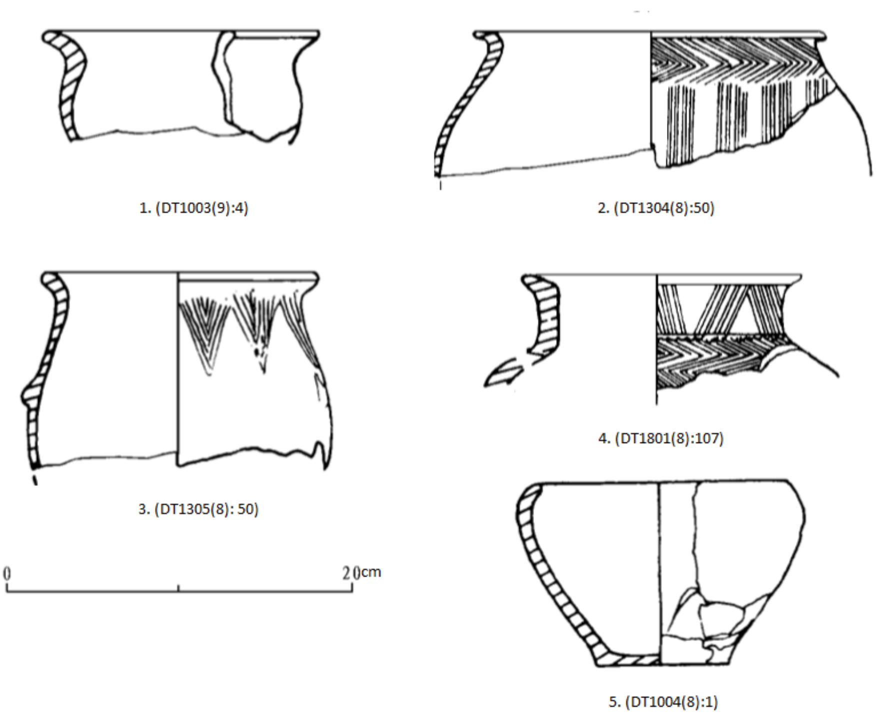


Fig. 6-2: Examples of ceramic vessels recovered at Haimenkou, from layers 10 to 8: 1. outward protruding opening *guan* jar; 2. *guan* jar; 3. *guan* jar; 4. high neck *guan* jar; 5. *bo* bowl. Redrawn from Yunnan et al., 2009.

During the second period of occupation, red coloured tempers, and a few painted vessels appear (Yunnan, et al., 2009). Production process and firing temperature were still similar to the earlier period, with vessels fired at high temperatures, and handmade (Yunnan, et al., 2009). The ceramic assemblage was composed mostly by *guan* jars, and *bo* bowls, secondarily by *pen* basins, and *ye* vessels (fig. 6-3). This particular type of vessel was not present during the earlier stage of occupation (fig. 6-3:7). Generally speaking, the overall size of the vessels increases, as do the presence of double-handled and high neck jars (fig. 6-3:5; 6-3:6), even though they still constitute the minority of the assemblage (Yunnan, et al., 2009). Moreover, some pottery fishnet weights have also been recovered from the deposits associated with this phase.

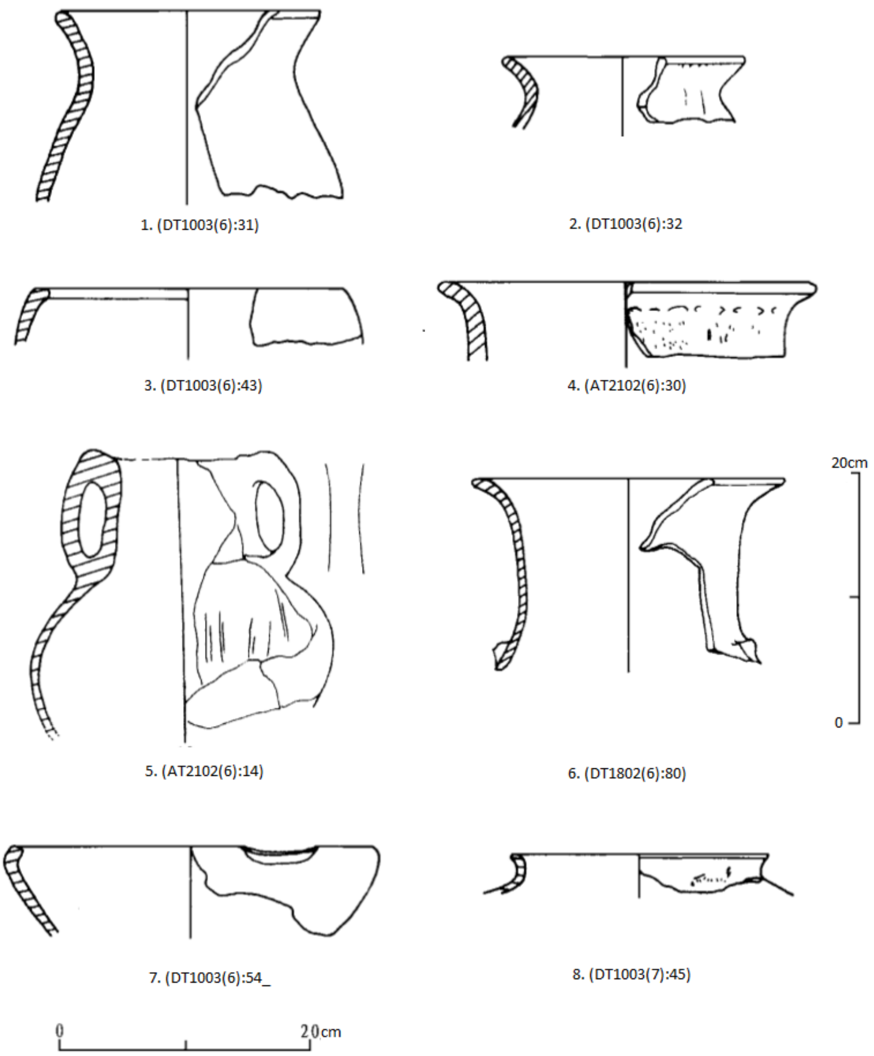


Fig. 6-3: Examples of ceramic vessels from Haimenkou, layer 7-6: 1. *guan* 2. *guan* jar; 3. *guan* jar; 4. *pen*; 5. double handled *guan* jar; 6. high neck *guan;* 7. *ye* vessel type; 8. short neck *guan*. Redrawn from Yunnan et al., 2009.

During the last period of occupation, vessels are fired at much lower temperatures, and temper is mostly reddish/greyish-brown coloured (Yunnan, et al., 2009). The overall vessel assemblage differentiates further, with a drastic increase of red painted double-handled *guan* jars (fig. 6-4:2). These double-handled *guan* jars are seen as evidence of cultural influence or connections with some Neolithic populations in Northwest China, including Qijia, Kayue and Xindian Cultures (Wang, 2018). It is not clear whether this represents some immigration or trade, but it is tempting to connect these material culture links to the diffusion of wheat and barley, which appear in the archaeobotanical assemblage from the second period of occupation (see below). Other vessels include *guan* jars, *bo* bowls, *pen* basins, *gang* jars, *fu* cauldrons, and *ye* vessels (fig. 6-4). Relatively to the previous period, more ceramic net sinkers were found. Finally, some tiles were also recovered.

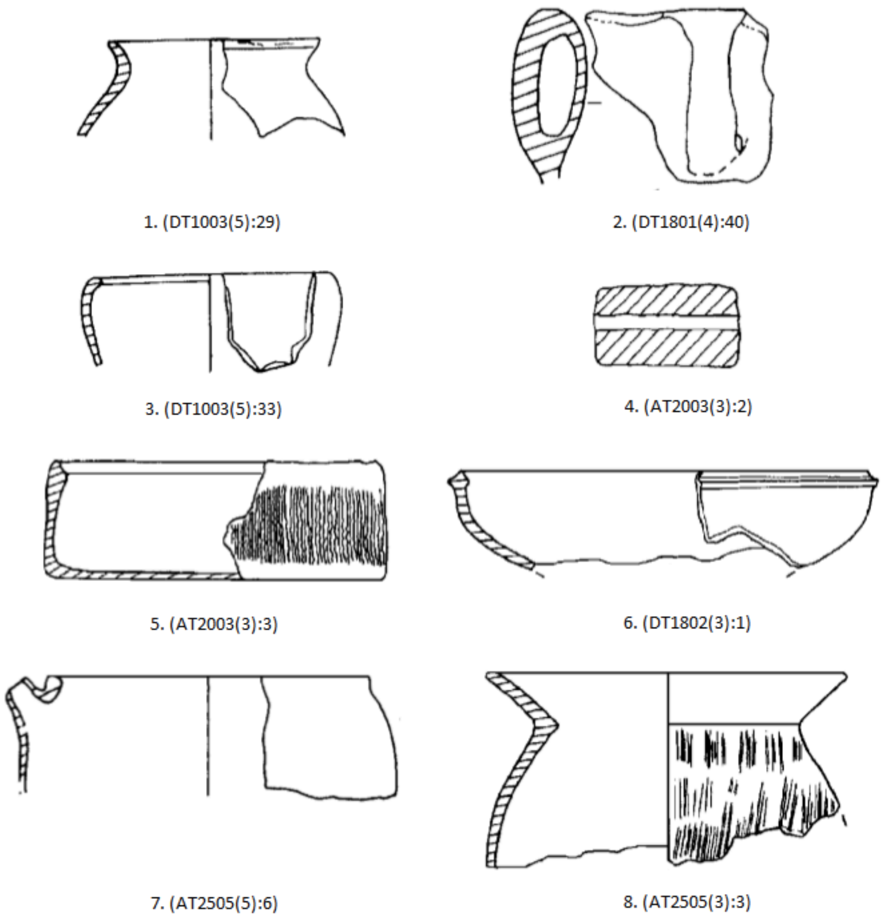


Fig. 6-4: Examples of vessels from Haimenkou, layers 5-3: 1. *guan* jar; 2. double-handled *guan* jar; 3. *bo* bowls; 4. fishnet weight; 5-6. *pen* (fig. 20-1; 20-6); 7. *gang* jar; 8. *fu* cauldron. Redrawn from Yunnan et al., 2009.

6.2.2. Stone implements

A set of stone tools linked with deforestation and construction activities, as well as harvesting, hunting, and manufacturing has been recovered from the site of Haimenkou throughout each excavation season.

According to Xiao (1995), 1 hatchet casting mould (i.e. fig. 6-5:6); 51 axes (i.e. fig 6-5:1); 49 adzes (i.e. fig. 6-5:2); 4 chisels; 81 knifes (i.e. 6-5:7 to 10); 78 arroheads (i.e. fig. 6-5:3); 57 awls (i.e. fig. 6-5:4); 26 needles (i.e. fig. 6-5:5); 16 saddle-querns; 9 spindle whorls; 2 bolas; and 2 grindstones were recovered during the first and second excavation campaigns. No further stratigraphic information was provided for these objects.

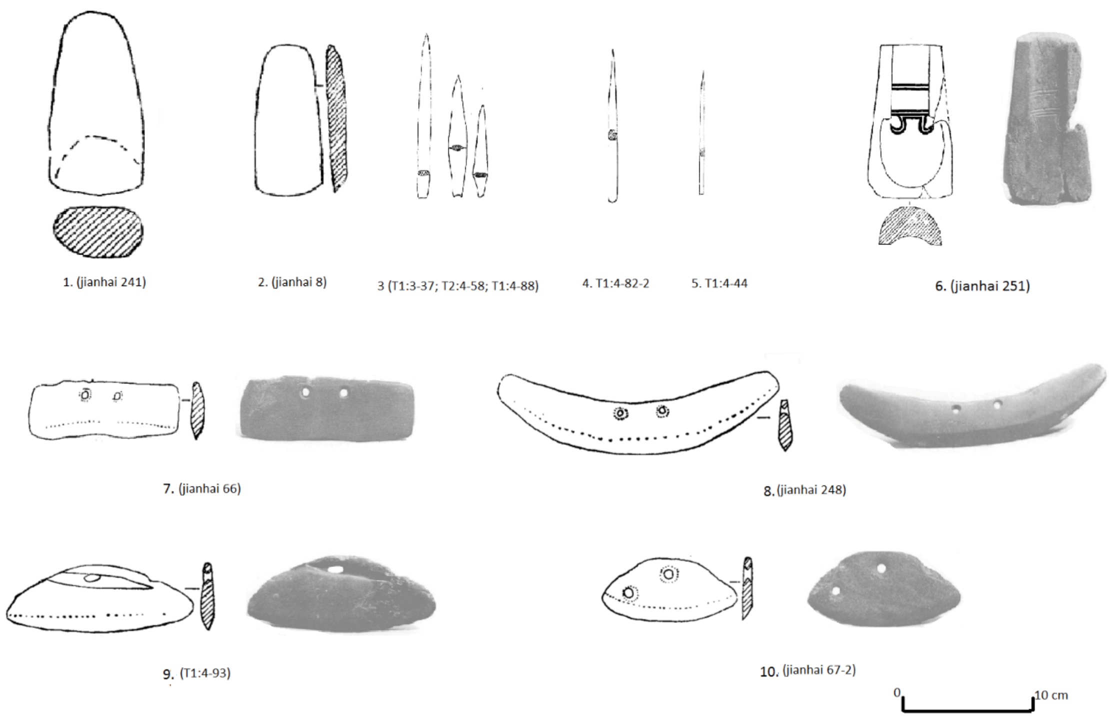


Fig. 6-5: Examples of stone tools, and a stone casting mould, recovered during the first and second season of excavation at Haimenkou: 1. axe; 2. adze; 3. arrowheads; 4. awl; 5. needle; 6. stone moulds; 7-10. knifes. Redrawn from Xiao, 1995.

During the last excavation campaign, further stone tools were recovered including adzes, axes, chisels, knifes, awls, arrowheads, and some grinding tools, as well as another stone casting mould (see table 6-1, fig. 6-6). All lithics are described as polished. The total number of stone tools increased considerably during the second period of occupation, and this is connected with an increased number of wooden posts for pile-dwelling, suggesting that increased human activities took place during that time, possibly following an enlargement of the population (Wang 2018).

Table 6-1. List of stone tools and objects recovered at Haimenkou during the last excavation season (2008-09), divided by period of occupation. After Yunnan et al., 2009.

Tool type	Period 1	Period 2	Period 3
Adze	(36)	166	47
Arrowhead	16	76	43
Awl	58	193	72
Axe	11	79	36
Casting mould			1
Chisel	5	22	8
Grinding tools		14	
Knife	16	69	49
Total	**142**	**619**	**256**

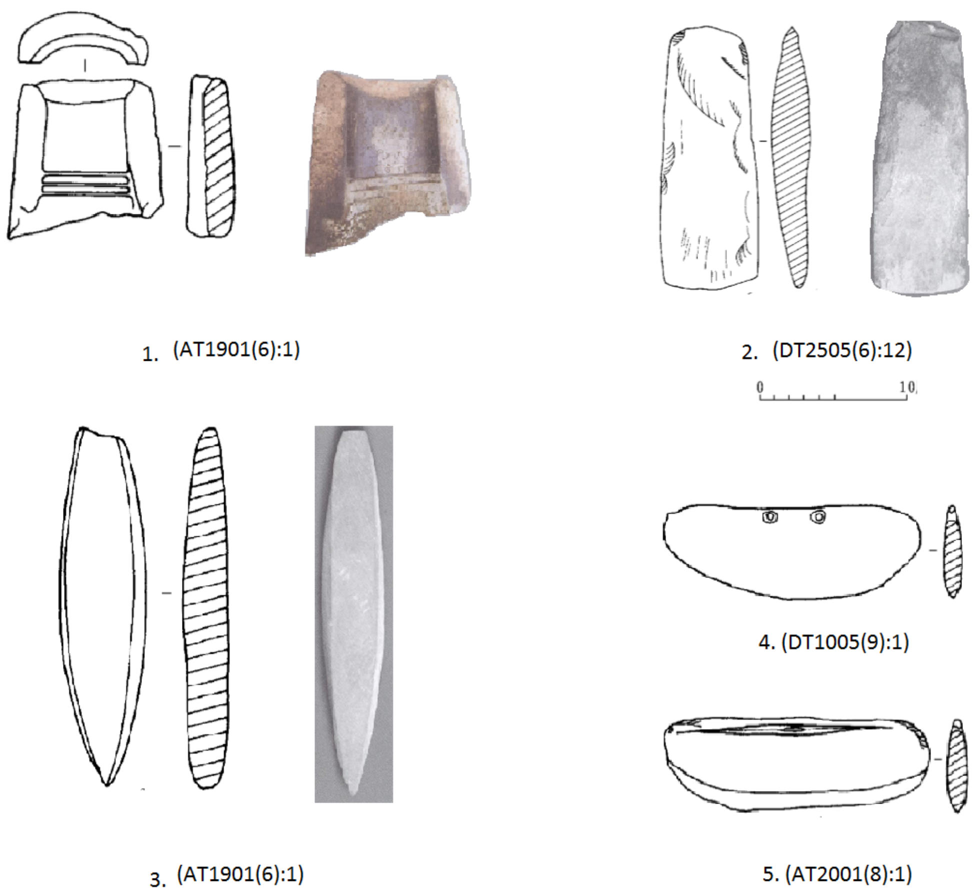


Fig. 6-6: Stone tools recovered from the third excavation campaign at Haimenkou: 1. stone casting mould; 2. axe; 3. chisel; 4-5. knifes. Redrawn from Yunnan et al., 2009.

6.2.3. Metal objects

A total of 14 bronze objects were recovered from the first season of excavation; and 12 more from the second season of excavation (Xiao, 1995). These include: 1 axe (fig. 6-

7:1); 3 hatchets (i.e. fig. 6-7:2, 6-7:3); 1 adze (fig. 6-7:4); 1 sickle (fig. 6-7:6); 1 knife (fig. 6-7:5); 1 fishhook; 1 chisel; 6 awls; 6 bracelets; and 3 variously shaped accessories (Xiao, 1995). No stratigraphic indication was given for the bronze objects recovered during the earlier excavation seasons.

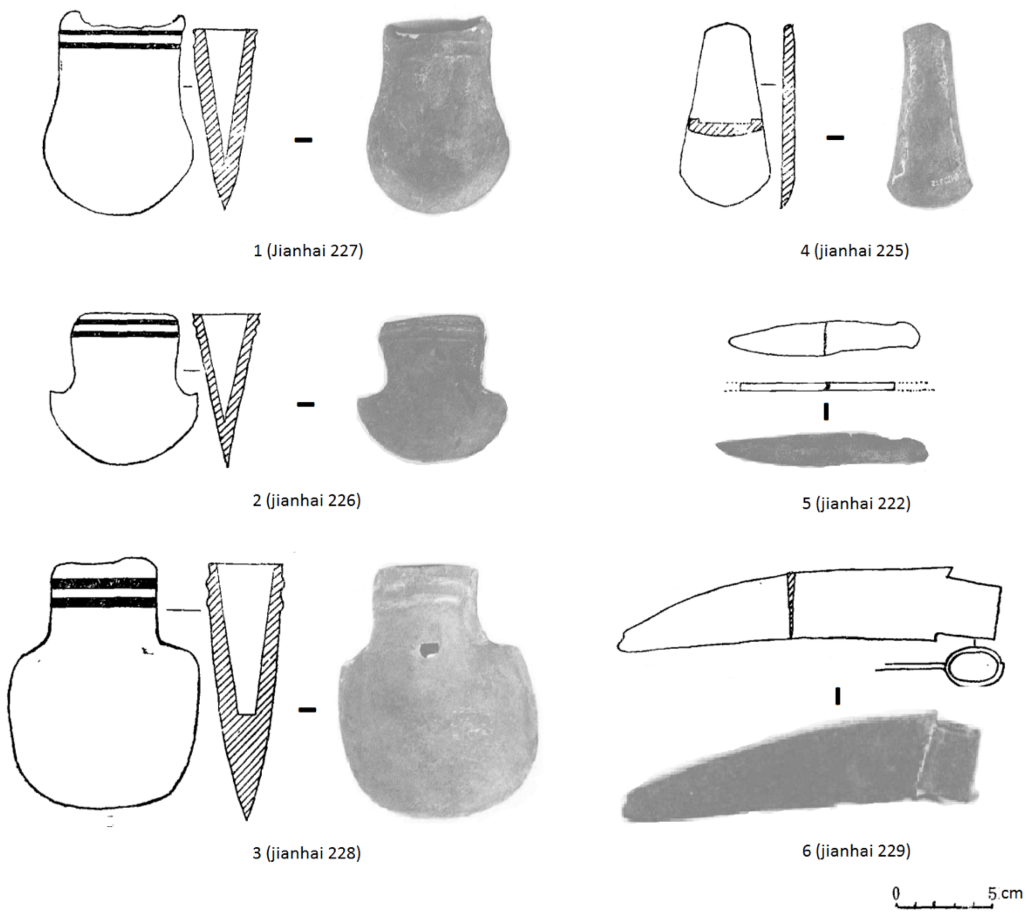


Fig. 6-7: Metal objects recovered during the first and second season of excavation at Haimenkou: 1. axe; 2-3. hatchet; 4. adze; 5. knife; 6. sickle. Redrawn from Xiao 1995.

During the last excavation season a few bronze objects were also recovered: 1 small knife (fig. 6-8:4), 1 chisel (fig. 6-8:2), 1 awl, and 1 bell (fig. 6-8:1) were recovered from layer 6 (Yunnan, et al., 2009). The bell is rather small in size, measuring only 3.8cm in length and 2.6cm in width. It presents two holes close to the hook at the top, and a larger elongated bilobe hole in the middle (fig. 6-8:1). The surface is otherwise undecorated. The bronze tools are also rather small, measuring only between 4.8-5.9cm in length.

From the upper layers (layers 5-4-3 corresponding to period 3), 2 arrowheads (i.e. fig. 6-8:5), 1 awl, 1 chisel, and 3 small bracelets (i.e. fig. 6-8:3) were recovered (Yunnan, et al., 2009).

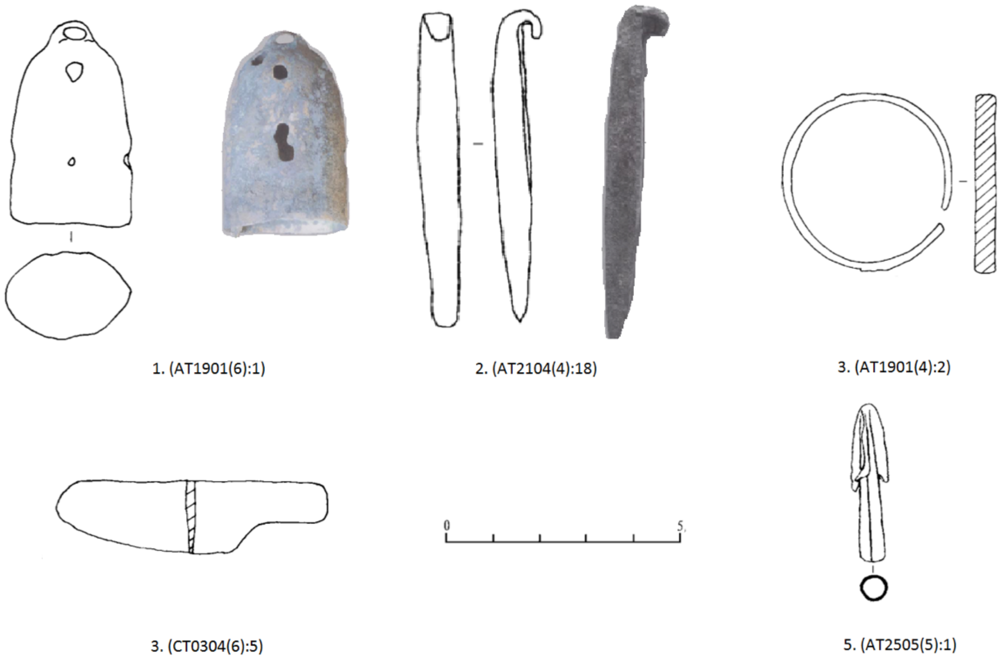


Fig. 6-8: Metal objects recovered during the last excavation season at Haimenkou: 1. bell; 2. chisel; 3. bracelet; 4. knife; 5. arrowhead. Redrawn from Yunnan et al., 2009.

Most of the metal objects recovered at Haimenkou were made of tin bronze, and only a few of lead bronze (see Lin & Min, 2014 for an in-depth discussion of the composition of metal objects from Haimenkou, and a discussion on early metal production in Yunnan). Stone casting moulds used for the production of bronze hatchets were recovered from both the second and third excavation campaigns, and authors suggested that bronzes at Haimenkou were locally produced (Lin & Min 2013).

6.2.4. Other implements

A variety of animal bone, horn, and wood tools and objects were recovered at Haimenkou. Bone tools include: 3 spears; 2 chisels; 1 spade; 1 awl; and 14 needles recovered during the first two excavation campaigns (Xiao, 1995).

Further 40 bone chisels; 24 bone hairpins; 2 bone arrowheads;1 bone spade; 23 bone awls were recovered during the last excavation season (Yunnan, et al., 2009). Some bone bracelets, and 1 bone and 14 horn ornaments were also recovered, mostly belonging to the later phases of occupation of the site (Yunnan, et al., 2009). No information has been provided regarding wooden tools.

6.3. Faunal remains

Systematic zooarchaeological analyses on animal bones collected during the third excavation campaign of the site were carried out by Dr. Juan Wang as part of her PhD research (Wang, 2018). Animal bones at Haimenkou were collected by hand during excavation, without following any systematic sampling strategy. Due to storage conditions, the preservation of the animal bones at Haimenkou was also rather deteriorated (Wang, 2018).

Identified animal taxa recovered at Haimenkou are listed in table 6-2 (after Wang, 2018). Some unidentified large, medium and small sized cervids (deers), some small felids, and a few bones of birds were also recovered (Wang, 2018).

Pig remains are the most prevalent not only among the domestic taxa, but also in the general zooarchaeological assemblage, accounting for more than half of it in NISP (number of identifiable specimens), and about 30% in MNI (minimum number of individuals; Wang, 2018). Pigs are the most prevalent taxon throughout all of the three phases of occupation of Haimenkou, showing a substantial increase during the second and third period of occupation (Wang, 2018). The domesticated status of pigs was ascertained through comparison of body size with wild boars, as well as through the analysis of killing patterns, which showed that pigs were systematically killed at an early (juvenile) age, indicating they were raised as livestock (Wang, 2018). The other two domestic taxa recovered at Haimenkou, sheep/goat, and dog, are not very prevalent. Although minor in the overall assemblage, sheep/goat remains increased considerably during the second and third period of occupation, and this has been seen as an additional indication of increased contacts with populations, or even population migrations, from Northwest China (Wang, 2018). This seems to be confirmed by the increased presence of western domesticates of wheat and barley in the archaeobotanical assemblage as outlined below, and fits with the influences noted in red painted pottery.

Table 6-2. List of identified animal taxa at Haimenkou (Wang, 2018).

Category	Taxon (latin name)	Common name
Domestic animals	*Sus domesticus*	pig
	Ovis/Capra sp.	sheep/goat
	Canis familiaris	dog
Wild animals	*Bos gaurus*	gaur
	Cervus unicolor	sambar
	Axis porcinus	hog deer
	Muntiacus muntjak	red muntjac
	Muntiacus reevesi	reeve's muntijac
	Moschus berezovskii	forest musk deer
	Sus scrofa	wild board
	Macaca sp.	macaque
	Ursus sp.	bear
	Vulpes vulpes	red fox
	Prionaiulurus bengalensis	leopard cat
	Paguma larvata	masked palm civet
	Lepus sp.	hare
	Hystrix brachyuran	porcupine
	Rattus sp.	rat
	Unio douglasiae	mussel

Among the wild mammals, gaur is the most prevalent taxon, accounting for 21.6% in NISP, and 7.1% in MNI. This species is found today only in the south of Yunnan, and adjacent regions of northeast India and Southeast Asia. Its recovery from Haimenkou suggests that it was once spread throughout the whole province. Gaur is the wild ancestor of the gayal (*Bos frontalis*), a bovid species currently sporadically found in parts of Myanmar, Northeast India and some parts of southwest China (Simmons & Simmons, 1968; Schaller, 1967; Larson & Fuller, 2014; Fuller & Murphy, 2018: fig. 8). Wang hypothesised that gaur at Haimenkou might be under domestication, although morphological indicators of domestication are unknown. If so, this would imply that gayal herding was taking place further north in the past than is indicated in any historical records and raises possibilities that it spread from the South or had later been pushed southwards from this region. Previously it has been supposed that this species might have been domesticated as late as 2000 years ago (Larson & Fuller, 2014). It is notable that no true cattle (*Bos taurus*) has been identified, although this species had been adopted in Central China from the end of the Longshan period, c. 2000 BC (Huang, 2010; Yuan, 2010; Fuller, et al., 2011).

Different size cervids were also recovered at Haimenkou, with large cervids having prevalence, and this is an indication of continued hunting activities (Wang, 2018). Finally, among the small-sized wild taxa, hare remains are quite abundant.

All other remains are present in low quantities and especially aquatic taxa are not very present, but this might be due to insufficient collection methods (Wang, 2018).

Generally speaking, all animal remains, but especially domestic animals, gaur, and cervids are found in increased quantity in periods 2 and 3. Although present in smaller quantities, few small game taxa are also constantly present, and this seems to suggest that a broad spectrum subsistence was carried out at the site, with the people inhabiting Haimenkou raising livestock, but also hunting, and possibly fishing (Wang, 2018).

6.4. Site chronology

Numerous radiocarbon dates are available from the several excavation campaigns carried out at the site. In 1972 the first set of dates for Haimenkou were obtained from wood charcoal samples, furnishing a date of 3115±90 BP/ 1150±90 BC (Zhongguo, 1972). In 1990, new wood charcoal samples provided the dates of 2595±75 BP/ 645±75 BC and 2520±75 BP / 570±75 BC (Zhongguo, 1990). Finally, following the 2008 excavation campaign, more precise AMS dates on short-lived plant material recovered from the archaeobotanical samples were obtained (Xue, 2010; Jin, 2013; Lin & Min, 2014; see table 6-3 below for a summary of all the available dates for Haimenkou). These new dates allowed for a much more refined chronology of the site, and three main periods of occupation have since been identified:

- Phase I, 1600- 1400 cal BC: layers 10-9-8 (see fig. 6-9);
- Phase II, 1400-1100 cal BC: layer 7-6 (see fig. 6-10);
- Phase III, 800-400 cal BC: layers 5-4-3 (see fig. 6-11).

Table 6-3. Radiocarbon dates from Haimenkou (from Jin, 2013; Li&Min, 2013; Min, 2013; Yunnan, 1959; see Appendix 5 for details).

Context	Material	Lab Code	date BP	68.20%	95.40%
1958 exc.					
n/a	Wood charcoal	n/a	3115±90		1150±90 BC
1990 exc.					
n/a	Wood charcoal	n/a	2595±75		645±75 BC
Trench 2, Layer 4	Wood charcoal	ZK2335	2520±75	800-540 BC	810-420 BC
2008 exc.					
T1005-4-s1	Rice grain	n/a	2400±20	490- 400 cal BC	540-400 cal BC
T1003-4-s2	Wheat grain	n/a	2405±35	520-400 cal BC	750-390 cal BC
2008JHAT2121-5	Plant rhizome	BA081095	2200±35	357-203 cal BC	371-179 cal BC
T1004-5-s6	Foxtail millet grain	n/a	2435±03	730-410 cal BC	760-400 cal BC
2008JHAT2002-5	Wheat grain	BA081096	2435±35	730-415 cal BC	752-406 cal BC
T1003-5-s2	Wheat grain	n/a	2445±35	740-410 cal BC	760-400 cal BC
2008JHDT1304-5	Seed	BA081094	3000±35	1288-1131 cal BC	1384-1120 cal BC
2008JHAT2003-6	Rice grain	BA081099	2930±35	1196-1057 cal BC	1226-1014 cal BC
T1005-6-s4	Rice grain	n/a	2960±25	1220-1120 cal BC	1270-1050 cal BC
T1003-6-s2	Wheat grain	n/a	2975±45	1262-1124 cal BC	1381-1047 cal BC
T1003-6-s1	Wheat grain	n/a	3000±35	1290-1130 cal BC	1390-1120 cal BC
2008JHDT1005-5	Charred plant	BA081097	3020±35	1374-1214 cal BC	1395-1129 cal BC
T1004-6-s3	Soybean (wild)	n/a	3045±40	1390-1230 cal BC	1400-1220 cal BC
T1004-6-s3	Foxtail millet grain	n/a	3050±30	1390-1260 cal BC	1410-11220 cal BC

Table 6-3. Radiocarbon dates from Haimenkou (from Jin, 2013; Li&Min, 2013; Min, 2013; Yunnan, 1959; see Appendix 5 for details).

Context	Material	Lab Code	date BP	68.20%	95.40%
2008JHDT1304-6	Plant fibre	BA081098	3075±35	1397-1292 cal BC	1423-1233 cal BC
T1003-6-S2	Chenopodium grain	n/a	3080±25	1399-1301 cal BC	1415-1274 cal BC
T1003-6-s2	Wheat grain	n/a	2975±45	1270-1120 cal BC	1390-1040 cal BC
2008JHAT2003-7	Foxtail millet grain	BA081100	2940±35	1214-1088 cal BC	1258-1027 cal BC
T1003-7-s2	Rice grain	n/a	3240±40	1610-1450 cal BC	1620-1430 cal BC
T1004-7-s6	Rice grain	n/a	3075±35	1400-1290 cal BC	1430-1230 cal BC
T1005-7-s2	Wheat grain	n/a	3095±30	1420-1300 cal BC	1430-1270 cal BC
T1005-7-s1	Wheat grain	n/a	3125±30	1440-1310 cal BC	1500-1290 cal BC
T1005-7-s1	Chenopodium grain	n/a	3170±25	1494-1419 cal BC	1500-1410 cal BC
T1004-7-s3	Foxtail millet grain	n/a	3210±30	1510-1440 cal BC	1600-1410 cal BC
T1003-7-s2	Wheat grain	n/a	3060±35	1400-1270 cal BC	1420-1220 cal BC
2008JHAT2505-7	Foxtail millet grain	BA081101	3550±40	1949-1780 cal BC	2016-1756 cal BC
T1005-8-s2	Rice grain	n/a	3250±35	1610-1460 cal BC	1620-1440 cal BC
T1005-8-s2	Wheat grain	n/a	3105±25	1420-1300 cal BC	1440-1290 cal BC
2008JHDT1205-8	Plant rhizome	BA081102	3205±35	1502-1440 cal BC	1601-1411 cal BC
T1003-8-s2	Foxtail millet grain	n/a	3275±35	1610-1460 cal BC	1620-1450 cal BC
T1003-8-s2	Chenopodium grain	n/a	3065±25	1389-1285 cal BC	1410-1261 cal BC
2008JHDT1205-8	Wood charcoal	BA081103	3605±40	2023-1916 cal BC	2130-1830 cal BC
T1003-9-s2	Rice grain	n/a	3275±35	1610-1500 cal BC	1640-1450 cal BC
T1003-9-s2	Foxtail millet grain	n/a	3230±40	1600-1440 cal BC	1620-1420 cal BC
2008JHDT1005-9	Wood charcoal	BA081104	3345±35	1688-1565 cal BC	1737-1530 cal BC
2008JHDT1004-9	Wood charcoal	BA081105	4210±35	2891-2706 cal BC	2901-2677 cal BC

Table 6-3. Radiocarbon dates from Haimenkou (from Jin, 2013; Li&Min, 2013; Min, 2013; Yunnan, 1959; see Appendix 5 for details).

Context	Material	Lab Code	date BP	68.20%	95.40%
T1003-10-s1	Rice grain	n/a	3380±25	1730-1630 cal BC	1750-1620 cal BC
2008JHDT1003-10	Plant rhizome	BA081106	4485±35	3331-3099 cal BC	3346-3031 cal BC

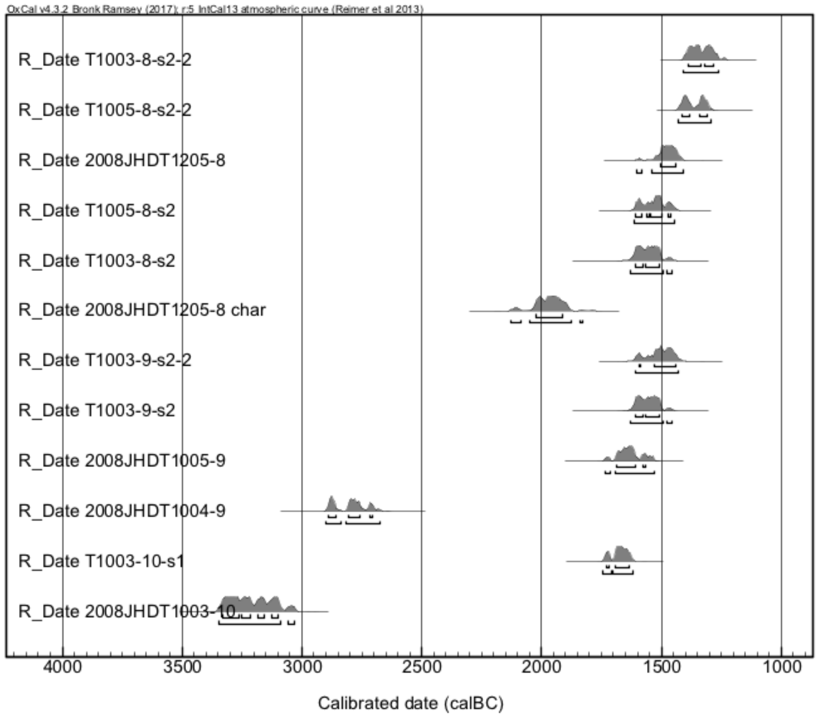


Fig. 6-9 Bayesian model of calibrated dates for the first period of occupation at the site of Haimenkou, corresponding to layers 10-9-8. Dates from Jin, 2013; Li&Min, 2013; Min, 2013; Yunnan, 1959 (see Appendix 6). Made with OxCal v. 4.3.2 (Bronk Ramsey, 1995; Bronk Ramsey, 2001).

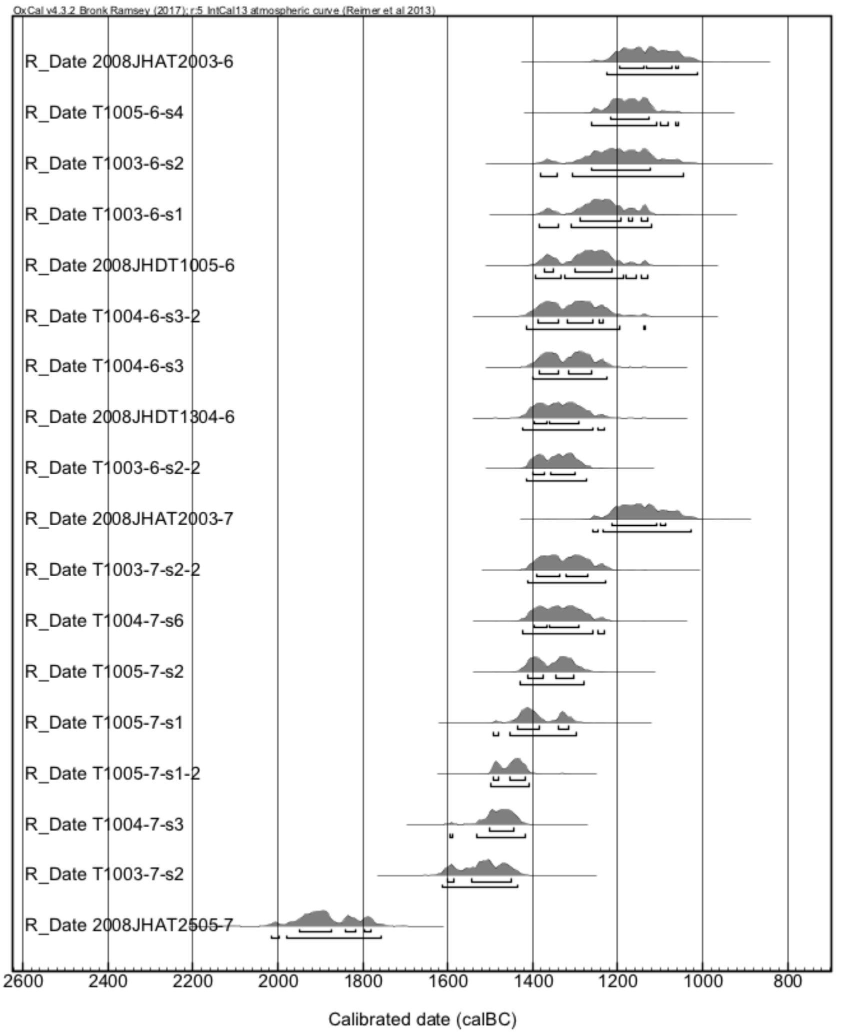


Fig. 6-10 Bayesian model of the radiocarbon calibrated dates for the second period of occupation at the site of Haimenkou, corresponding to layers 6-7. From Jin, 2013; Li&Min, 2013; Min, 2013; Yunnan, 1959 (see Appendix 6). Made with OxCal v. 4.3.2 (Bronk Ramsey, 1995; Bronk Ramsey, 2001).

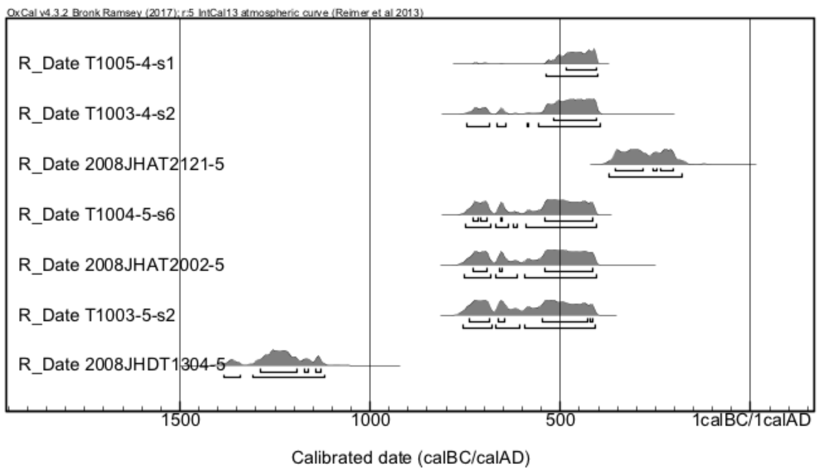


Fig. 6-11. Bayesian model of the radiocarbon calibrated dates for the last period of occupation at the site of Haimenkou, corresponding to layers 5-4-3. From Jin, 2013; Li&Min, 2013; Min, 2013; Yunnan, 1959 (see Appendix 6). Made with OxCal v. 4.3.2 (Bronk Ramsey, 1995; Bronk Ramsey, 2001).

6.5. Archaeobotanical remains

For the purpose of this dissertation, 10 previously unstudied samples, including from previously unstudied trenches (JHDT1803, JHDT1204, JHDT1304, JHDT1907, JHAT2004, JHAT2003, see table 6-5), were sorted at the UCL Institute of Archaeology-Archaeobotany Laboratory (see Chapter 4 for a description of the precise methodology).

Previous archaeobotanical analyses had been undertaken by Yining Xue, as part of her master thesis at Peking University (Xue, 2010), and by Dr. Hetian Jin, as part of her PhD dissertation at Peking University (Jin, 2013).

Differing from the samples studied by Xue and Jin for their dissertations, which also contained waterlogged remains, the 10 samples sorted by the author at UCL only contained charred remains. The purpose of sorting further samples from the site of Haimenkou for this dissertation was to perform some more detailed analyses, such as SEM imaging and systematic morphometrics on crops (rice, millets, soybean, wheat, and *Chenopodium*), that had not been previously undertaken. This was especially necessary for the study of *Chenopodium* and soybean remains, as well as possible buckwheat remains, in order explore their local use, and their possible domestication trajectories in Southwest China.

Below first a brief analysis of the samples sorted at UCL will be presented, followed by their comparison with the datasets from Xue (2010), and Jin (2013), so as to build a comprehensive overview of Haimenkou archaeobotanical assemblage. Due to the fact that all archaeobotanical samples analysed came from cultural deposits (layers), no contextual analysis has been carried out.

6.5.1. Sample size and sample diversity

The archaeobotanical samples from Haimenkou analysed at UCL were extremely rich in charred remains. A total number of 24,601 identifiable items from 17 families were recovered (tables 6-3, 6-4). The density of items per litres floated at the site shows clearly the very high level of preservation present (see table 6-3).

Table 6-3. Breakdown of samples analysed at UCL by period, including indication of total number of identified (ID) remains and their density index.

Period of occupation	No. of samples analysed	Total ID remains	Density (mean)
Period 1	1	8,235	2020
Period 2	6	6,256	208.53
Period 3	3	10,110	674
TOTAL	10	24,601	492.02

The archaeobotanical remains recovered were classified into the following categories (category criteria are outlined in Chapter 4):

- Crops (including rice, *Setaria italica, Panicum miliaceum,* indeterminate millets, wheat, barley, buckwheat);
- *Chenopodium* might also have been exploited as food resources, as attested by the high number of remains and its co-occurrence in cereal rich contexts;
- other economic species (including pulses, nuts, fruits, and other economically important species such as *Cannabis* sp.);
- seeds of field weed species.

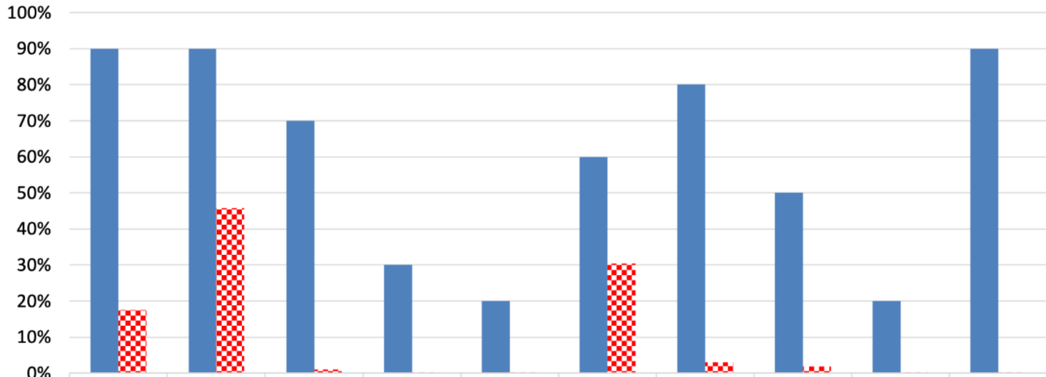
Table 6-4. Table showing main families and species recovered from the Haimenkou samples analysed at UCL.

Main species and families	No. of samples (n=10)	Ubiquity index	Absolute counts (n=26,466)	Frequency index
Asteraceae	1	10%	4	0.02%
Bombaceae	2	20%	23	0.09%
Butomaceae	3	30%	5	0.02%
Cannabaceae: *Cannabis* sp.	3	30%	453	1.84%
Chenopodiaceae: *Chenopodium* sp.	6	60%	7,473	30.38%
Cucurbitaceae: *Cucumis* cf *melo*	2	20%	2	0.01%
Cyperaceae	4	40%	21	0.09%
Fabaceae: *Glycine* cf *max*	2	20%	3	0.01%
Fabaceae	1	10%	1	0.004%
Hydrocharitaceae	2	20%	3	0.01%
Juglandaceae: acorns	3	30%	5	0.02%
Juncaceae	1	10%	1	0.004%
Lamiaceae	3	30%	591	2.40%
Nymphaeaceae: *Euryale ferox*	1	10%	1	0.004%
Poaceae: *Hordeum vulgare*	3	30%	3	0.01%
Poaceae: *Oryza sativa*	9	90%	4296	17.46%
Poaceae: *Panicum miliaceum*	4	40%	95	0.39%
Poaceae: *Setaria italica*	9	90%	11,113	45.17%
Poaceae: *Triticum aestivum*	7	70%	253	1.03%
Poaceae- various	4	40%	196	0.80%
Polygonaceae- *Fagopyrum* cf *esculentum*	2	20%	3	0.01%
Polygonaceae	3	30%	9	0.04%
Rosaceae	3	30%	16	0.07%
Verbenaceae	2	20%	2	0.01%
Indet.	9	90%	29	0.12%
TOT	**n/a**	**n/a**	**24,601**	**100%**

6.5.2. Ubiquity and frequency

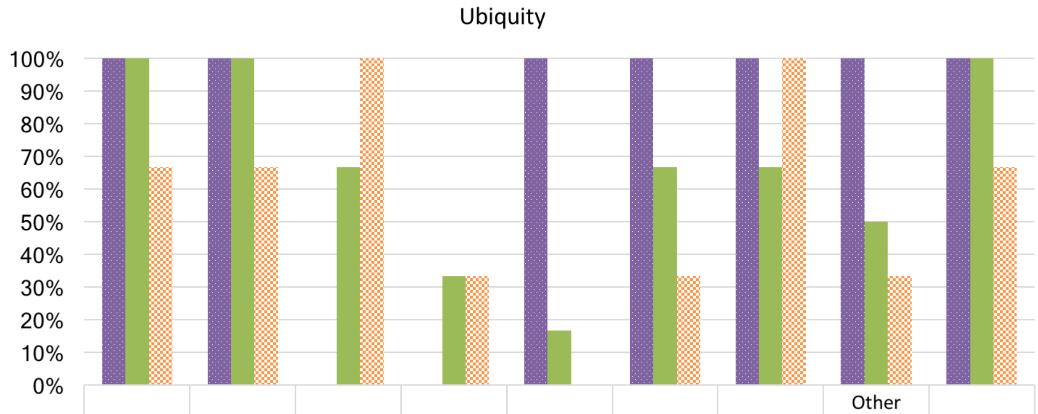
Overall, taxa are spread quite evenly across the samples analysed, with the exception of barley and buckwheat, which are found in only a couple of samples (fig. 6-12).

Crops are the most prevalent taxa, accounting for more than 90% of the total identified remains (fig. 6-12). *Setaria italica* takes up the majority of the remains recovered, accounting for 45.69% of the total identified remains, followed by *Chenopodium* (30.38%), and rice (17.46%; see fig. 6-12).

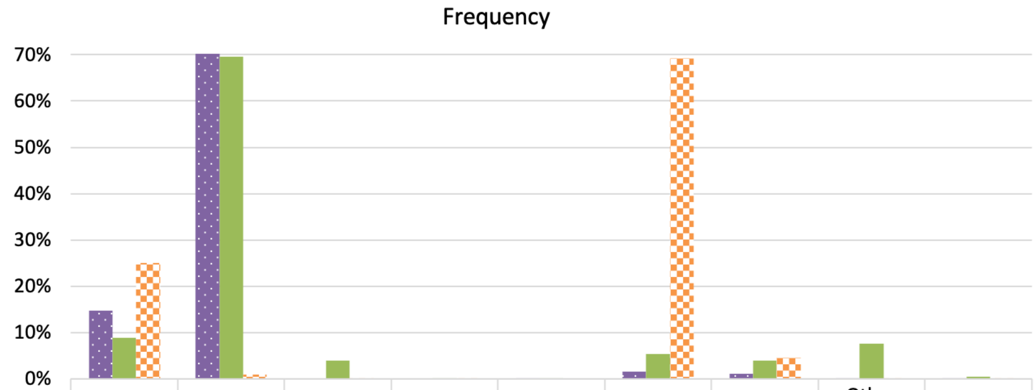


	Rice	Millets	Wheat	Barley	Buckwheat	Chenop.	Weeds	Other economic species	Tree species	Indets
ubiquity	90%	90%	70%	30%	20%	60%	80%	50%	20%	90%
frequency	17.46%	45.69%	1.03%	0.01%	0.01%	30.38%	3.03%	1.81%	0.09%	0.12%

Fig. 6-12: Ubiquity and frequency index for the Haimenkou samples analysed at UCL.



	Rice	Millets	Wheat	Barley	Buckwheat	Chenop.	Weeds	Other Economic species	Indet
period 1	100.00%	100.00%	0.00%	0.00%	100.00%	100.00%	100.00%	100.00%	100.00%
period 2	100.00%	100.00%	66.67%	33.33%	16.67%	66.67%	66.67%	50.00%	100.00%
period 3	66.67%	66.67%	100.00%	33.33%	0.00%	33.33%	100.00%	33.33%	66.67%



	Rice	Millets	Wheat	Barley	Buckwheat	Chenop.	Weeds	Other Economic species	Indet
period 1	14.67%	82.50%	0.00%	0.00%	0.01%	1.64%	1.14%	0.01%	0.02%
period 2	8.81%	69.55%	3.93%	0.03%	0.03%	5.40%	3.87%	7.61%	0.40%
period 3	25.09%	0.94%	0.07%	0.01%	0.00%	69.24%	4.60%	0.03%	0.02%

Fig. 6-13: Ubiquity (top); and frequency (bottom) index for the samples analysed at UCL, divided by period of occupation. Period 1 was represented by one sample only.

Chronologically, differences are present between the three periods of occupation. However, only one sample belonging to the first period of occupation was analysed, therefore, these results are not statistically significant. During the second period, rice and millets are found in all of the samples analysed, with wheat and other remains found only in half or less than half of the samples analysed (fig. 6-13 top). This pattern is inverted in period 3, with wheat and weeds found in all of the samples analysed, and the other categories declining in ubiquity (fig. 6-13 top).

Looking at the compositional changes of the assemblage, most of the remains recovered from the first period are constituted by millets (82.50%) and rice (14.67%, see fig. 6-13 bottom). During the second period of occupation, millets account for almost 70% of the total identified remains, followed by rice (8.81%), and *Chenopodium* (5.40%). In samples from this period wheat remains have also been recovered, as well as most of the "other economic species", including *Cannabis*, and soybean. This pattern, however, shifts abruptly during the last period of occupation, when *Chenopodium* takes up the majority of the remains (69.24%), followed by rice (25.09%), which together with weeds, show an increase from the previous period of occupation (fig. 6-13 bottom). Particularly noteworthy is the almost total disappearance of millets, wheat, and other economic species during the last period of occupation from the samples analysed.

However, the very small number of samples, as well as the unevenness of the total number of samples analysed (1 for period 1; 6 for period 2; and only 3 for period 3) might be biasing the data and these results such that differences, especially of period 1, are not statistically meaningful.

6.5.3. Cereal Crops

6.5.3.1. Rice

Rice remains found at Haimenkou include grains, some of which were preserved in whole spikes, and some were immature; a few detached embryos, spikelet bases, and culm nodes. Rice husk fragments were also found in 1 sample (table 6-5). Rice remains were found in 9 out of 10 samples analysed, and they constitute about 17% of the total identified remains. Chronologically, rice remains first decreased during period 2 to about 8% of the total identified remains, and then increases during the later period of occupation to about 25% of the total remains identified. No morphologically wild spikelet bases or grains were recovered from the samples analysed at UCL, suggesting that rice was present at the site as already fully domesticated. Rice remains were also found in "lumps" from context JHDT 1304(5), as shown in fig. 6-14.

Table 6-5. Breakdown of rice remains with indication of numbers of samples in which they were found from the Haimenkou samples analysed at UCL.

Remain type	Total	Ubiquity (no. of samples)
Rice caryopsis (whole with embryo)	3930	6
Caryopsis fragment[10]	140	4
Detached embryo	8	3
Immature caryopsis (whole with embryo)	21	2
Immature caryopsis fragment	33	1
Spikelet base- domesticated	87	3
Spikelet base- indeterminate	17	3
Husk fragments	25	1
TOTAL	**4296**	**9**

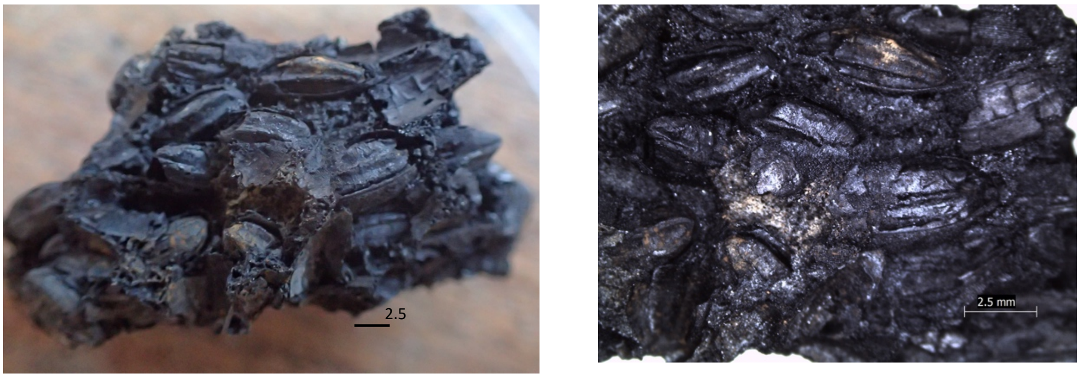


Fig. 6-14: Lumps of rice from context JHDT 1304(5). Photos by author.

Morphometrics

95 rice grains were measured; rice average width was 2.09mm, with a standard deviation of 0.30mm. Average L/W ratio was 1.7mm, with a standard deviation of 0.19mm (fig. 6-15). Apart from 1 grain, the rest of the rice grains measured at Haimenkou have a L/W <2.2mm, therefore, they have been classified as *Oryza sativa* subsp. *japonica* (Harvey, 2006; Castillo et al., 2015).

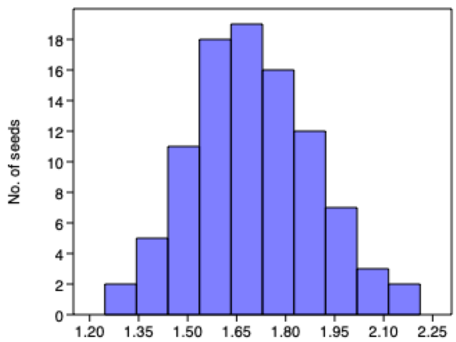


Fig. 6-15: Histogram plot of Haimenkou rice L/W measurements. Made with Past.

[10] Rice fragments count is approximated to whole grain equivalent through ml weighting approximation, 1ml= 50 grains (see Chapter 4).

6.5.3.2. Millets

Millet remains found at Haimenkou include both foxtail millet (*Setaria italica*) and broomcorn millet (*Panicum miliaceum*, see tables 6-6; 6-7). Additionally, 32 grains were too badly preserved to be able to identify them to the genus level, and have thus been classified as "indet. millet" (fig. 6-16).

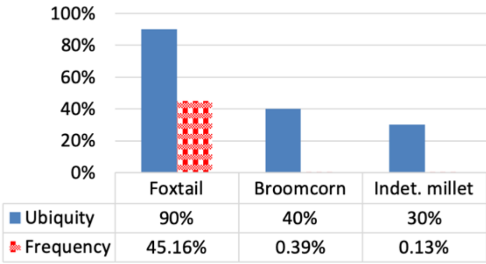


Fig. 6-16: Ubiquity and frequency of millet remains at Haimenkou.

Foxtail millet

Setaria italica is the primary millet species found at the site of Haimenkou, as well as the main crop recovered. It constitutes about 45% of the total identified remains, and is found in 9 out of 10 samples analysed. *Setaria italica* grains were often found lumped together, sometimes still attached to the panicle ear (fig. 6-16). In this instance, millet remains were weighted against their single grain equivalent. A very high percentage of single grains also showed the husk still attached to the grain, possibly indicating that the grains were stored as whole ears, previous to any crop processing activities. However, given the fact that the samples analysed come from cultural layer deposits, and considering the high preservation conditions at the site, those kind of remains might also be an indication of remains both prior to or shortly after harvesting, which had not been stored yet. We do not have any information regarding the location of the samples in relation to the features on the overall site, so it is difficult to interpret further.

Table 6-6. Breakdown of foxtail millet remains found in the Haimenkou samples analysed at UCL.

Remain type	Total	Ubiquity (no. of samples)
Caryopsis- *Setaria italica*	10,608	9
Immature caryopsis- *Setaria italica*	148	3
Cf *Setaria*	357	4
TOTAL	11,113	n/a

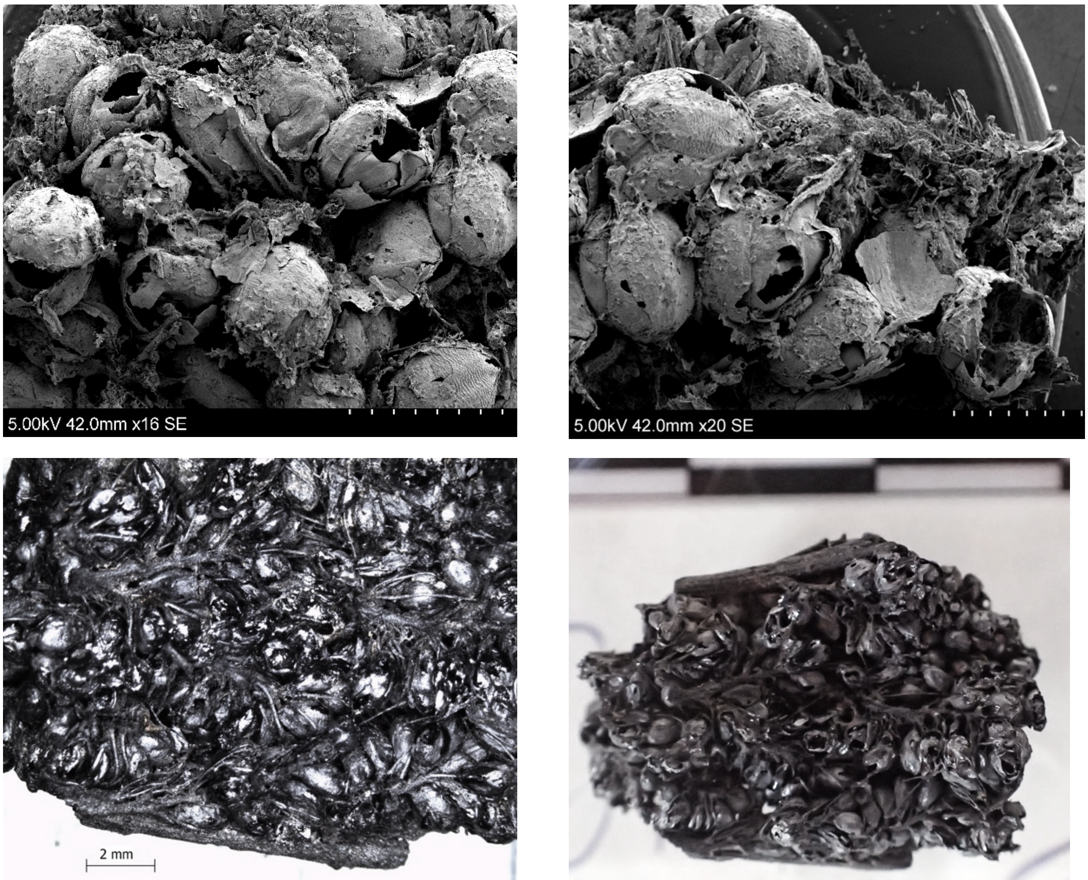


Fig. 6-17: top left and right: SEM pictures of *Setaria italica* remains from sample HDT 1003(8), showing clearly grains still attached to the panicle ear. Bottom left: low power binocular microscope photo of *Setaria italica* remains from sample JHDT2004(6). Photos by author.

Morphometrics

48 grains of *Setaria italica* from Haimenkou were measured. They were on average 1.29mm long, 1.34mm wide; and 1.15mm thick. Average L/W ratio was 0.96mm, with a standard deviation of 0.11mm (fig. 6-18).

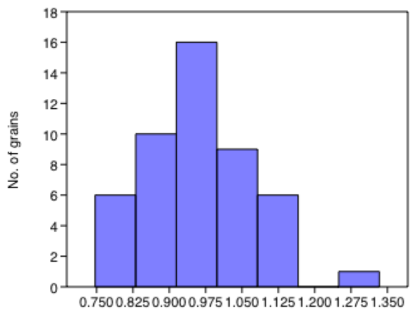


Fig. 6-18: Histogram plot of *Setaria italica* L/W measurements from Haimenkou. Made with Past.

Broomcorn millet

Only 95 grains of broomcorn millet were found in the Haimenkou samples. These are spread across the first and second period of occupation, with no grains of broomcorn millet recovered from samples from the third period of occupation.

Table 6-7. Breakdown of the broomcorn millet remains found in the Haimenkou samples analysed at UCL.

Remain type	Total	Ubiquity (no. of samples)
Panicum miliaceum caryopsis	95	4
TOTAL	95	4

Morphometrics

The broomcorn millet grains from Haimenkou were not very well preserved. Only two grains could be measured, and they were on average 1.66mm long; 1.98mm wide, and 1.40mm thick. Average L/W was 0.09mm (see Appendix 4).

6.5.3.3. Western domesticates

Wheat and barley grains, as well as some wheat rachises, were recovered from 7 out of the 10 samples analysed at UCL (see table 6-8). Together they constitute only 1.04% of the total identified remains, and during the last period of occupation their abundance decreases to less than 1% (fig. 6-12; 6-13).

Table 6-8 Breakdown of wheat and barley remains found in the Haimenkou samples analysed at UCL.

Remain type	Total	Ubiquity (no. of samples)
Triticum cf. *aestivum* grains	245	6
Hordeum vulgare	3	3
Rachis- *Triticum aestivum*	8	4
TOTAL	256	7

Morphometrics

37 grains of wheat were measured. They were on average 3.38mm wide, with a stdev of 0.38mm. L/W ratio was 1.48mm, with a stdev of 0.19mm (fig. 6-19).

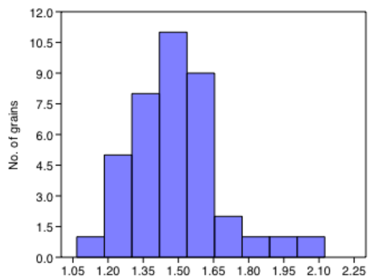
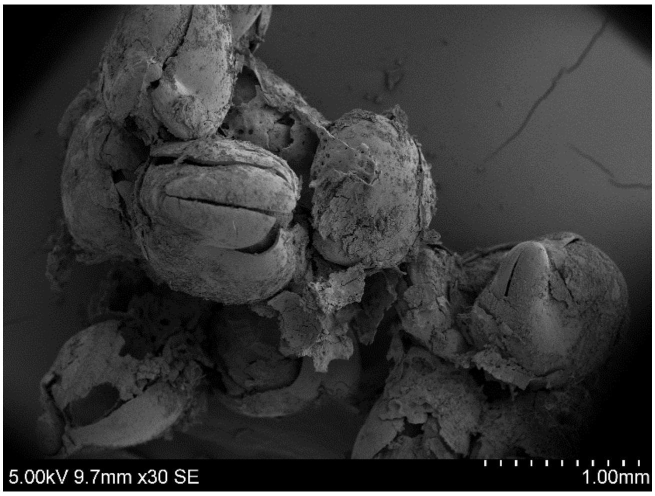


Fig. 6-19: Histogram plot of wheat L/W measurements from Haimenkou. Made with Past.

6.5.4. Chenopodium

An extremely high number of *Chenopodium* grains was recovered from the 10 samples analysed at UCL: 7,473 grains, constituting 30.38% of the total identified remains, that were found in 6 samples (fig. 6-12), often in the same context where high quantity of rice or millets remains have been recovered, such as sample JHDT1304(5) (see fig. 6-14). Chronologically, *Chenopodium* remains double during the later phase of occupation, and finally increase substantially during the last phase of occupation, reaching almost 70% of the total identified remains for that phase (fig. 6-13). All *Chenopodium* remains were found charred, and sometimes lumped together; however, SEM analysis of these lumps revealed that, different from the millets, *Chenopodium* clustered as result of charring, rather than becoming charred while still attached on the plant (fig. 6-20).



Chenopodium remains are often reported from many archaeological sites throughout China (e.g. Fuller & Zhang, 2007; Lee, et al., 2007; Zhao, 2007). However, these are very rarely identified to the species level. The very high quantity in relation to the overall assemblage, as well as the specific context provenance of Chenopodium remains suggest that at Haimenkou this species was actively exploited. Cultivated forms of *Chenopodium album* (also known as fat hen) are present in parts of modern day China, and are grown both for leafy vegetables and for seeds (see Chapter 2). These are sometimes segregated as *C. giganteum,* although this is part of the species complex of *C. album.* Whether *Chenopodium* at Haimenkou was used as food, or instead as animal fodder, is an issue that requires further studies.

Morphometrics

Chenopodium seeds at Haimenkou show heterospermy, a pronounced nose, and truncate margin. Exploratory measurements were taken from 113 individual grains of Chenopodium, following morphometric standards set out in Smith (2007); and Bruno

(2006). Two sets of diameters were taken from each seed, perpendicularly. At Haimenkou, Chenopodium diameter measures on average between 1.32-1.18mm (stdev of 0.14-0.12mm). The first set of measurement refers to the diameter from end to nose, including the nose of the seed, which account for the slighter longer measurement. Finally, overall average of L/W measured 1.03mm, with a standard deviation of 0.15mm (fig. 6-21 left).

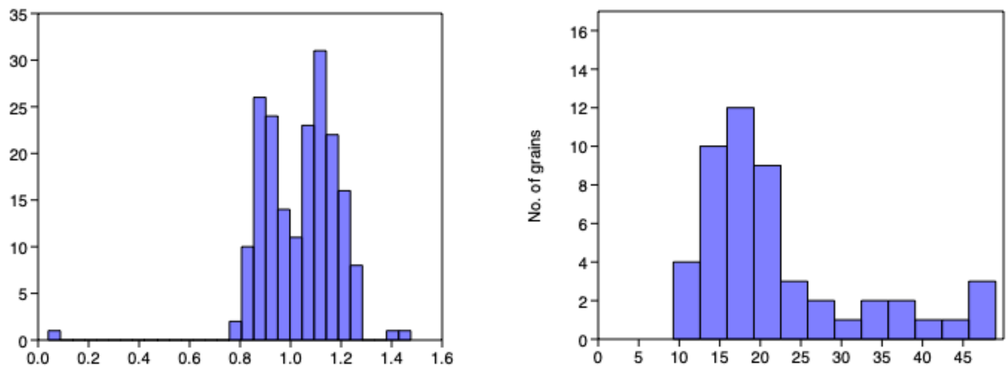


Fig. 6-21: Histogram plot of *Chenopodium* L/W measurements (left) on 113 grains, and seed coat thickness (right)on 49 grains from Haimenkou. Made with Past.

Moreover, 49 grains were further analysed in order to measure seed coat thickness, as this is believed to be an indicator of domestication status. Several measurements were taken along the seed coat of the same grain, in different parts of the grain, then averaged. Seed coat thickness varied greatly between 9.26um and 49.02um (fig. 6-21 right, for the complete list of measurement see Appendix 4). Chronologically, there seems to be a slight increase of grain size, and a thinning of the seed coat over time (table 6-9; 6-10). This could possibly indicate that *Chenopodium* at Haimenkou was undergoing a domestication process through intensive cultivation; however, the grain size and the seed coat thickness do not show a positive correlation, and further studies across other sites in China will be needed in the future to better explore this issue.

Table 6-9: Breakdown of *Chenopodium* measurement averaged per context of provenance and time period.

Chronology	Context	Grains measured	Lenght mm	Nose mm	Width mm	L/W mm	Seed thickness mm
Phase 1	JHDT 1003(8)	34	1.28	0.153	1.14	1.12	0.653
Phase 2	JHDT 1204(6)	30	1.30	0.16	1.17	1.11	0.8
	JHAT 2004(6)	19	1.34	0.15	1.15	1.16	0.647
Phase 3	JHDT 1304(5)	30	1.36	0.16	1.19	1.14	0.95

Table 6-10. Haimenkou Chenopodium seed coat thickness measurements.

Chronology	Context	Grains measured	Seed coat thickness um
Phase 1	JHDT 1003(8)	10	33.51 Stdev=14.27
Phase 2	JHDT 1204(6)	11	15.17 Stdev=3.7
	JHAT 2004(6)	6	22.08 Stdev= 6.48
Phase 3	JHDT 1304(5)	22	20.95 Stdev=7.16

6.5.5. Buckwheat

A total of 3 buckwheat grains from 3 samples were recovered from the samples analysed at UCL. Buckwheat remains were only found in samples from period 2, and although they constitute a very negligible amount in the total archaeobotanical assemblage, their recovery is important to investigate possible domestication trajectory of the species in the future. Two grains were measured; average length was 2.42mm (stdev 0.59mm); width 1.7mm (stdev 0.09mm); and thickness of 1.7mm (stdev 0.02mm). The measurements are slightly smaller compared to those from Xueshan, a later site located in the Dian Basin (Wang, 2014), where buckwheat measured on average 2.89mm in length, and 2.43mm in width.

6.5.6. Other economic species

A few species of wild foods were recovered from the samples analysed. These include mostly *Cannabis* sp. grains, and a few specimens of *Glycine* cf *max*, as well as some fragments of nuts species, and several fragments of peach/apricot stones, including possible *Prunus* cf *persica*, *Prunus* cf *armeniaca*, and *Prunus* cf *nume* (fig. 6-22; table 6-11). These remains have been mostly found in samples dating to the second period of occupation (fig. 6-23).

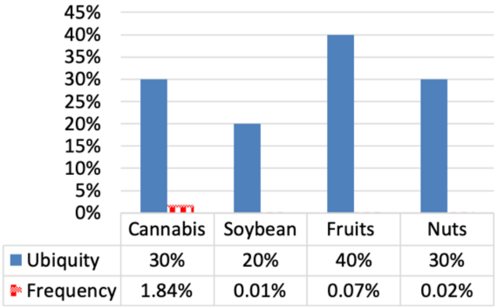


Fig. 6-22: Ubiquity and frequency of other economic species at Haimenkou.

Table 6-11. Breakdown of other economic species remains found from the Haimenkou samples analysed at UCL.

Species	Total	Ubiquity (no. of samples)
Cannabis sp.	453	3
Glycine cf *max*	3	2
Rubus sp.	6	1
Prunus cf *nume*	4	1
Prunus cf *armeniaca*	3	1
Prunus cf *persica*	3	1
Cucurbitaceae indet.	2	2
Euryale ferox	1	1
Acorns	1	1
Nutshell	4	4
TOTAL	480	5

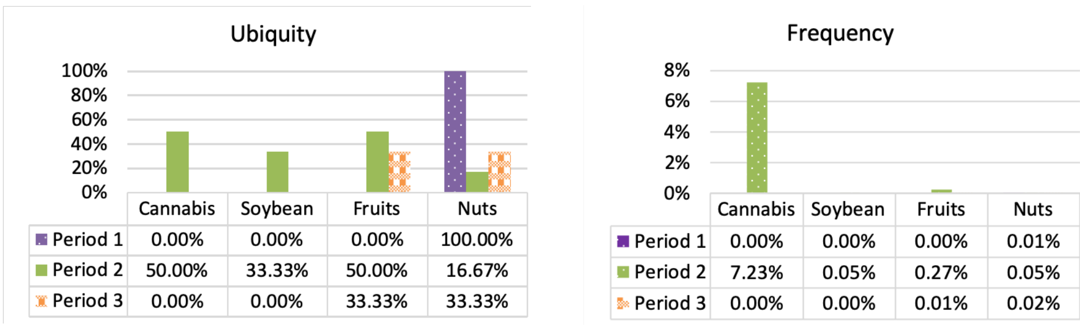


Fig. 6-23: Ubiquity (left) and frequency) right of other economic species at Haimenkou, divided by periods.

6.5.6.1. Cannabis

The rather high percentage of *Cannabis* sp. remains seems to suggest that the species was intentionally exploited. *Cannabis* sp. might have been actively exploited for the production of hemp, however, there is no clear information regarding possible textile remains recovered during excavation. This hypothesis, although plausible, still needs further investigations. The seeds may also be directly eaten, or processed as a source of cooking oil, referred to in early Chinese texts (Li, 1974; Huang, 2000; Clarke & Merlin, 2013). The use of *Cannabis,* both as fibre and as grain, has been mentioned in the *Shi Jing* (诗经 -Book of Odes), a compilation of poems dating to the Warring States period (c. 1000-700 BC)[11], as well as in the *Zhou Li* (周礼 -Rites of Zhou), one of the five classic Confucian texts describing ceremonial rites from the Warring States period, but probably written at the end of the 1st millennium BC (Li 1974). In the *Zhou Li*, *Cannabis* is referred to as one of the nine *gu* (谷 meaning grain), a word used for both cereals and non-cereals grains, including foxtail and broomcorn millets, barley, rice, soybean, etc (Li 1974:443). Interestingly, in some of these early Chinese text, *Cannabis* is differentiated in male *yi*, and female *ma* (麻), with reference to their distinctive uses: *yi* was grown for hemp, while *ma* was cultivated for grains (Li 1974; Huang, 2000; Clarke & Merlin, 2013: 203).

The presence of this species also raises the possibility that it was exploited as a drug plant, medicinally or recreationally. The early medicinal herbs treatise *Shennong Ben Cao Jing (*神農本草經 "The Classic of Herbal Medicine"), compiled during the Western Han Dynasty (1st-2nd century AD) mentions that "the fruits of hemp…if taken in excess will produce hallucinations (literal translation- seeing devils)" (Li 1974: 446). Later commentaries and supplementations to the treatise included references to various *Cannabis* and other herbs mixtures used by doctors as anesthetic, or by necromancers to see the future (Li 1974: 446). Indeed, Li (1974) inferred from early linguistic data that

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[11] The poem "The seventh month" in *Bin Feng* (豳风 -Poems of Bin) says:

"In the ninth month, they prepare the vegetable gardens for their stacks,
And then in the tenth month they convey the sheaves to them;
The millets, both the early sown and the late,
With other grain, the **hemp**, the pulse, the wheat […]"
(Zhou, 2006: 15)

Cannabis must have been exploited in such a way by shamans in late prehistoric central China.

6.5.6.2. Cannabis morphometrics

30 grains of *Cannabis* were measured, measuring on average 3.39mm in length, 2.2mm in width, and 1.2mm in thickness (fig. 6-24).

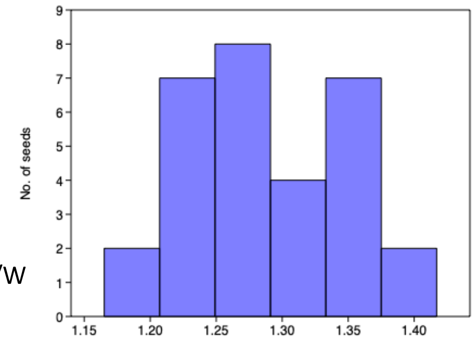


Fig. 6-24: Histogram plot of *Cannabis* L/W measurements from Haimenkou. Made with Past.

6.5.6.3. Soybean morphometrics

2 grains of soybean were measured, averaging 3.1mm in width, with a standard deviation of 0.94mm. L/W was 1.4mm. These measurements suggest that soybean at Haimenkou was domesticated, as judged by their similarity to Early Bronze Age soybean metrics from central China that are regarded as domesticated (see Fuller, et al., 2014: Fig. S1; see also Chapter 8 fig. 8-15 of this thesis).

6.5.7. Seeds of field weed species

A similar set of field weed species to those found at Baiyangcun has been recovered from the archaeobotanical samples at Haimenkou. The same dryland- wetland- dry and wetland division has been applied to the species found at the site of Haimenkou as was employed at Baiyangcun, and this is outlined in table 6-12.

Table 6-12. Breakdown of field weed species found at Haimenkou, with indication of category they belong to.

Dryland weeds	Wetland weeds	Both dry and wetland weeds
Setaria viridis	*Polygonum persicaria*	*Echinochloa* sp.
Setaria cf *verticillata*	Juncaceae- indet.	*Cyperus* sp.
Digitaria sp.	*Najas* sp	*Carex* sp.
Poaceae- indet .	*Butomus* sp.	Lamiaceae- indet.
Perilla sp.		
Fabaceae- indet.		
Verbena officinalis		
Galeopsis sp.		
Asteraceae- indet.		
Leonurus sp.		

Of the 10 samples analysed at UCL, only about 3% of the archaeobotanical remains recovered were constituted by seeds of field weeds (fig. 6-25). Seeds of dryland field weeds are the most abundant within the weed assemblage (corresponding to 2.90% of the total identified remains). *Echinochloa* remains, although present (see Appendix 2), are not very abundant, and have been included in the overall count of the both dry and wetland weeds.

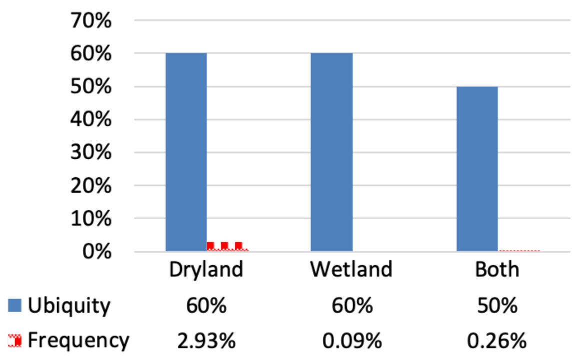
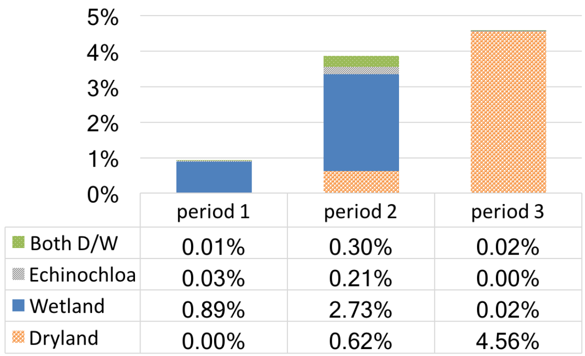


Fig. 6-25: Ubiquity and frequency of weeds at Haimenkou.

Chronologically, there is a shift from predominantly wetland weeds to dryland weeds from period 1 to period 3 (fig. 6-26). The overall proportion of weeds within the archaeobotanical assemblage also shows an increasing trend (figs. 6-26).



	period 1	period 2	period 3
Both D/W	0.01%	0.30%	0.02%
Echinochloa	0.03%	0.21%	0.00%
Wetland	0.89%	2.73%	0.02%
Dryland	0.00%	0.62%	4.56%

Fig. 6-26: Haimenkou weeds composition divided by periods samples analysed at UCL.

The paleoclimate data from the Erhai region indicates that a cooling event took place in at around c. 1500-1000 BC; this is reflected in the weed assemblage at Haimenkou. The increased presence of dryland weeds is also a reflection of the increased presence of dryland crops at the site, especially *Chenopodium,* and the introduction of wheat and barley.

6.6. Comparison with other archaeobotanical datasets

Tables 6-13; 6-14 provide a summary of the samples analysed for the site of Haimenkou, divided by trench, with indication of who undertook the analyses, and period of occupation, including total number of identified items and density of remains.

Table 6-13. Breakdown of archaeobotanical dataset analysed from the site of Haimenkou.

Period of occupation	No. of contexts[12] analysed	Total ID remains	Density (mean)	Reference
Period 1	1	8,235 charred	5L/ 1647	Dal Martello, 2019
	8	2937 charred	65L/ 97.88	Xue, 2010
	6	4605	155L/ 29.7	Jin, 2013
Period 2	6	6,256 charred	35L/ 208.53	Dal Martello, 2019
	6	6736 charred	30L/ 96.22	Xue, 2010
	9	7031	110L/ 63.91	Jin, 2013
Period 3	3	10,110 charred	70L/ 674	Dal Martello, 2019
	7	2297 charred	85L/ 27.02	Xue, 2010
	6	2503	120L/ 20.85	Jin, 2013

[12] So far at Haimenkou only samples from cultural layers have been analysed. The total number of contexts indicated in table 6-13 refers to the number of samples analysed after the merging of multiple S from the same individual context. See footnote 11, next page.

Table 6-14. List of archaeobotanical samples analysed from Haimenkou, including a breakdown of samples[13] per trench and person who analysed them.

Trench	Samples ID Dal Martello 2019	Samples ID Xue 2010	Samples ID Jin 2013
JHD T1803	⑦		
JHD T1204	⑥		
JHD T1304	Z1		
JHD T1304	⑤		
JHA T1907	⑦		
JHA T2004	⑥		
JHA T2003	⑥ S5		
JHD T1003		⑩ S2	⑩ S1
		⑨ S2 STERILE	⑨ S1; S2
	⑧	⑧ S2	⑧ S1; S2
	⑦	⑦ S2	⑦ S1; S2
		⑥ S2	⑥ S1; S2
		⑤S2	⑤ S1; S2
		④S2	④ S1; S2
JHD T1004		⑩ S4	⑩ S5; S6
		⑨ S4	⑨ S1; S4; S5; S6; S7
		⑧S4; S3; S6	⑧ S1; S3; S4; S5; S6; S7
		⑦ S4; S3; S6	⑦ S1; S3; S4; S5; S6; S7
		⑥ S4; S3; S6	⑥ S1; S3; S4; S5; S6; S7
		⑤ S4; S3; S6	⑤ S1; S3; S4; S5; S6; S7
	④	④ S4; S3; S6	④ S1; S3; S4; S5; S6; S7
		③ S4; S3; S6	
JHD T1005		⑩ S2	⑩ S2; S3; S6
		⑨ S4	⑨ S1; S3; S4; S5
		⑧S2; S6; S4	⑧ S1; S2; S3; S4; S5; S6
		⑦ S2; S6; S4	⑦ S1; S2; S3; S4; S5; S6
		⑥ S2; S6; S4	⑥ S1; S2; S3; S4; S5; S6
		⑤ S2; S6; S4	⑤ S1; S2; S3; S4; S5; S6
		④ S2; S6; S4	④ S1; S2; S3; S4; S5; S6
TOTAL no. of contexts analysed	**10**	**21**	**21**

[13] Numbers in circles indicate the cultural layer (deposit), followed by the specific sample number (S stands for sample). As standard practice in Chinese Archaeology, multiple samples from the same context are labelled with consecutive S#. This is indicated in table 6-14 where each S# after each semicolon refers to multiple samples from the same context. These have been merged for analysis, and number of contexts analysed refers to the total number of individual contexts after merging of multiple S samples.

The 10 samples analysed at UCL only contained charred remains, whereas samples analysed by Xue (2010), and Jin (2013) also contained waterlogged remains, which were deposited during the occupation hiatus between period 2 and 3 (Dorian Fuller, personal comment 2015). According to Xue, waterlogged remains were constituted by aquatic weedy species, such as *Potamogeton* sp., *Ranunuculus* sp., *Najas* sp., *Butomus* sp., *Ceratophyllum* sp., and *Polygonum* sp. Some of these have been recovered also in a charred state.

For this analysis and in the graphs below, when possible, a direct comparison of charred remains only has been made. This was not possible for the Jin (2013) dataset, as charred and waterlogged remains were not differentiated. Considering that Xue and Jin analysed samples from the same trenches and that their results show substantial similarities, I have, therefore, assumed the same set of aquatic weedy species, also found by Jin, might have been similarly waterlogged. For this reason, in the graphs below showing Jin (2013) dataset, wetland weeds might have been overrepresented by including waterlogged species.

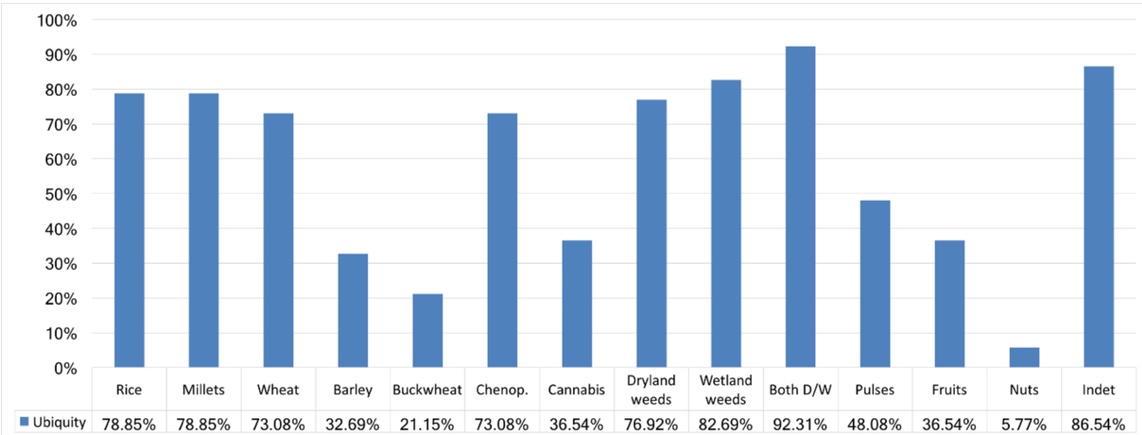


Fig. 6-27: Ubiquity at Haimenkou based on all three datasets combined (Dal Martello, 2019; Jin, 2013; Xue, 2010).

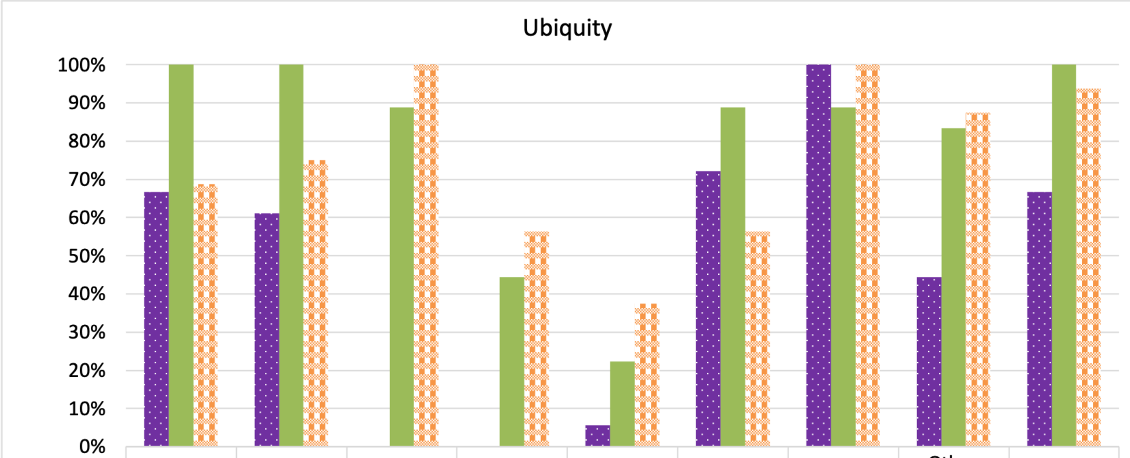
When considering ubiquity across all of the samples analysed, for a total of 52 contexts, the main characteristics are evident (fig. 6-27):

- crops and field weeds are the two most ubiquitous categories. Especially rice, millets, and wheat have been found in a similar number of contexts analysed, indicating that all three were systematically exploited;
- *Chenopodium* remains have a comparable presence to crops, being found in above 70% of the contexts analysed;
- Overall, field weeds show the highest ubiquity, with wetland weed taxa and those weeds that have been categorised as possibly both dry and wet being found in more samples than crops (close to 90%);
- Other economic species, such as *Cannabis*, pulses (mostly soybean), fruits and nuts have been recovered in less than half of the contexts analysed. Nuts especially have been recovered only in the samples analysed at UCL, with no reported nut remains in Xue (2010) or Jin (2013). This might indicate that nuts, if exploited at all, were not brought on site. However, it may be that fragmentary nut remains were not identified by previous workers, but were instead included in among the many indeterminates reported by Xue and Jin.

Fig. 6-28: top to bottom: ubiquity (blue) and frequency (checked red) index for main species and categories recovered at Haimenkou, samples analysed by author, Dal Martello, 2019 (top); Xue, 2010 (middle); Jin, 2013 (bottom).

In terms of overall archaeobotanical assemblage composition, the three subsets of samples show strong similarities (fig. 6-28):

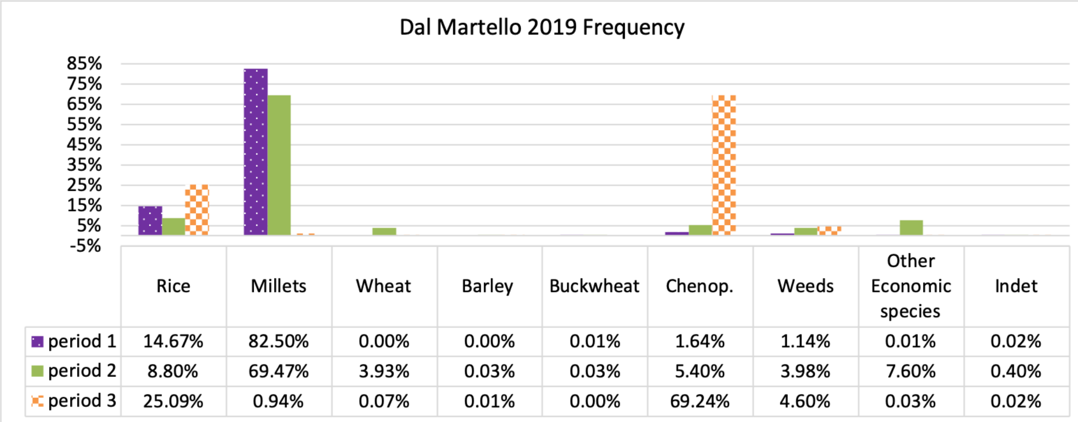
1. CEREAL CROPS:
   - rice, millet and wheat (and to a minor extent barley) are present throughout all three subsets, millet remains are present in higher quantities from the samples analysed at UCL, followed by rice and wheat; samples analysed by Xue (2010) and Jin (2013), instead, are constituted primarily by remains of rice, followed by wheat and millets.
2. *CHENOPODIUM:*
   - *Chenopodium* remains were recovered by all. This is in fact a very prevalent species, present in higher quantities than any other species in both Xue (2010) and Jin (2013) datasets. This prevalence supports its identification as a food crop, as does the preliminary morphometric data reported above.
3. FIELD WEEDS:
   - seeds of field weed species are present in high quantities from the samples analysed by Xue (2010) and Jin (2013). In the samples analysed at UCL, instead, they constitute a smaller proportion of the overall assemblage. Some of the higher representation in previous analyses may be accounted for inclusion of waterlogged preservation.
4. OTHER ECONOMIC SPECIES
   - Not many remains of fruit, pulses, and nuts were recovered. Remains of *Cannabis* were recovered from all the datasets. Moreover, remains of *Prunus* spp. have also been recorded by the other two researchers.



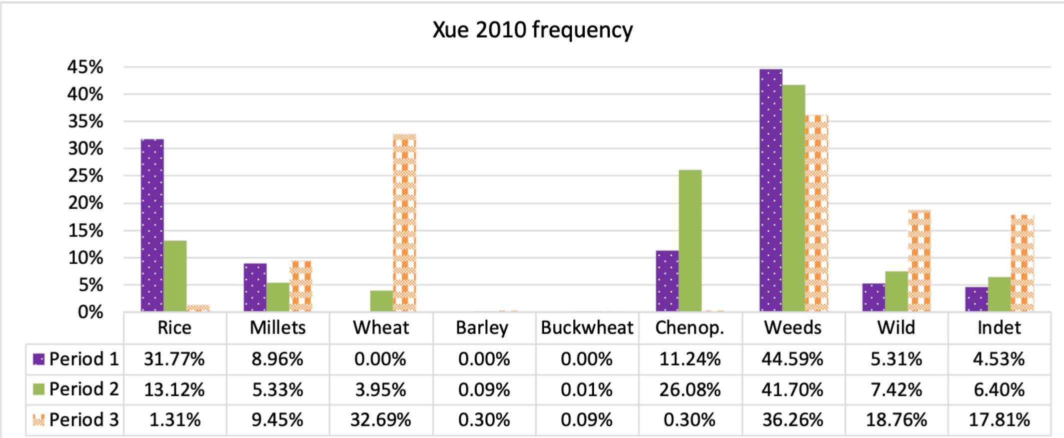
	Rice	Millets	Wheat	Barley	Buckwheat	Chenop.	Weeds	Other economic spp.	Indets
Period 1	66.67%	61.11%	0.00%	0.00%	5.56%	72.22%	100.00%	44.44%	66.67%
Period 2	100.00%	100.00%	88.89%	44.44%	22.22%	88.89%	88.89%	83.33%	100.00%
Period 3	68.75%	75.00%	100.00%	56.25%	37.50%	56.25%	100.00%	87.50%	93.75%

Fig. 6-29: Combined ubiquity index at Haimenkou, showing main archaeobotanical categories presence across 52 samples, divided by period of occupation (from Dal Martello, 2019; Xue, 2010; and Jin, 2013). Total samples per period: 1=15; 2=21; 3=21.

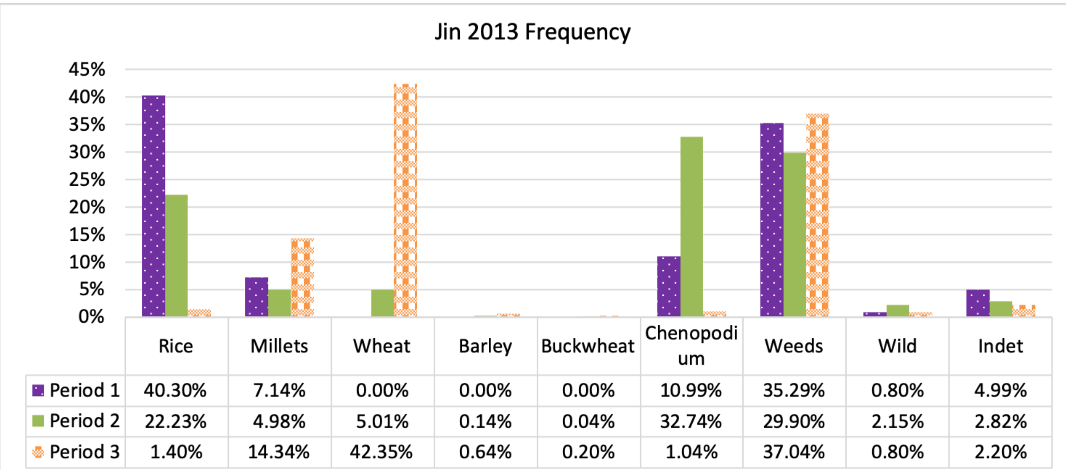
The combined ubiquity index divided by period highlights the uneven recurrence of the species throughout the phases (fig. 6-29). However, an uneven number of contexts was analysed across the three researchers, especially for period 1, for which only 15 total contexts have been analysed, in comparison to the 21 for each of the last two periods. The same general patterns as those observed for the overall ubiquity are seen. Rice, millets, and *Chenopodium* are found in the highest number of samples in period 2, but then decline. After the introduction of wheat and barley, these increase in ubiquity over time.



	Rice	Millets	Wheat	Barley	Buckwheat	Chenop.	Weeds	Other Economic species	Indet
period 1	14.67%	82.50%	0.00%	0.00%	0.01%	1.64%	1.14%	0.01%	0.02%
period 2	8.80%	69.47%	3.93%	0.03%	0.03%	5.40%	3.98%	7.60%	0.40%
period 3	25.09%	0.94%	0.07%	0.01%	0.00%	69.24%	4.60%	0.03%	0.02%



	Rice	Millets	Wheat	Barley	Buckwheat	Chenop.	Weeds	Wild	Indet
Period 1	31.77%	8.96%	0.00%	0.00%	0.00%	11.24%	44.59%	5.31%	4.53%
Period 2	13.12%	5.33%	3.95%	0.09%	0.01%	26.08%	41.70%	7.42%	6.40%
Period 3	1.31%	9.45%	32.69%	0.30%	0.09%	0.30%	36.26%	18.76%	17.81%



	Rice	Millets	Wheat	Barley	Buckwheat	Chenopodium	Weeds	Wild	Indet
Period 1	40.30%	7.14%	0.00%	0.00%	0.00%	10.99%	35.29%	0.80%	4.99%
Period 2	22.23%	4.98%	5.01%	0.14%	0.04%	32.74%	29.90%	2.15%	2.82%
Period 3	1.40%	14.34%	42.35%	0.64%	0.20%	1.04%	37.04%	0.80%	2.20%

Fig. 6-30: Top to bottom: frequency indexes of archaeobotanical assemblages analysed by author, Dal Martello, 2019 (top); Xue, 2010 (middle); Jin, 2013 (bottom), divided by period of occupation.

When comparing the three datasets from Haimenkou according to their period of occupation, there are some noticeable differences on the overall abundance of the archaeobotanical remains (fig. 6-30).

1. CEREAL CROPS:
   - considerable shifts in abundance occur for rice; millets and wheat across the three subsets of samples. Of the 10 samples analysed at UCL rice increases during the last period of occupation; both in Xue (2010) and Jin (2013) rice instead shows a decreasing trend, to almost no rice remains recovered from period 3. A decreasing trend of millet remains is also evident from samples analysed at UCL; In Xue (2010) and in Jin (2013), however, millets first decrease from period 1 to 2; but then increase again in period 3. Wheat remains are not very abundant from the samples analysed at UCL, but they show an increasing trend in both Jin (2013) and Xue (2010).
2. *CHENOPODIUM*:
   - *Chenopodium* remains increase considerably by the end of the occupation of the site in the samples analysed at UCL; in those analysed by Xue (2010) and Jin (2013) they increase form period 1 to period 2, but then decrease by the end of the occupation of the site.

These contrasting differences seen across the three subsets are most probably due to the different samples' provenance across the excavated area. As shown in picture 6-31, the samples analysed at UCL came from different trenches to those analysed by Xue (2010) and Jin (2013). This suggests that differentiated used of space may be represented in different crop frequencies across the site at any one time.

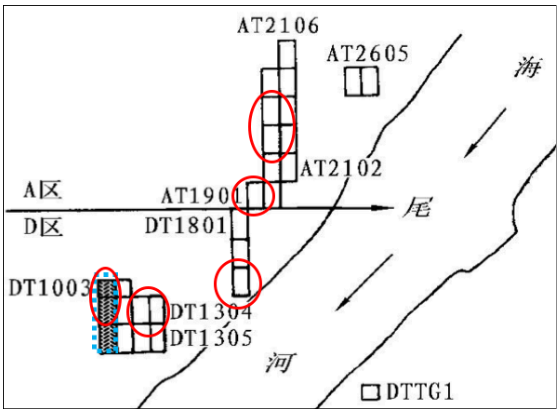


Fig. 6-31: Excavation area and provenance of samples analysed by author shown in red circles, and by Xue and Jin, shown in dotted light blue and filled. Map redrawn from Xue (2010).

6.7. Haimenkou: summary

At Haimenkou people practiced a mixed economy based on a variety of crops, including rice, millets, wheat, and *Chenopodium.* Rice seems to be more prevalent at the start of the occupation of Haimenkou, but declines over time, in favour of cold and drought resistant crops such as millets and wheat. This could be due to the increasing cold and dry climatic conditions following the continuous decline of the monsoon, which would have significantly affected rice productivity; this is also reflected in shifts in weed ecology from wet to dryland dominated.

The very high presence of *Chenopodium* strongly suggests that it was actively collected, and possibly exploited as food resource. *Chenopodium* is present in comparable, or higher quantities than the other crops recovered at the site. The cold and dry climatic conditions might have had a part in the exploitation of *Chenopodium* as the crop of choice in times of climate instability, as well as being part of a risk reducing strategy in times of high chances of insufficient yields or harvest failure for the other crops. Preliminary morphometrics analyses suggests that *Chenopodium* might have been under domestication at Haimenkou.

The appearance of wheat and barley during the second period of occupation of the site suggests some increased crop diversity came about through new introductions of crops, presumably from the North, which is indicated also by the presence of painted ceramics with parallels in Northwest China and the presence of sheep/goat in the faunal assemblage.

Other economic species, especially pulses and fruits, are constantly present throughout the assemblage, although recovered in smaller quantities. This indicates a wide range of food resources was exploited to supplement the diet. Their lower quantity might also be an indication that these resources where less intensively processed on-site, and could, instead, have been consumed or processed off site, unlike cereals that must have been systematically stored and routinely processed on-site. However, the presence of rice and millet grains preserved still attached to the panicle, seems to suggest that they were stored pre-processing. Additionally, the high presence of *Cannabis* remains points its active exploitation, however its specific use is unclear.

Cannabis might have been used for a variety of purposes, including as grain crop, oil, or recreationally as a drug.

CHAPTER 7. The site of Dayingzhuang

7.1. Introduction

The site of Dayingzhuang takes its name from a small village located about 37km southwest from Kunming, the capital city of Yunnan province, and just 13km from the northwestern side of the Lake Dian (N 24.84; E 102.53, fig. 7-1; 7-2). The Dian Lake has an area of 312km^2 and is the sixth largest freshwater reservoir of the whole country. It is 32km long, and on average 7km wide, 12.5km at its widest point. Average depth is about 5.7m, reaching up to 8m in the deepest point. The Dian Basin is located right in the middle of the Yungui Plateau, at an altitude of 1886m asl. The mild environment and climate present nowadays at the Plateau allow for spring-like weather conditions year-round, making Kunming known as the "city of the eternal spring" (Zhang, 1986). Here, the average annual temperature is 15˚C, there are about 2200 hours of sun per year, and at least 240 frost-free days. Annual precipitation is around 1035mm, and due to the influence of the Asian Summer Monsoon, it occurs mostly between May and August (Zhang, 1986).

Being closer to the Lake Dian and at a slightly higher altitude than Kunming, at 1920m asl, Dayingzhuang presents a slightly colder weather, with an annual average temperature of 13.2˚C. January average temperature is attested at about 5˚C, and July around 19˚C, although coldest temperatures can sometimes reach more than -8˚C, and hottest temperatures are usually attested around 28˚C. The average daily thermal excursion is usually around 9.4˚C. There are between 180-220 frost free days per year, and the wind mostly blows in a southwestern direction (Zhang, 1986). The environmental conditions present in the area at the time of the occupation of the site of Dayingzhuang were very close to those of present day (see Chapter 3).

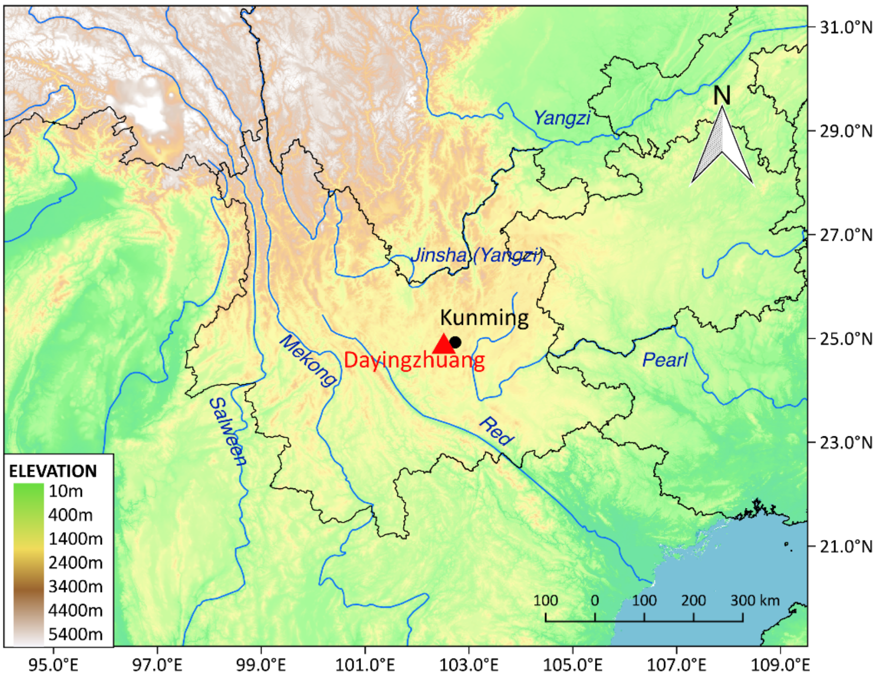


Fig. 7-1: Map showing location of the site of Dayingzhuang, and its relation to the Lake Dian and Kunming city. Made qith QGIS.

Fig. 7-2: Modern day surroundings at the site of Dayingzhuang, facing North. Photo by author.

The area surrounding the Lake Dian can be divided into the following three altitudinal zones:

- Below1900m: alluvial floodplains. Present day economy is based on double cropping of rice and vegetables. Human occupation concentrates in this altitudinal area, and, especially in the northern and eastern coasts of the lake, it has been attested since early times (Yao, 2016).

- Between 1900-2100m: piedmont and low terraces.
- 2100-2800m: high terraces and steep mountains, which have been historically unsuitable for long term permanent occupation (Yao, 2016).

7.2. Site description and material culture

7.2.1. Features

A total of 35 pits, 5 *hedao* "rivers" (contexts from deposits within the river course), 4 houses, 2 living floors, 5 *jicao* "wall foundations", and 1 hearth were revealed during the excavation of the Dayingzhuang site. Beneath the lowest level, vestiges of a natural occurring river were also found (no signs of human intervention could be distinguished on the banksides, Li Xiaorui, personal comment 2018). This river has been identified as being the ancient riverbed of the modern Tanglang River, which still exists just west of the excavation area (see fig. 4-6 in Chapter 4). The Tanglang is believed to have changed course several times during the millennia, settling on its current location during the Han dynasty (Li Xiaorui, personal comment 2018). The Tanglang Valley, which flows into the western bank of the Lake Dian, connects the Dian Basin with the Anning area, historically important as a centre for the production of copper, as well as the location of the Dian cemetery of Tajishan (Yunnan et al., 2015). The Dayingzhuang settlement, therefore, functioned as an important connection point between the two areas. Further evidence of settlements located along the Tanglang River, both upstream and downstream, indicate that the Tanglang Valley possibly connected the Dian Basin with the northern Jinsha Basin during the Bronze Age (Yunnan et al., 2015).

The house structures unearthed were classified into 2 main categories:

- Early houses, which cut straight into the bedrock, were of oval shaped perimeter, with deep foundations. They are believed to have been similar to a closed "pavilion" structure (Li Xiaorui, personal comment 2018).
- Later houses are mostly rectangular in perimeter and show a clear set of postholes running along each side of the building. They have been classified as wattle and daub structures, however the living floor area was not as visible

as for the earlier houses. The so-called *jicao* features were most likely wall foundations belonging to the perimeter of these later dwellings, whose whole limits could not be clearly identified. Inside of each of the *jicao* there were several postholes.

The site has been estimated to be between 4-10ha in site, and it is one of the biggest Dian settlements known so far (Yunnan et al., 2015).

7.2.2. Ceramics

The ceramic assemblage found at Dayingzhuang was composed of *fu* caulderons, *bo* bowls, *guan* jars, high neck *guan* jars, and *pen* plates (Li Xiaorui, personal comment 2018, see fig. 7-3). The pottery temper was mainly coarse, either red/reddish, or greyish in colour. Rice husk inclusions were often found trapped in the temper. The pottery decoration as well as the range of vessels are typologically similar to those found at other early sites belonging to the so-called Dian/ Shizhaishan Culture, with the typical decorations characterised by incised wave (*shuibowen* 水波纹), comb (*zhiwen* 栉纹), bow-string (*xianwen* 线纹), and corded patterns (*shengwen* 绳纹; Li Xiaorui, personal comment 2018).

Fig. 7-3: Ceramic vessels unearthed at the site of Dayingzhuang. Left to right: *guan* jar with spout; *pen* basin; high neck *guan* jar. Photos by Li Xiaorui.

7.2.3. Stone and other implements

Numerous stone tools, as well as bone and shell implements were excavated. The stone assemblage included polished *fu* axes, *ben* adzes, and *bing*-round stone fragments, grindstones, etc. Bone and shell implements were mostly in the shape of needles, pins, scrapers, etc.

Finally, some agate stone fragments showing clear signs of processing, and cowrie shells were also discovered. Many of the cowrie shells had a hole in their upper extremity, possibly indicating their use as accessories and jewellery of some sort (Li Xiaorui, personal comment 2018). As the excavation report has yet to be published, no further details are available regarding stone and other implements.

7.2.4. Metal objects

Finds of metallurgical slags were reported from Dayingzhuang after the Dian Basin survey (Yunnan et al., 2015). However, only a few, small metal objects have been found at the site during the 2017 excavation campaign; these include a bracelet, a dagger (fig. 7-4), and some metal chips. The bracelet is made from a large and thin metal ring, and shows a plain, undecorated surface (Li Xiaorui, personal comment 2018). Later sites, especially burial sites, belonging to the Dian Culture will reveal a flourishing metalworking production, which include sophisticatedly decorated drum shaped containers (see below).

Fig. 7-4: Metal dagger unearthed at the site of Dayingzhuang. Photos by Li Xiaorui.

7.2.5. The Dian

Typological characteristics of the material culture, especially of ceramic remains, found at the site of Dayingzhuang have been associated with the Dian Culture. The so-called “Dian Culture” (formerly known as Shizhaishan Culture) was discovered in 1955 following the excavation of the burial site of Shizhaishan, located on the Southwestern bank of the Lake Dian. Here, numerous bronze objects were found, including sophisticatedly produced weapons and prestige items, such as drum shaped and elaborated cowrie shell containers, as well as a gold seal bearing the inscription: “The

Seal of the King of Dian” (Yao, 2017). Following this find, remains of the Dian Culture have been associated with the so-called “Southwestern Barbarians” group, as referred to in early Chinese historical texts such as the *Shiji* (史记 *Records of a Gran Historian*; Shiji 116, see Qian, 1993). This was a polity that had contacts with both the early Chinese State in the Central Plains, as well as the broader Southeast Asian civilisations, and it was present in Yunnan from about the 8th century BC, until when it was conquered by the Han dynasty in 109 BC (Zhang, 1997; Allard, 1999).

The limited occurrence of bronze objects at the site of Dayingzhuang has been explained with the site being a settlement rather than a cemetery. Dian bronzes are in fact mostly associated with (wealthy) burials, such as those at Shizhaishan, and not so frequently found at settlement sites (Li Xiaorui, personal comment 2018).

7.2.6. Faunal remains

Pig, cattle, horse, deer, and fish bones were found during excavation at the site (Li Xiaorui, personal comment 2018). However, no in-depth analysis of the animal bones unearthed at Dayingzhuang has been carried out yet. The thick deposit of freshwater shells found at the site also indicates that the Dayingzhuang people relied heavily on the exploitation of the nearby lacustrine resources for their subsistence, especially gastropod species *Margarya melanioides*, which was found in the shell mound site layers (Yunnan et al., 2015).

7.3. Site Chronology

Preliminary dating of the site of Dayingzhuang had been undertaken during "The Dian Heartland Archaeology Survey Project" (Yunnan, et al., 2015; Yunnan et al., 2014; Yao & Jiang, 2012). The material used for the dating has not been specified in available publication, but it is believed this might be a seed, as flotation samples were collected from an exposed pit profile. The resulting (calibrated) date provided is 780-550 BC (Yunnan et al., 2015: 158; see table 7-1).

More recently, following the excavation of the site, the analysis of the stratigraphic relationships and ceramic typology at Dayingzhuang distinguished at least three phases of occupation:

- Early period: layer 5, characterized by a high presence of incised decoration on grey, coarse temper pottery. The ceramic assemblage is mostly composed of *guan* jars, some with pouring sprouts. Houses are oval in shape.
- Middle period: layer 4: sharp decline of grey coloured pottery; appearance of coarse, red coloured pottery temper, with a ceramic assemblage comprised of *bo* bowls. The overall size of the site expands; wattle and daub type house structure appears. The riverbed of the Tanglang river shifts southward.
- Late period: layer 3; decrease in *bo* bowls, and appearance of circles (*tongxinyuan* 同心圆纹*)* decorated *pen* plates (Li Xiaorui, personal comment 2018).

Archaeobotanical material obtained through flotation during excavation allowed for AMS dating of the site. In summer 2018 wheat grains from contexts 2017YHD(2)S4; 2017YHD(4)S4; 2017YHD(5)S1 were submitted to the Beta Analytic Ltd. London BioScience Innovation Centre for AMS radiocarbon dating. The Bayesian model derived from the AMS dates obtained on the wheat grains suggests an occupation of the site between ca. 750 cal. BC and ca. 390 cal. BC (fig. 7-5). One wheat grain from context 2017YHD(2)S4 was dated as intrusive (modern, see details in table 7-1), and therefore, all contexts associated with layer 2 have been excluded from the archaeobotanical analysis below.

At the moment, no direct dates are available for layer 3, and contexts from layer 4 and 3 have been considered together as part of period 2/3 in the analysis below.

Table 7-1. Radiocarbon dates from Dayingzhuang, indicating context of provenance, material dated, and lab code (Yunnan et al., 2015; Dal Martello, 2019).

Context	Material	Lab code	Cal. Date BP	95.40%	68.20%
2010 survey	n/a	Beta-312946	n/a	780-550 cal. BC	
2017 exc.					
Layer 2 (modern)	Wheat grain	Beta-501549	100±30		
Layer 4	Wheat grain	Beta-051550	2380±30	727-393 cal. BC	485-400 cal. BC
Layer 5	Wheat grain	Beta-051549	2430±30	750-405 cal. BC	726-414 cal. BC

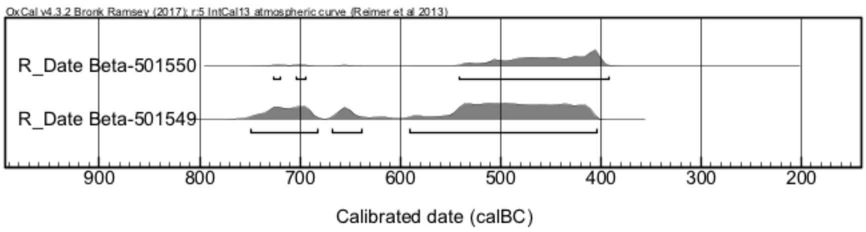


Fig. 7-5: Bayesian model of the calibrated radiocarbon dates from the 2017 excavation at Dayingzhuang. Made with Oxcal v.4.3.2 (Bronk Ramsey, 1995; Bronk Ramsey, 2001).

7.4. Archaeobotanical remains

Flotation samples had been previously taken from an exposed pit during the 2010 Chinese-American-Canadian Dian Basin Survey, revealing the presence of foxtail millet at the site (Yunnan et al., 2015: 158), but no further information is known as no formal archaeobotanical report has been published.

Over 130 archaeobotanical samples were collected through flotation during the 2017 excavation of Dayingzhuang. After scanning them under a low power binocular microscope at the Yunnan Provincial Institute of Archaeology in Kunming in April 2018, 30[14] were selected and were subsequently analysed at the UCL Institute of Archaeology-Archaeobotany Laboratory for this dissertation (table 7-2). The results are discussed below. A description of the methods of recovery and analysis has been provided in Chapter 4.

Table 7-2. Summary of the Dayingzhuang samples, indicating total number of contexts analysed for each period of occupation, including a breakdown of context type per each period, litres floated, tot number of identified (ID) remains and density item per litre.

Period of occupation	No. of contexts analysed		Total litres flotated	Total ID remains (NISP)	Density (mean)
Period 1	Layers	4	120	121	
	Houses	3	60	37	
	Pits	7	140	58	
	Hedao[15]	2	40	338	
	Total	**16**	**360**	**558**	**1.55**
Period 2/3	Layers	2	140	58	
	Houses	4	80	95	
	Pits	8	160	359	
	Total	**14**	**380**	**512**	**1.28**
TOTAL		30	740	1070	1.59

[14] Originally, 6 samples from 2 contexts stratigraphically associated with stratum 2 were selected and sorted. However, since direct radiocarbon dating of charred archaeobotanical remains from layer 2 furnished a modern date, they have been regarded as mixed with intrusive remains and have been excluded.

[15] *Hedao* 河道 means river; here it indicates a natural occurring river present in the area. As seen above, this has been hypothesized to be the ancient riverbed of the modern Tanglang River, which flows into the Lake Dian.

7.4.1. Sample size and diversity

The archaeobotanical samples from Dayingzhuang contained only charred remains, but not in great quantity (fig. 7-6). The preservation conditions at the site were rather poor, and this is most probably due to the intensive agricultural activities carried out in the area, as well as the extreme vicinity of the Lake Dian and the Tanglang River, whose erosion activities are particularly intense.

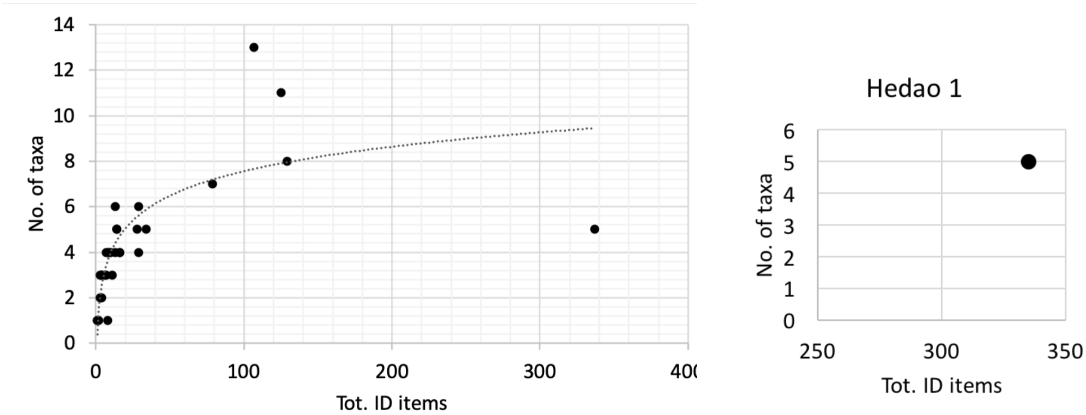


Fig. 7-6 Graphs showing sample size vs. sample diversity for the archaeobotanical assemblage at Dayingzhuang, excluding outlier: Hedao 1, shown on the right.

A total number of 1070 identified charred remains, belonging to 14 families, and over 20 individual species, have been recovered from the samples analysed (tables 7-2; 7-3).

Identifiable remains were categorised in the following groups:

- Crops (including wheat, barley, rice, *Setaria italica, Panicum miliaceum* and indeterminate millets);
- *Chenopodium* is found in high quantity but the analysis was inconclusive in determining its status in the overall assemblage at Dayingzhuang;
- other economic species (including pulses, nuts, and fruits and other wild species);
- seeds of field weeds species.

Categories criteria are outlined in Chapter 4.

Table 7-3. Ubiquity and frequency index, including absolute counts, per each family, and main species of macro remains recovered at Dayingzhuang.

Main species and families	No. of samples (n=30)	Ubiquity index	Absolute counts (n=1070)	Frequency index
Alismataceae- *Alisma* sp.	1	3.33%	1	0.09%
Apiaceae	1	3.33%	1	0.09%
Aquifoliaceae	1	3.33%	1	0.09%
Chenopodiaceae: *Chenopodium* sp.	20	66.67%	353	32.99%
Euphorbiaceae	1	3.33%	1	0.09%
Fabaceae- various	3	10%	5	0.47%
Fagaceae- *Castanea* sp.	1	3.33%	1	0.09%
Juglandaceae- acorns	2	6.67%	6	0.56%
Nymphaceae- *Euryale ferox*	12	40%	43	4.02%
Poaceae- *Hordeum vulgare*	7	23.33%	8	0.75%
Poaceae- O*ryza sativa*	27	90%	139	12.99%
Poaceae- *Panicum miliaceum*	7	23.33%	26	2.43%
Poaceae- *Setaria italica*	10	33.33%	37	3.46%
Poaceae- *Triticum aestivum*	22	73.33%	416	38.88%
Poaceae- various	5	16.67%	6	0.56%
Polygonaceae- various	5	16.67%	6	0.56%
Portulaceae	2	6.67%	2	0.19%
Rosaceae	1	3.33%	3	0.28%
Rutaceae- *Zanthoxylum* sp.	2	6.67%	3	0.28%
Solanaceae	1	3.33%	1	0.09%
Indet.	7	23.33%	11	1.03%
TOTAL	**N/A**	**N/A**	**1070**	**100%**

7.4.2. Ubiquity and frequency

Taxa recovered in the archaeobotanical assemblage at Dayingzhuang are not very homogeneous (fig. 7-7). Wheat, rice and *Chenopodium* are the most ubiquitous species, found in 22, 27, and 20 respectively out of the 30 samples analysed. Wheat, rice and *Chenopodium* also constitute the majority of the remains recovered, altogether accounting for almost 85% of the total identified remains. Wild species are found in almost half of the samples analysed, but they account for slightly over 5% of the total identified remains. All other taxa are found in less than half of the samples analysed, with some, such as barley, found in slightly over 20% of the samples analysed. The frequency index of these categories is extremely low.

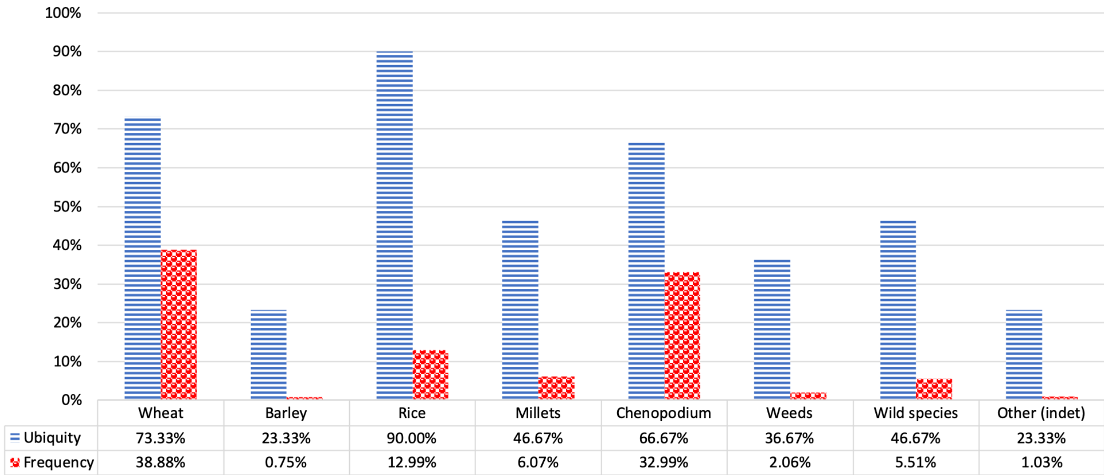
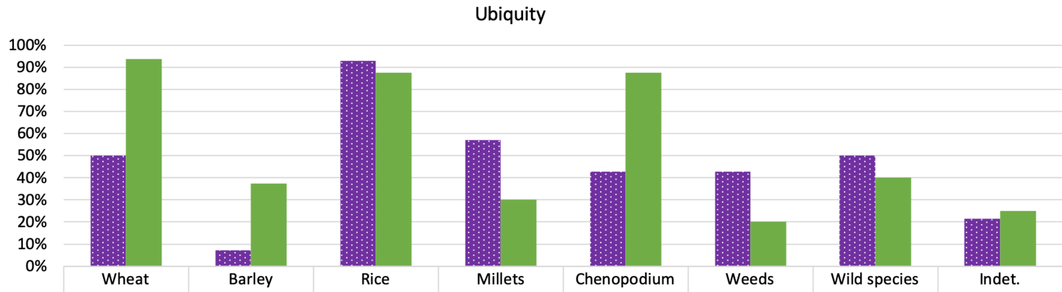


Fig. 7-7: Ubiquity and frequency for main macro remains categories at Dayingzhuang.

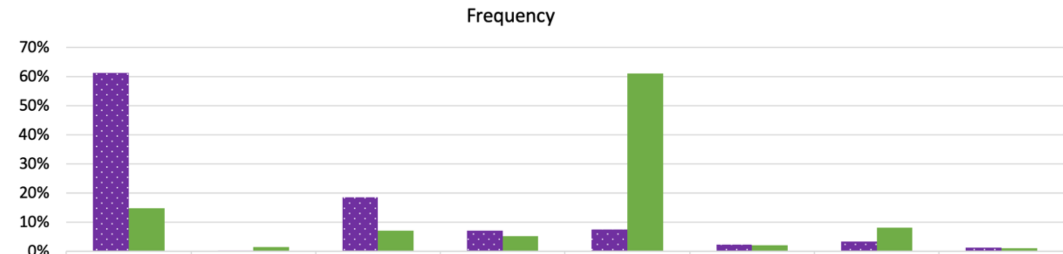
The composition of the assemblage changes over the two periods of occupation.

During period 1, rice is the most ubiquitous species, followed by millets, and then wheat (fig. 7-8). However, wheat is the most abundant crop found in this period (fig. 7-9), but this is largely due to the extremely high number of wheat grains from a single context: *Hedao* 1 (which included over 300 wheat grains; see Appendix 2). Ubiquity for wheat, barley, and *Chenopodium* increases during period 2/3, whereas all other taxa show a general decreasing trend (fig. 7-8). During period 2/3 *Chenopodium* and wild species remains increase greatly in absolute numbers, while all other taxa show a general decrease (fig. 7-8). In period 2/3, the total number of wheat remains decreases sharply, and *Chenopodium* remains increase (fig. 7-9).



	Wheat	Barley	Rice	Millets	Chenopodium	Weeds	Wild species	Indet.
Period 1	50.00%	7.14%	92.86%	57.14%	42.86%	42.86%	50.00%	21.43%
Period 2/3	93.75%	37.50%	87.50%	30.00%	87.50%	20.00%	40.00%	25.00%

Fig. 7-8: Ubiquity for main macro remains categories at Dayingzhuang, divided by period of occupation.



	Wheat	Barley	Rice	Millets	Chenopodium	Weeds	Other economic species	Indet
Period 1	61.11%	0.18%	18.46%	6.99%	7.35%	2.15%	3.23%	1.08%
Period 2/3	14.65%	1.37%	7.03%	5.08%	60.94%	1.95%	8.01%	0.98%

Fig. 7-9: Frequency of main macro remains at Dayingzhuang, divided by period of occupation.

7.4.3. Cereal Crops

Several cereal crop species have been recovered from Dayingzhuang. Western domesticates *Triticum aestivum* (wheat), and *Hordeum vulgare* (barley); Chinese domesticates *Oryza sativa* (rice); *Setaria italica* (foxtail millet); and *Panicum miliaceum* (broomcorn millet).

7.4.3.1. Wheat & barley

Dryland Western domesticates wheat and barley were found in 80% of the samples analysed and accounted for c. 40% of the total identified remains. Of these, wheat is more prevalent, and barley constitutes less than 2% of the total identified remains at Dayingzhuang. Wheat density per litre is 0.5items/L. Both wheat and barley remains include: whole grains, grain fragments, and rachises (see table 7-4). Some of the barley grains were hulled, and only 2 grains were of the naked type.

Table 7-4. Breakdown of remain types of wheat and barley at Dayingzhuang.

Remain type	Total	Ubiquity (no. of samples)
T. aestivum whole caryopsis	290	28
T. aestivum caryopsis fragment	106	9
T. aestivum immature caryopsis	1	1
T. aestivum -rachis	1	1
T. aestivum caryopsis -husk preserved[16]	18	1
H. vulgare whole caryopsis -naked	1	1
H. vulgare immature caryopsis -naked	1	1
H. vulgare caryopsis -hulled	5	5
H. vulgare -rachis	1	1
TOTAL	424	n/a

Morphometrics- wheat

90 grains of wheat from Dayingzhuang were measured (Appendix 4). Dayingzhuang wheat average length was 4.06mm, with a standard deviation of 0.43mm; width was 2.95mm with a standard deviation of 0.38; and thickness was 2.53mm, with a standard deviation of 0.30mm. Wheat L/W at Dayingzhuang was 1.38mm, with a standard deviation of 0.14mm (fig. 7-10).

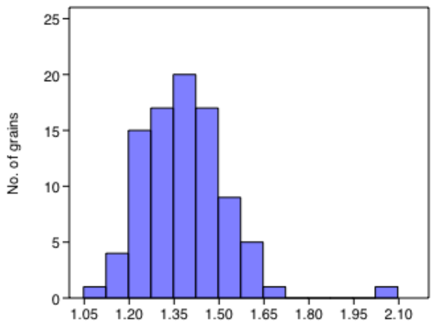


Fig. 7-10: Histogram plot of L/W ratio of wheat grains at Dayingzhuang. Made with Past.

Morphometrics- barley

4 grains of barley from the Dayingzhuang samples were measured. These were on average 5.13mm long, 2.61mm wide, and 2.12mm thick; average L/W was 1.96mm, with a standar deviation of 0.21mm (see Appendix 4).

Context analysis

Deposits from an ancient river have been excavated and sampled as part of the Dayingzhuang 2017 excavation campaign (labelled as *hedao,* see table 7-2). The riverbed has been stratigraphically linked to the 5th layer, and therefore associated to the earlier

[16] These grains had the tip of the husk still attached, indicating that they became charred while still on the ear of the plant, possibly due to some burning event while in storage (Appendix 3).

period of occupation. Archaeobotanical samples from these contexts are well preserved and very rich in charred plant remains, especially in wheat remains.

These deposits considerably skew the data, as evident from fig. 7-11, which shows that wheat remains have been found proportionally mostly in *hedao* samples. If we exclude them, wheat remains are constantly present in higher quantities in layers, followed by pits, and lastly, houses (fig. 7-11). However, this pattern could be due to the fact that comparatively fewer houses were sampled per each period: 3, and 4, compared to the 7 pits from period 1, and 8 pits from period 2 (table 7-2).

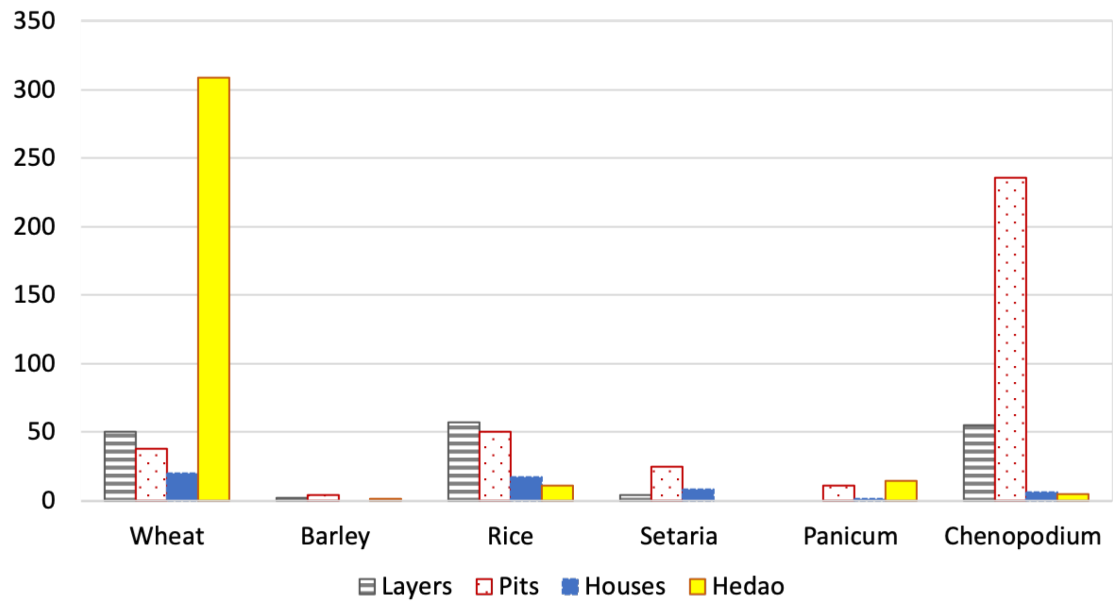


Fig. 7-11: Cereals crops and *Chenopodium* remains context analysis at Dayingzhuang, with indication of absolute counts divided by periods.

7.4.3.2. Rice

Compared to previous sites in Yunnan, at Dayingzhuang rice prominence decreases sharply. This crop, although being present in 90% of the samples analysed, constitutes only about 13% of the total identified remains (fig. 7-7). Moreover, rice remains decrease by half during period 2/3 (fig. 7-9). Overall, rice density per litre is only 0.18items/L. Rice remains at Dayingzhuang are constituted of whole grains, grain fragments, detached embryos, and spikelet bases (table 7-5). At Dayingzhuang, no wild rice grains or spikelet bases were recovered, thus this species was most certainly fully domesticated.

Table 7-5: Breakdown of rice remains at Dayingzhuang.

Remain type	Total	Ubiquity (no. of samples)
Rice caryopsis	52	22
Rice- caryopsis fragment	56	18
Rice- detached embryo	1	1
Rice- immature caryopsis with embryo	7	4
Rice- spikelet bases (domesticated)	22	5
Rice- spikelet bases (immature)	1	1
TOTAL	139	27

Morphometrics

21 grains of rice from Dayingzhuang have been measured (Appendix 4). Average length was 4.71mm, with standard deviation of 0.52; average width 2.65, with standard deviation of 0.27; average thickness was 2.31, with standard deviation of 0.33. Dayingzhuang rice grains average L/W was 1.78mm, with a standard deviation of 0.24mm (fig. 7-12). Only 2 grains measured <2.2mm in L/W, therefore, rice at Dayingzhuang has been classified as *Oryza sativa* subsp. *japonica* (Harvey, 2006; Castillo et al., 2015).

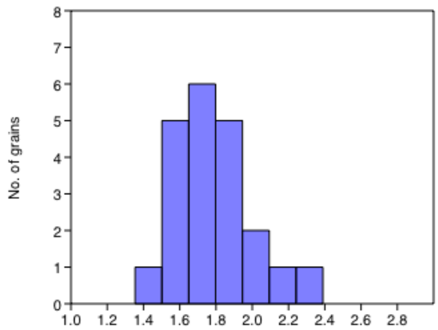


Fig. 7-12: Histogram plot of rice L/W measurements from Dayingzhuang. Made with Past.

Context analysis

The context analysis for rice shows that the crop is present in higher quantities in layers from period 1, and then mostly in pits from period 2/3 (fig. 7-13).

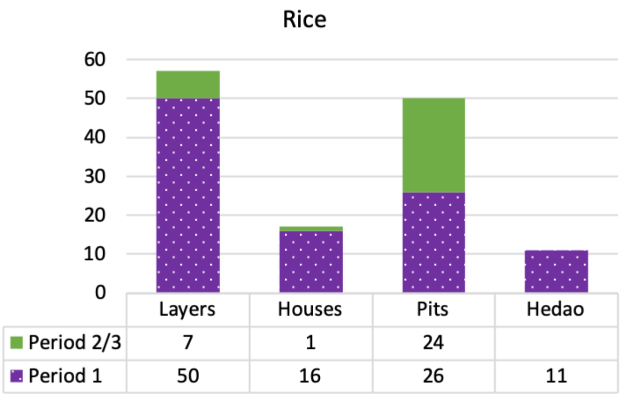


Fig. 7-13: Rice remains context analysis at Dayingzhuang, with indication of absolute counts divided by periods.

7.4.3.3. Millets

Both foxtail and broomcorn millets were found at Dayingzhuang (table 7-6). They together account for only c. 6% of the total identified remains and although foxtail millet is present in slightly higher quantity than broomcorn millet, their difference is negligible within the overall archaeobotanical assemblage at Dayingzhuang (table 7-6). Their overall ubiquity is also rather low (fig. 7-7). Millet density per litre is 0.8items/L.

Table 7-6: Breakdown of millets remains at Dayingzhuang.

Remain type	Total	Ubiquity (no. of samples)
Setaria italica caryopsis	18	6
Setaria italica immature caryopsis	4	2
Cf. *Setaria*	15	4
Panicum miliaceum caryopsis	26	7
TOTAL	65	14

Morphometrics

18 grains of *Setaria italica* from Dayingzhuang have been measured (Appendix 4). Foxtail millet average length was 1.16mm, with a standard deviation of 0.13mm; width 1.19mm (stdev 0.11mm); and thickness 0.9mm (stdev 0.10mm). Average L/W for *Setaria* was 0.97mm (stdev 0.10mm, see fig. 7-14).

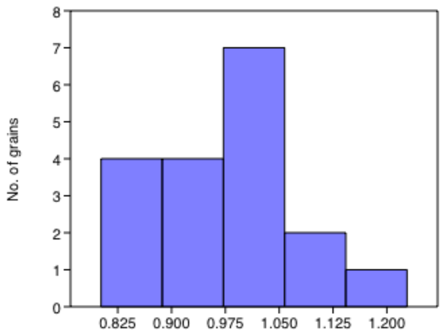


Fig. 7-14: Histogram plot of *Setaria italica* L/W ratio from Dayingzhuang. Made with Past.

15 grains of *Panicum miliaceum* were also measured (Appendix 4). This species average length was 1.76mm (stdev 0.15mm). width 1.73mm (stdev 0.21mm), and thickness 1.3mm (stdev 0.21mm). Average L/W was 1.33mm (stdev 0.21mm; see fig. 7-15).

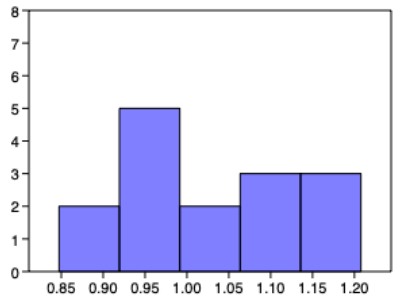


Fig. 7-15： Histogram plot of *Panicum miliaceum* L/W ratio from Dayingzhuang. Made with Past.

Context analysis

With the exception of some broomcorn millet grains found in *hedao* contexts, both millet species are found proportionately more in pit contexts (fig. 7-16).

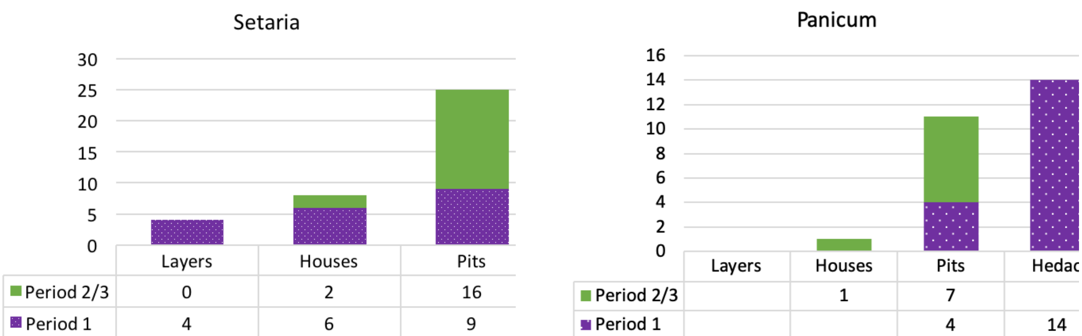


Fig. 7-16: *Setaria* and *Panicum* remains context analysis at Dayingzhuang, with indication of absolute counts divided by periods.

7.4.4. Chenopodium

Chenopodium remains have been found in 20 out of the 30 total samples analysed, and they account for about 33% of the total identified remains. *Chenopodium* is the second most abundant species in the overall archaeobotanical assemblage at Dayingzhuang, after wheat, and followed by rice (fig. 7-7). *Chenopodium* density per litre is of 0.46items/L. *Chenopodium* remains are composed of mostly whole seeds, more rarely of split half seeds. Chronologically, *Chenopodium* has been found in more samples and in much higher quantity during period 2/3 (figs. 7-8; 7-9).

Morphometrics

28 grains of *Chenopodium* from Dayingzhuang were measured (Appendix 4). Average L/W was 1.09mm, with a standard deviation of 0.07mm (fig. 7-17). This is slightly smaller than *Chenopodium* remains found at Haimenkou, which measure on average 1.13mm in L/W (Chapter 6), but the seed coat thickness of *Chenopodium* grains at Dayingzhuang measures on average 32.7um (Appendix 4). More measurements from other sites in China and Yunnan in the future might be able to correctly interpret this find.

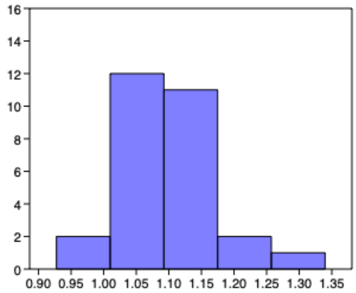


Fig. 7-17: L/W measurements on *Chenopodium* grains from Dayingzhuang. Made with Past.

Context analysis

The great increase of *Chenopodium* remains in period 2/3 corresponds to a very sharp increase of this species from pit contexts H8 and H11, as well as from house context F1-1 (see Appendix 2, fig. 7-18 below). Whereas during the first period of occupation almost all of the *Chenopodium* remains came from layer deposits, during the later period they come almost exclusively from pits (fig. 7-18).

This is somewhat similar to dryland weed remains (fig. 7-19), however the extremely low quantity of weed remains at Haimenkou (see below) hinders our full understanding of the role of *Chenopodium* at Dayingzhuang.

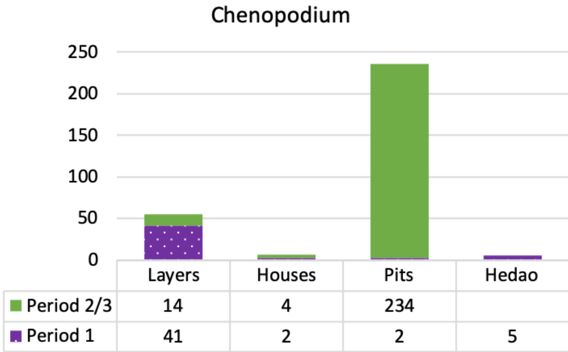


Fig. 7-18: *Chenopodium* remains context analysis at Dayingzhuang, with indication of absolute counts divided by periods.

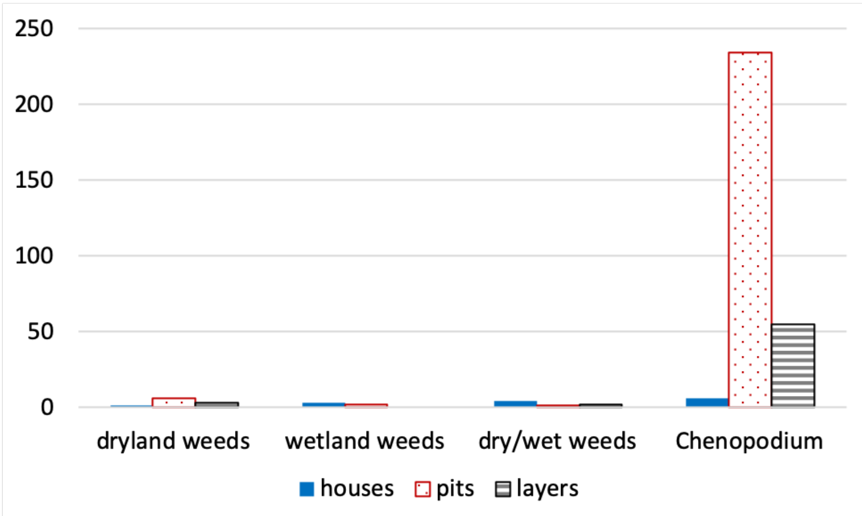


Fig. 7-19: Comparison of context analysis of *Chenopodium* vs. weeds remains from Dayingzhuang.

7.4.5. Other economic species

A few species of nuts and fruits, as well as some seeds of *Zanthoxylum* sp. (Sichuan pepper), were recovered at Dayingzhuang. Although 5 seeds of pulses, including indet. Fabaceae, and some small *Vicia* sp. seeds were also recovered, because of their very low absolute count, they are not considered as potentially economic plants, but are instead grouped with the seeds of dryland weeds. Wild species at Dayingzhuang are found in less than half of the samples analysed, but account for only about 5% of the total identified remains (fig. 7-7).

7.4.5.1. Nuts

Nuts are the most numerous wild species found. These include *Euryale ferox* (foxnut), some indet. acorns, and 1 possible fragment of *Castanea* sp. (table7-7). The increase of wild species remains during period 2/3 is largely due to the increase of nut remains.

Table 7-7. Breakdown of nut remains, with absolute counts and number of samples in which they were found.

Nut remain	Total	Ubiquity (no. of samples)
Euryale ferox (fragments)	43	13
Acorns	6	2
Castanea sp.	1	1
TOTAL	**50**	**15**

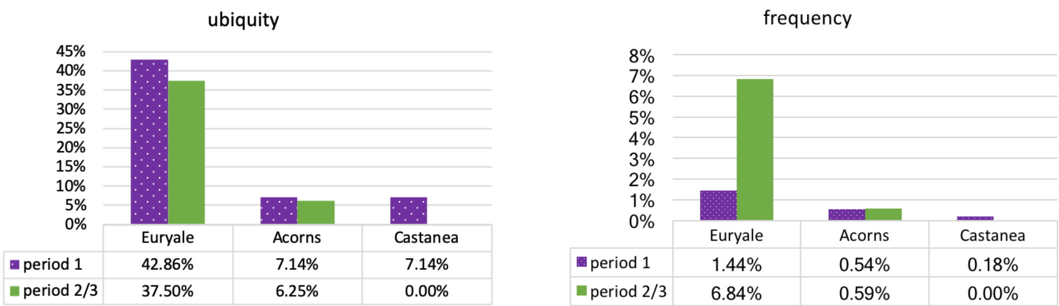


Fig. 7-20: Ubiquity (left); and frequency (right) indexes of main nut remains at Dayingzhuang divided by periods.

Foxnut remains take up the majority of the nut remains; they are found in over 30% of the total samples analysed from both periods, but during period 2/3 they increase sharply (fig. 7-20). This is largely due to the increase of *Euryale* from pits contexts during the later period of occupation of Dayingzhuang (fig. 7-21).

Fig. 7-21: Context provenance of nut remains at Dayingzhuang, with indication of absolute counts.

7.4.5.2. Fruits

A very small number of seeds from fruit species have been found at Dayingzhuang, and these include some indet. Rosaceae seeds, and 1 seed of *Solanum/Lycium* sp. (table 7-8). Both taxa are found only in samples from period 1, and both come from layer contexts.

Table 7-8. Breakdown of fruit remains at Dayingzhuang, with indication of absolute counts.

Remain type	Total	Ubiquity (no. of samples)
Rosaceae indet.	3	2
Solanum/Lycium sp.	1	1
TOTAL	4	3

7.4.5.3. Other: Zanthoxylum sp.

Finally, 3 seeds of *Zanthoxyum* sp. were recovered from the samples analysed. They all come from pit contexts dating to the later phase of occupation of the site. With the systematic application of flotation during excavation in many sites in Southwest China, *Zanthoxylum* sp. specimens have been recovered with increasing frequency (e.g. D'Alpoim Guedes, 2014). Very little is known about the domestication of Sichuan pepper (*Zanthoxylum* spp.), 36 out of the 41 total Chinese *Zanthoxylum* species are found in Southwest China, therefore, this area is a likely candidate for this species' domestication centre (Zhu, et al., 2016), but no detailed morphological or genetical studies on archaeological remains to address this topic have been undertaken yet.

7.4.6. Seeds of field weed species

Differently from Baiyangcun, seeds of field weed species at Dayingzhuang are not very prominent. Field weed species belonging to the families of Poaceae, Polygonaceae, Fabaceae, Euphorbiaceae, Alismaceae, Apiaceae, and Portulaceae were found at Dayingzhuang. They account for slightly over than 1.8% of the total identified remains, but nevertheless, seeds of field weed species are found in more than 30% of the samples analysed. The same categories that were applied to the classification of weeds at Baiyangcun have been utilized for the analysis of the field weed assemblage at Dayingzhuang, as outlined in table 7-9.

Table 7-9. Weed ecology indicating species of field weeds found at Dayingzhuang.

Dryland weeds	Wetland weeds	Both dry/wetland weeds
Euphorbiaceae indet .	*Alisma* sp.	Apiaceae indet.
Pennisetum sp.	*Schoenoplectus* sp.	*Echinochloa* sp.
Portulaca sp.	*Rumex* sp.	
Vicia sp.		

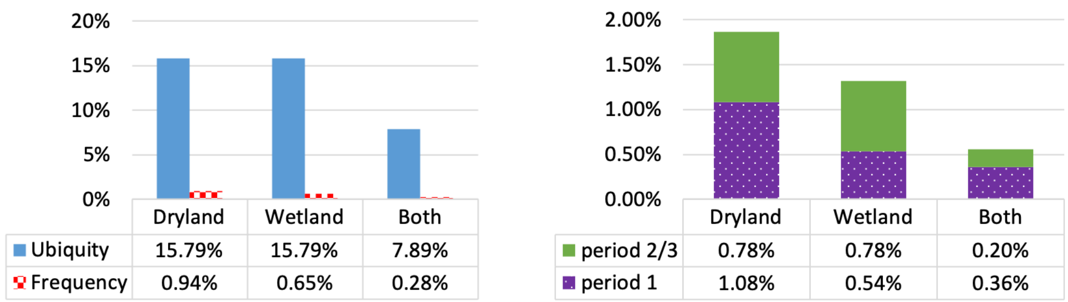


Fig. 7-22: Ubiquity and frequency index for weed species at Dayingzhuang (left); and frequency through the two periods of occupation (right).

The overall weed assemblage is composed primarily of dryland weed species (fig. 7-22).

Opposite to wild species, field weed species show a decreasing trend, both in ubiquity and frequency, from period 1 to period 2/3, apart from wetland field weeds that show a very slight increase in absolute count (fig. 7-22 right). Seeds of field weed species are found mostly in pits, and houses, and then layers. However, their extremely low absolute count makes it very difficult to make meaningful inferences about the weed assemblage.

The rather homogeneous presence of all three categories of weeds is in line with the mixed crop economy as indicated by the crop assemblage at Dayingzhuang.

The presence of wetland weeds associated with rice cultivation seems to suggest that rice was cultivated in a wetland regime. Early Chinese historical documents dating to 16 AD describe that, in the north-eastern area of the Lake Dian, irrigation was being practiced in rice agriculture (Yao, et al., 2015).

7.5. Phytoliths

A total of 12 phytolith samples were processed to slide, but only 11 were counted (see Chapter 4), including 2 modern samples (no. 3 and 10). On average, the percentage weight of phytoliths was 6.48%, with a minimum of 0.37% for sample 30, and a maximum of 22.7% for sample 34. However, as evident from table 7-10, there was a great diversity in phytolith weight throughout the samples, with less than half having high percentages (between 9 and 22%), and the rest with very low measurements between 0.3 and 1.2% (table 7-10).

Table 7-10. Percentage weight of phytoliths, Dayingzhuang samples.

Layer	Sample ID	% weight
5	34	22.7
	32	0.38
	30	0.37
	26	9.9
4	24	14.8
	22	1.76
	20	0.62
	18	1.24
3	16	13.07
Modern	10	5.86
	3	0.53

Overall, monocot single cells make up the majority of the remains in most of the samples, constituting around 70% of the total single cells (fig. 7-23). The most common single cells morphotypes are long cells (either smooth, echinate or dendritic) followed by rondels and saddles. The most common multi cells morphotypes are indet. husk and *Oryza* husk (including *Oryza* double-peaked glume cells). In samples 20, 18, and 16, monocot single-cell phytoliths decrease overall to between 8-18% (although are still higher in frequency than eudicot phytoliths), and this is due to the very high presence of *Oryza* husk remains (fig. 7-24). *Oryza* husk remains are found in all 11 samples; 7 samples also contained wheat husk multi-cells and millet husk multi-cells, predominantly of *Setaria* type (fig. 7-24, see Appendix 2B for full results).

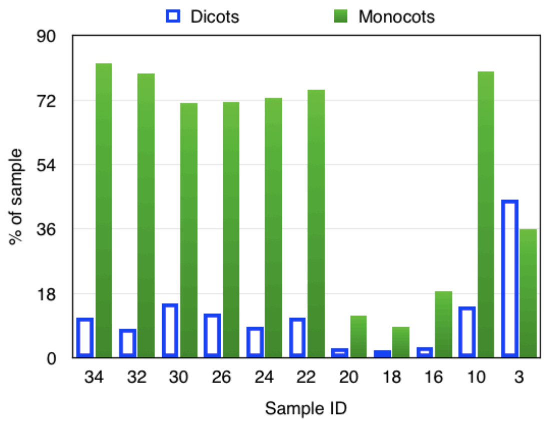
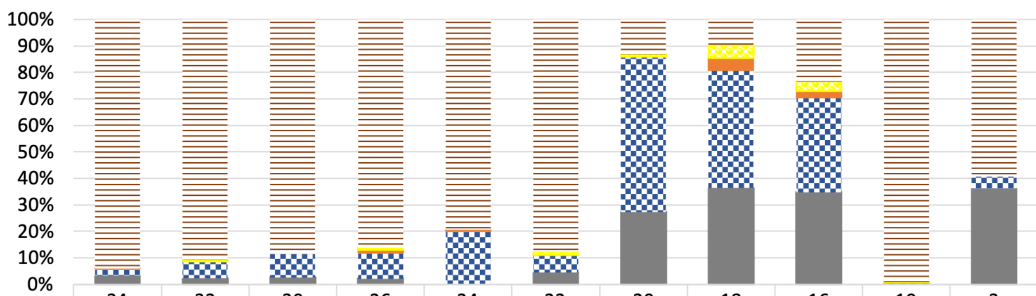


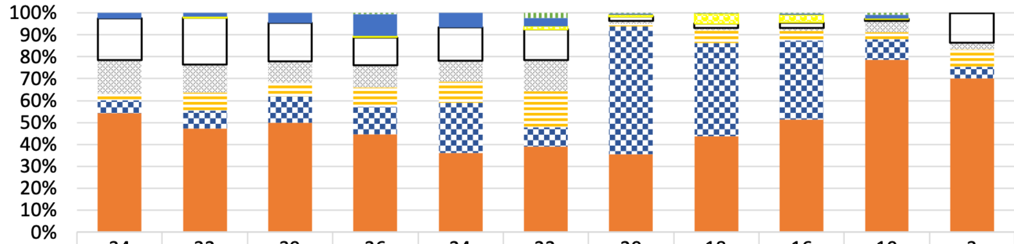
Fig. 7-23: Relative frequencies of dicot and monocot single cells from Dayingzhuang.



	34	32	30	26	24	22	20	18	16	10	3
Monocots	82.1330	79.3970	71.1268	71.4360	72.4371	74.7598	11.8523	8.5638	18.7452	79.8104	35.8442
Wheat husk	0.0000	0.5025	0.0000	0.6594	0.0000	0.9978	0.7231	4.2819	2.7716	0.1896	0.0000
Setaria husk	0.0984	0.0000	0.0000	0.8792	0.5525	0.2217	0.0000	4.2819	2.0787	0.2844	0.0000
Oryza husk	2.2636	5.5276	7.0423	8.1327	18.2320	5.5432	52.7838	39.2507	28.4091	0.2844	2.7273
Indet husk	2.8541	2.0101	2.1127	1.7584	0.0000	3.7694	24.5842	32.1142	27.7162	0.0000	21.8182

Fig. 7-24: Relative percentages of crops husk at Dayingzhuang.

Comparing the morphotypes from the different grass taxa shows that the samples from Dayingzhuang have a high input from the Poaceae subfamily, followed by Pooid for the earlier phase (samples 30-26, corresponding to Layer 5), and *Oryza* for the later phase (especially samples 20-16, corresponding to layer 4, as highlighted above). In general, there is a lower input from the Chloroideae, Panicoideae, Cyperaceae, Triticaceae, and Bambusoideae subfamilies (fig. 7-25).



	34	32	30	26	24	22	20	18	16	10	3
Bambusoideae	0.0000	0.0000	0.0000	0.5233	0.0000	1.8108	0.2109	0.0892	0.3234	0.5687	0.0000
Cyperaceae	1.9325	1.5075	3.5211	7.8501	5.8932	3.1042	0.6327	0.2676	0.3695	1.1374	0.0000
Triticaceae	0.0000	0.5025	0.0000	0.6594	0.0000	0.9978	0.7231	4.2819	2.7716	0.1896	0.0000
Pooid	14.4941	18.5930	13.3803	10.2051	13.2597	11.1234	1.8559	1.7247	1.9863	0.5687	7.2727
Chloroideae	11.9173	11.0553	7.3944	8.1118	8.5942	11.1234	1.1810	1.0705	0.9239	3.4123	1.5584
Panicoideae	2.3530	7.0352	4.5775	7.1593	8.4101	12.8603	1.1388	5.5902	3.6031	2.1801	4.2857
Oryza	4.5182	7.0352	9.1549	9.9644	20.1964	7.0953	53.7117	39.5480	28.4553	6.3507	2.7273
Indet Poaceae	41.5765	41.2060	38.0282	36.0163	31.8600	30.7095	32.9597	41.0943	40.3639	52.6066	37.4026

Fig. 7-25: Relative frequencies of grass subfamilies at Dayingzhuang.

Grasses short cells were classified following categories outlined in Madella et al (2009) and Weisskopft et al (2015). Short single cells, such as rondels, saddles, bilobates, and crosses, are so-called fixed phytoliths, produced by the plant independently by the water availability, and therefore can be used as indicators of dry ecology. Long cells instead, including long smooth, echinate, and dendritic cells, are instead sensitive to the water intake of the plant during growth, therefore their higher presence indicate a wetter ecology (Madella, et al., 2009; Jenkins, et al., 2016).

This kind of analysis at Dayingzhuang could not produce conclusive results (table 7-11), as the majority of the samples analysed are not crop dominant. For those few samples that are crop dominant, we see some contrasting results: samples 20 and 18 have a very low sensitive:fixed ratio, which suggests a drier ecology, but sample 16 shows a completely opposite signature, with a sensitive:fixed ratio over 3, which suggests a wetter, possibly irrigated, ecology (following dry for values <1.5, and wet for >1.8; following Kingwell-Banham, 2019; Kingwell-Banham, 2019b). For these three samples there is a slight increase of *Setaria* and wheat husk (fig. 7-21), which could account for the dry signature. All three samples correspond stratigraphically to layer 4, and phytolith samples were taken at 10cm vertical increments (see Chapter 4). As the excavation report hasn't been published yet, it is unclear how each phytolith sample relate to the site features.

Table 7-11. Breakdown of *Oryza* phytoliths percentage in relation to each sample sensitive: fixed ratio per sample from Dayingzhuang.

Layer	Sample ID	*Oryza* morphotypes %	S:F ratio
Modern	3	2.72	0.87
	10	6.35	2.92
3	16	28.45	3.08
4	18	39.54	0.51
	20	53.71	1
	22	7.09	0.51
	24	20.19	0.74
5	26	9.96	1.02
	30	9.15	0.93
	32	7.03	0.75
	34	4.51	0.98

The D/P index at Dayingzhuang is consistently below 1, with the exclusion of modern sample 3, indicating grassland (Chapter 4). This suggests that the area on the northeastern side of the Lake Dian was already heavily deforested by the beginning of the occupation of the site of Dayingzhuang (fig. 7-26 right). This is further confirmed by the comparison of grasses short cells and woody morphotypes, as these are consistently present in higher quantities (fig. 7-26 left).

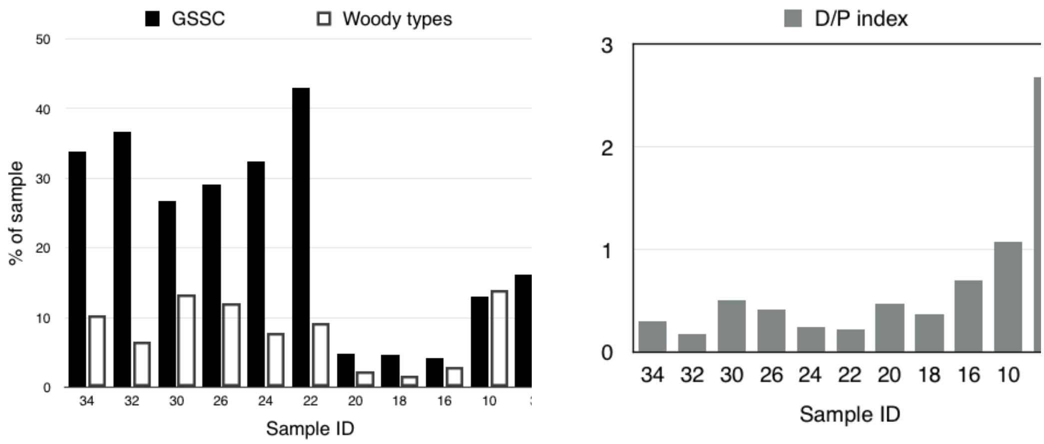


Fig. 7-26: Grass short cell vs. woody morphotypes (left), and D/P index (right) at Dayingzhuang.

Finally, the phytolith remains at Dayingzhuang were grouped in leaf and husk morphotypes to investigate possible crop processing patterns on site, as phytoliths samples were collected at the heart of the settlement, between the dwellings (see Chapter 4). During the first period (phytolith samples 34 to 26), leaf remains are slightly higher than husk remains, but these samples are generally not very crop rich (fig. 7-27 top). In samples 20-16 (corresponding to period two) overall husk remains are recorded at a much higher frequency than leaf remains. This is largely due to the presence of *Oryza*-type husk, but also due to *Setaria*-type husk multicells in sample 18 (fig. 7-27 bottom). This would suggest that the later stages of crop processing were possibly carried out on-site during the later phases of occupation of Dayingzhuang, as evidenced by the higher quantity of husk remains over leafy remains, which are associated with de-husking activities (see fig. 4-9 in Chapter 4).

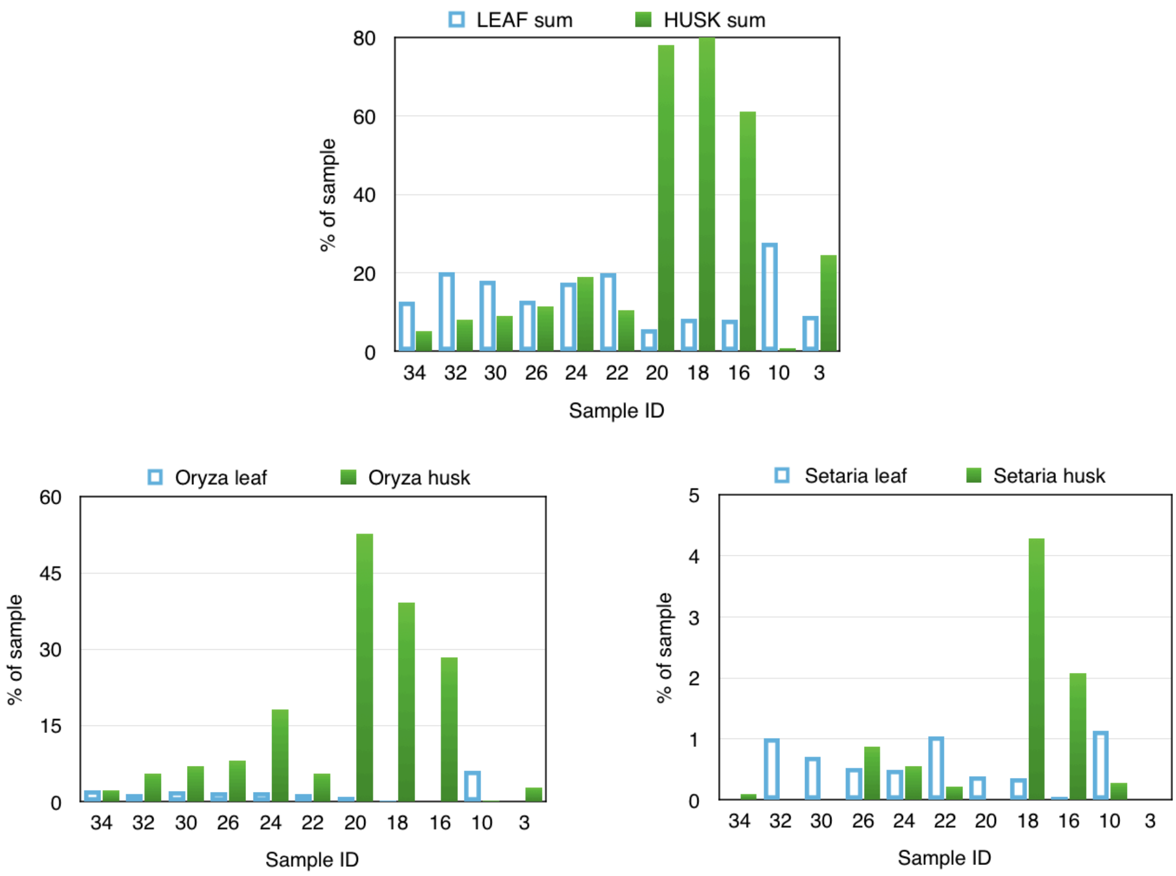


Fig. 7-27: Relative percentages of leaf vs. husk remains at Dayingzhuang: overall (top); *Oryza* (bottom left); *Setaria* (bottom right).

7.6. Dayingzhuang: summary

Dayingzhuang is one of the few Dian settlements that have been systematically excavated so far. The archaeobotanical analyses undertaken as part of this thesis have revelaed that the preservation at the site was very poor, and this is most probably due to the specific nature of the site (a shell-midden site), and the location, extremely close to the Lake Dian and the Tanglang River, which could have caused a continuous erosion action of the soil.

The main crops recovered at Dayingzhuang include wheat, rice, and millets (mostly foxtail millet). A few grains of barley were also recovered, as well as high quantities of *Chenopodium,* however, it is unclear if *Chenopodium* became included in the assemblage as a weed, or if it was actively exploited for food.

A few other additions to crop remains have been found, including foxnut, and unidentified acorns and Rosaceae type fruits. This points to a varied subsistence strategy which a mixed crop cultivation system that possibly relied on crop rotation. The mild and favourable to agriculture climatic conditions also suggest the possibility that two cropping per year were practiced: a summer harvest of rice and millets, and a winter harvest of wheat.

Historical records indicate that irrigated rice cultivation might have been practiced during the Dian, however, there is no archaeological report of irrigation features until the first centuries AD (Yao et al., 2015). Even though the area surrounding the Lake Dian might have supported wet rice cultivation, our phytoliths analysis from Dayingzhuang has been inconclusive in this regard, as have other studies (i.e. Yao et al., 2015). Although high quantities of rice remains are indeed present, a too small of a number of seeds of wetland field weeds have been recovered, and, thus, this issue remains unresolved.

CHAPTER 8. Tracing the spread and the development of agriculture in Southwest China between the 3rd and 1st millennia BC

8.1. Introduction

In this chapter the new data presented in the Chapters 5-6-7 will be compared against other available archaeobotanical datasets from Yunnan and the neighbouring Chinese provinces of Sichuan, Tibet, Chongqing and Guizhou, as well as available datasets from the mainland Southeast Asian countries of Laos, Vietnam, and Thailand (see fig. 8-1 for a list of sites analysed in this chapter and their location). This meta-data analysis is the first of its kind to be carried out in the region, with previous studies on agricultural development in Yunnan taking mostly a localised, individual case-study approach. The analysis provided in this chapter will thus allow for the comprehensive investigation of plant resources and their specific use not only in Yunnan, but also in the broader Southwest China region and the adjacent areas between the 3^{rd} and 1^{st} millennia BC. This provides a working synthesis and a solid framework from which to develop future research, which so far has been limited. Additionally, the new data derived from the 3 sites analysed in this thesis provides comparative material that by spanning chronologically across the three millennia greatly expands our knowledge of early plant use in the province.

The data compiled in this meta-data analysis is derived mostly from site-specific archaeobotanical reports published in both Chinese and English academic journals, as well as master and doctorate theses. These usually provide raw data, both quantitative and qualitative, in relation to each site archaeobotanical assemblage composition (frequency index), and domestications/exploitation status of plant species recovered as relevant. Tables included in the text of these primary sources allow for the extrapolation of numerical values which the author collated in an excel spreadsheet, and from which histograms were produced, with sites analysed plotted according to their absolute chronology. In contrast to published archaeobotanical reports in academic articles, master and doctorate theses often provided raw data on a sample by sample basis (i.e. Xue 2010; D'Alpoim et al., 2013), however, due to the fact that the majority of the sources consulted for this analysis did not provide detailed sample by sample information, here only the overall archaeobotanical assemblage composition, with frequency index as main comparative value, has been taken into account.

The information gathered as part of this meta-data analysis focus on plant resources which have a strong economic value within each site archaeobotanical assemblage (cereal crops, fruit, nuts, pulses and other economic species as relevant), this is plotted separately and against data from seeds of field weeds, to further discuss the ecology of the agricultural systems and their possible evolution through time and space.

There are clear limitations on the reconstruction of regional subsistence patterns from the comparison of such different datasets as those included in this section. The different provenance of the samples, from either excavations or surveys, the different people involved in the collection of the samples, all might affect the archaeobotanical remains, and, therefore, the results obtained from each site. However, as we have seen in Chapter 4, the collection of archaeobotanical remains in China is standardized across the country through national guidelines since 2009. Moreover, most of the publications consulted for this section provided information regarding the mesh size used for flotation, which was between 0.2-0.3mm for all sites here considered. A similar situation exists for the remains analysed from mainland Southeast Asian countries, and collection methods are stated in summarising table for each region (see tables 8-1, 8-2, and 8-3). For this reason, although there may still be some difference in the level of sorting or identification based on care and experience of different workers, the results are broadly comparable. In order to help contextualise each archaeobotanical assemblage and frequency index in comparison to the other sites, absolute numbers relating to the overall quantity of identifiable remains from each site are provided in footnotes across this chapter. This will provide the basis for discussing the chronological and geographical changes of the subsistence strategies carried out in broader Southwest China.

Finally, through the analysis of the available archaeobotanical evidence from some of the mainland Southeast Asian countries (Thailand, Vietnam, and Laos) the question of possible cultural contacts and agricultural spread between Neolithic Yunnan and mainland Southeast Asia will be addressed, and previous theories and hypothesis regarding the so-called Austroasiatic language/farming dispersal hypothesis will be evaluated against the newly established archaeological framework.

8.2. State of prior knowledge

Before the year 2010, archaeobotanical analyses in Yunnan had been carried out only at a handful of sites, many of which were not systematically undertaken and relied on material hand-picked with the naked eye (of mostly rice grains) during excavation. This includes the sites of Haidong (He, 2000); Xinguang (Yunnan, 2002), and Nanbiqiao (Kan, 1983). Similarly, two sites underwent selective archaeobotanical sampling of those contexts that appeared particularly rich to the naked eye during excavation (i.e. Shifodong and Mopandi; Zhao 2010; Zhao 2003). At these sites remains recovered included rice and, although in lower quantities, foxtail millet. Finally, archaeobotanical samples were also collected during survey of the sites of Anjiang and Xiaogucheng (Yao et al., 2015), and possibly Shizhaishan (Yao & Jiang, 2012), where rice, foxtail and broomcorn millets, as well as wheat were recovered.

The only site that underwent systematic archaeobotanical sampling before 2010 was Haimenkou, excavated in 2008 (Xue, 2010; Jin, 2013). Here, archaeobotanical analyses revealed an economy based on a variety of different crops, including mostly *Setaria italica*-foxtail millet, rice, as well as the western domesticates *Triticum aestivum*-wheat and *Hordeum vulgare*-barley from at least c. 1400 BC (Xue, 2010; Jin, 2013).

After 2010, environmental sampling started being undertaken at an increasing number of sites, including at Dadunzi (Jin, 2014), Baiyangcun (Dal Martello et al., 2018), Shilinggang (Li et al., 2016), Guangfentou (Li & Liu, 2016); Xueshan (Wang, 2014); Yubeidi and Hebosuo (Yang, 2016). Through these studies, knowledge of early plant use in Yunnan has expanded greatly.

During the late 3rd millennium BC, at Dadunzi, a mixed millet-rice economy with prevalence of foxtail millet was attested (Jin 2014). Here, the majority of the archaeobotanical assemblage was constituted by crop remains.

At the later sites of Shilinggang (Li et al., 2016), Xueshan (Wang, 2014), Guangfentou (Li & Liu, 2016), and Yubeidi and Hebosuo (Yang, 2016), dating to the early 1st millennium BC, crop remains also constitute the majority of the recovered archaeobotanical remains, and a similarly mixed economy based on rice and millets, with the addition of western domesticates, with a prevalence of wheat, was attested.

A three-phase agricultural development for Yunnan was proposed on the basis of this recent archaeobotanical work (Li, et al. 2016):

4. Rice-based economy (c. 2800–1900 BC);
5. Mixed rice-millet economy (c. 1900–1400 BC);
6. Introduction of Western domesticates, and mixed rice, millet, wheat and barley economy (c. 1400–300 BC).

An initial rice only phase of agricultural development during the early 3rd millennium BC was challenged through preliminary archaeobotanical analyses done at the site of Baiyangcun for this dissertation and partly published before the submission of this thesis (Dal Martello et al., 2018). At Baiyangcun, both rice and millets have been found together since the earliest occupation stages and from samples from the lowest stratigraphic contexts.

Moreover, Li et al.'s (2016) synthesis only accounted for cereals, without taking into consideration cultivation ecologies, as well as input from other economic species, such as fruits and nuts. The meta-data analysis undertaken in this chapter attempts to fill in this gap, by comprehensively analysing not only the overall composition of the archaeobotanical assemblages at each site, but also through an analysis of the specific cultivation ecologies; it attempts to understand changes in human behaviours as well as address questions regarding the spread of agricultural practices across the broader region of Southwest China and mainland Southeast Asia.

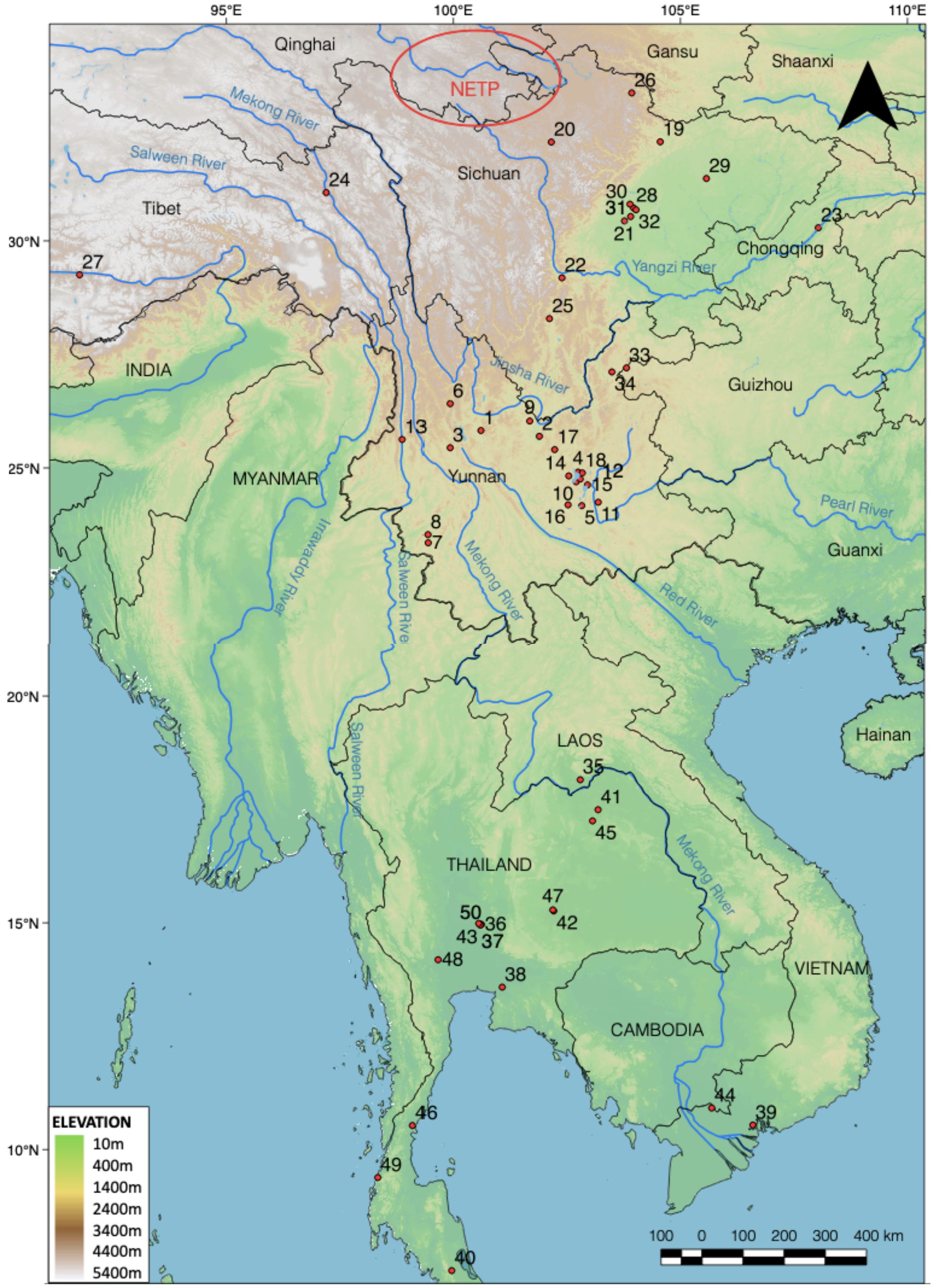


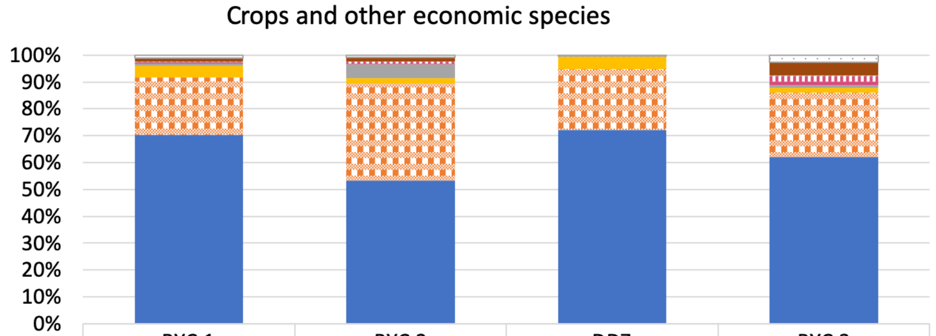
Fig. 8-1: Location of sites mentioned in text: 1. Baiyangcun; 2. Dadunzi; 3. Xinguang; 4. Haidong; 5. Xingyi; 6. Haimenkou; 7. Shifodong; 8. Nanbiqiao; 9. Mopandi; 10. Shizhaishan; 11. Hebosuo; 12. Anjiang; 13. Shilinggang; 14. Dayingzhuang; 15. Xueshan; 16. Guangfentou; 17. Yubeidi; 18. Xiaogucheng; 19. Yingpanshan; 20. Haxiu; 21. Baodun; 22. Maiping; 23. Zhongba; 24. Karuo; 25. Gaopo; 26. Ashaonao; 27. Changguogou; 28. Guojishequ; 29. Zhengjiaba; 30. Boluocun; 31. Sangongtang; 32. Jinsha 5C; 33. Jigongshan; 34. Wujiadaping; 35. Lao Pako; 36. Non Pa Wai; 37. Non Mak La; 38. Khok Phanom Di; 39. Rach Nui; 40. Tha Kae; 41. Ban Chiang; 42. Ban Non Wat; 43. Nol Kham Haeng; 44. Lo Gach; 45. Ban Na Di; 46. Khao Sam Kheo; 47. Non Hua Raet; 48. Ban Don Ta Phet; 49. Phu Khao Thong; 50. Phromtin Tai. NEPT label indicates Northeast Tibetan Plateau region.

8.3. Comparison of crop systems and early agricultural trajectories in Yunnan between the 3rd and 1st millennium BC

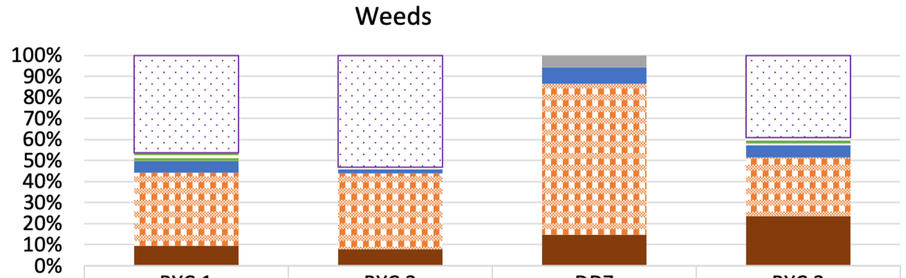
8.3.1. Evidence for agriculture in Yunnan between the 3rd and 2nd millennium BC

In Yunnan, sites dating to between the 3rd to 2nd millennia BC sites mostly follow a north to south, early to late chronological distribution, suggesting that possible migrations of agriculturalists in the region reached Yunnan through its northern border (see Chapter 2). Of all known sites dating to this time period, only two sites have undergone systematic archaeobotanical collection: Baiyangcun (Dal Martello et al., 2018; Chapter 5 of this thesis), and Dadunzi (Jin et al., 2014). The crop assemblage at both these sites was dominated by rice and millets, with foxtail millet predominant over broomcorn millet (fig. 8-2). Moreover, crop remains account for the majority of the assemblages, especially at Dadunzi, where the crops reach over 86% of the total identified remains (Jin, 2014; fig. 8-2). Other edible plants such as pulses (i.e. soybean), wild fruits, and nuts are not numerous, but their high ubiquity across the samples at Baiyangcun indicates that a variety of resources were exploited (Chapter 5). A set of field weeds was recovered at both sites, and although it has been difficult to disentangle weeds in mixed crop systems, at both sites we find weeds typically associated with irrigated rice, such as *Fimbristylis* sp., and *Scirpus* sp. This would therefore indicate that in the mid-3rd to late 3rd millennium BC, rice production in northwest Yunnan was characterised by a wet regime. This is also the kind of ecology inferred for early rice in both the Yangzi Basin and northern China (Fuller & Qin, 2009; Weisskopf et al., 2015; Deng et al., 2015; Fuller et al., 2016).

Although systematic flotation has also been carried out at the site of Xingyi, the archaeobotanical report has not been published yet. A preliminary assessment during excavation individuated rice remains, as well as abundant acorn and freshwater mollusc shell remains (*Margarya* sp.). According to the excavation director, people at the site were strongly reliant on lacustrine and wild resources, with rice being possibly cultivated in a small-scale system, as a sort of back-up resource (Min Rui, personal comment 2016). At Haidong, lacustrine resources (such as *Margarya* sp.) have also been reported as present in extremely high quantity (Li & Hu, 2009; Yunnan, 2017).



	BYC 1	BYC 2	DDZ	BYC 3
Indet.	0.91%	0.70%	0.24%	1.94%
Nuts	1.16%	1.18%		3.54%
Fruits	0.05%	0.04%	0.08%	0.17%
Pulses	0.11%	0.46%	0.28%	1.55%
Spybean	0.34%	0.31%		0.86%
Indet. millets	0.81%	3.86%		0.82%
Broomcorn m.	3.52%	1.65%	4.49%	1.12%
Foxtail m.	17.89%	27.76%	22.36%	17.48%
Rice	59.00%	41.01%	70.81%	44.76%



	BYC 1	BYC 2	DDZ	BYC 3
Environm. Weeds			0.10%	
Echinochloa	7.50%	12.25%		10.88%
Both dry and wet	0.64%	0.23%		0.99%
Wetland weeds	0.92%	0.46%	0.14%	1.60%
Dryland weeds	5.65%	8.32%	1.26%	7.73%
Chenopodium	1.51%	1.78%	0.26%	6.56%

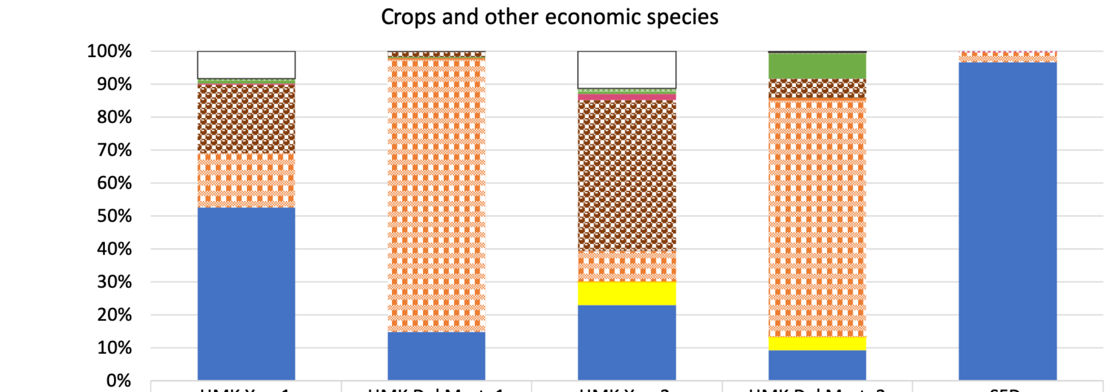
Fig. 8-2: Comparison of frequency index for sites in Yunnan with flotation, dating between c. 2600-1600 BC. The site initials are used to indicate the site (BYC= Baiyangcun; DDZ= Dadunzi)[17], with number indicating chronological phase.

[17] Total numbers of identified remains per site: BYC 1=7948; BYC 2=7460; DDZ=3520; BYC 3=2317.

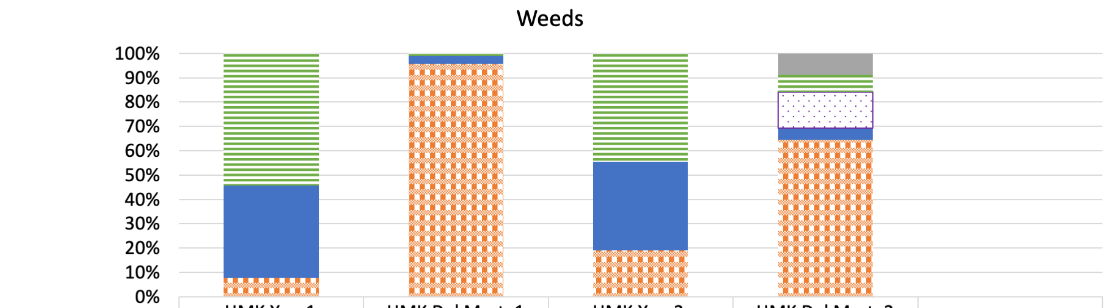
Although no systematic faunal studies have been undertaken at any of the sites mentioned above, general information regarding the presence of specific animal taxa shows that a similar suite of animals was present at each site. Animal bones of pig (domesticated?), sheep/goat, dog, possibly cattle and chicken (fowl?) have been reported, as well as few other wild animals such as deer and other small game. This could indicate that animal husbandry and hunting practices were both carried out at as part of the subsistence strategies. Moreover, extensive lacustrine resources have been recovered at both Haidong and Xingyi, indicating that fishing was a very important subsistence strategy at sites located close to lakes (see table 8-1 for a list of plant and animal remains recovered at these sites).

8.3.2. 2nd and 1st millennium BC sites

Comparatively more sites dating to this time period have undergone archaeobotanical collection in Yunnan; these include the sites of Haimenkou, Mopandi, and Shifodong. At all of these sites, rice and millets remains have been reported. This mixed crop economy was present since the beginning of Haimenkou occupation (fig. 8-3). The introduction of new crops brought in by incoming migrants during the second occupation phase increased the variety of resources exploited, but it did not push for its specialisation in fewer cultigens. The intensive exploitation of *Chenopodium*, who was possibly undergoing domestication, is also part of this strategy (Chapter 6). Moreover, the wide variety of local wild foods recovered at Haimenkou suggests that the local collection of wild resources was still heavily practiced and constituted an important part of the diet (Chapter 6). Buckwheat, recovered from Haimenkou in very small numbers, is an interesting find, but the extremely low quantity prevents us from fully understanding its status and role within the overall economy of Haimenkou.



	HMK Xue 1	HMK Dal Mart. 1	HMK Xue 2	HMK Dal Mart. 2	SFD
Indet.	4.55%	0.03%	6.40%	0.40%	
Nuts		0.01%		0.05%	
Fruits	0.24%		0.56%	0.27%	
Cannabis	0.55%		0.46%	7.24%	
Tamarindus					0.32%
Soybean	0.24%		0.98%	0.05%	
Chenopodium	11.28%	1.64%	26.08%	5.40%	0.00%
Buckwheat		0.01%	0.01%	0.03%	
indet. millets		0.26%		0.03%	
Broomcorn m.	0.03%	0.55%	0.07%	0.80%	0.06%
Foxtail m.	8.96%	81.70%	5.26%	68.72%	2.95%
Barley			0.09%	0.03%	
Wheat			3.95%	3.93%	
Rice	28.61%	14.67%	13.12%	8.81%	96.67%



	HMK Xue 1	HMK Dal Mart. 1	HMK Xue 2	HMK Dal Mart. 2
Environm. Weeds				0.37%
Both dry and wet	24.69%	0.01%	19.09%	0.30%
Echinochloa				0.62%
Wetland weeds	17.37%	0.04%	15.78%	0.21%
Dryland weeds	3.49%	1.09%	8.14%	2.73%

Fig. 8-3: Comparison of frequency index for sites in Yunnan with flotation, dating between c. 1600-1000 BC. The site initials are used to indicate the site (HMK= Haimenkou; SFD= Shifodong)[18], number refers to chronological phase.

[18] Total number of identified remains per site: HMK Xue 1= 2926; HMK Dal Mart. 1=8235; HMK Xue 2= 6736; HMK Dal Mart. 2= 6256; SFD= 8112.

During the author's visit to the Archaeobotany Laboratory at the Chinese Academy of Social Sciences (CASS) in April 2018, archaeobotanical material from Shifodong was consulted. In addition to rice and millet remains, at Shifodong two types of large tree legumes were also recovered. One has now been identified as possible *Tamarindus indica*; the specimens show a round shape with a raised centre (fig. 8-4 top). Around 20 individual specimens of *Tamarindus* cf *indica* were counted in the Shifodong samples stored at the CASS-Archaeobotany Laboratory. This species is usually regarded as native of Africa and only later introduced in India, and then China. However, recently it has also been proposed that there could be some native population of this species present in South Asia (Asouti & Fuller, 2008). This idea is supported by preliminary finds of archaeological wood remains, as well as linguistic data (Asouti & Fuller, 2008: 104; Fuller, 2007).

The other type of indet. tree legume is of oblong thin shape, and over 2cm in length (fig. 8-4 bottom). 9 individual specimens of this unidentified tree legume were counted in the Shifodong samples stored at the Chinese Academy of Social Sciences (CASS)- Archaeobotany Laboratory.

Moreover, mixed with seeds of *Setaria italica,* a few seeds of *Chenopodium* were also found, which had not been reported in previous publications (Zhao, 2010). Upon this discovery, the author consulted with prof. Zhijun Zhao, leading archaeobotanist in China and responsible for the Archaeobotany Laboratory at CASS. Prof. Zhao stated that the material stored from the site is not exactly the result of systematic flotation; he was sent the already extracted material to identify, therefore, the reported cultigens only show a partial assemblage, which includes a great quantity of rice husks, as well some possible fruit stones (Zhijun Zhao, personal comment 2018; Liu & Dai, 2008).

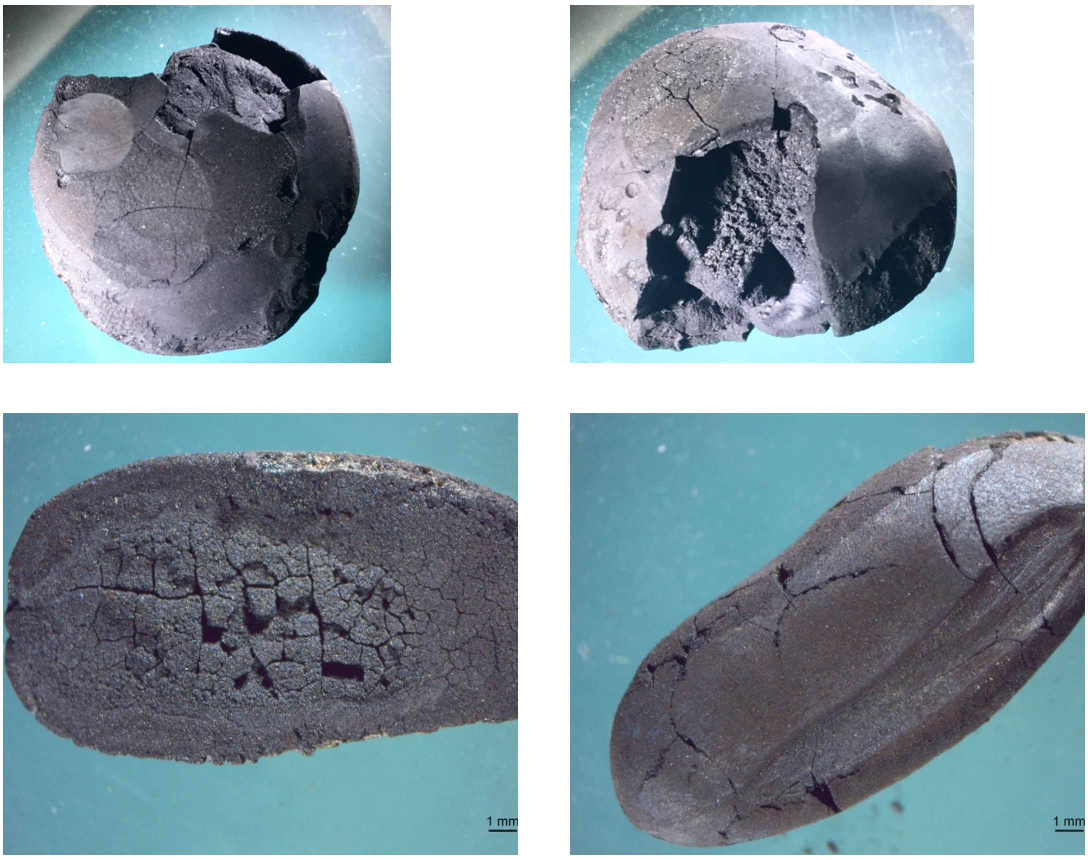


Fig. 8-4: Shifodong tree legumes: *Tamarindus indicus* (top); indet. tree legume type A (bottom). Photos by author.

The cultural division between the Jinsha and Mekong Basins, which was slightly evident from differences in material culture between the sites of Baiyangcun-Dadunzi, and Xinguang respectively, seems to become more accentuated in this millennium. This could possibly suggest that each site had stronger ties with Northwest China and Southeast Asia respectively. However, horse bones have been reported from the site of Shifodong (Liu & Dai, 2008), but no more detailed information has been provided about this find.

At Mopandi, a similar suite of animal bones found at the earlier sites of Baiyangcun and Dadunzi has been reported, including remains of pig, cattle, sheep/goat, etc. (see table 8-1). At Haimenkou, zooarchaeological analyses indicated that animal husbandry (especially pig) was practiced and contributed substantially to the diet but hunting and fishing activities were also still heavily practiced (Wang, 2018).

8.3.3. 1st millennium BC sites

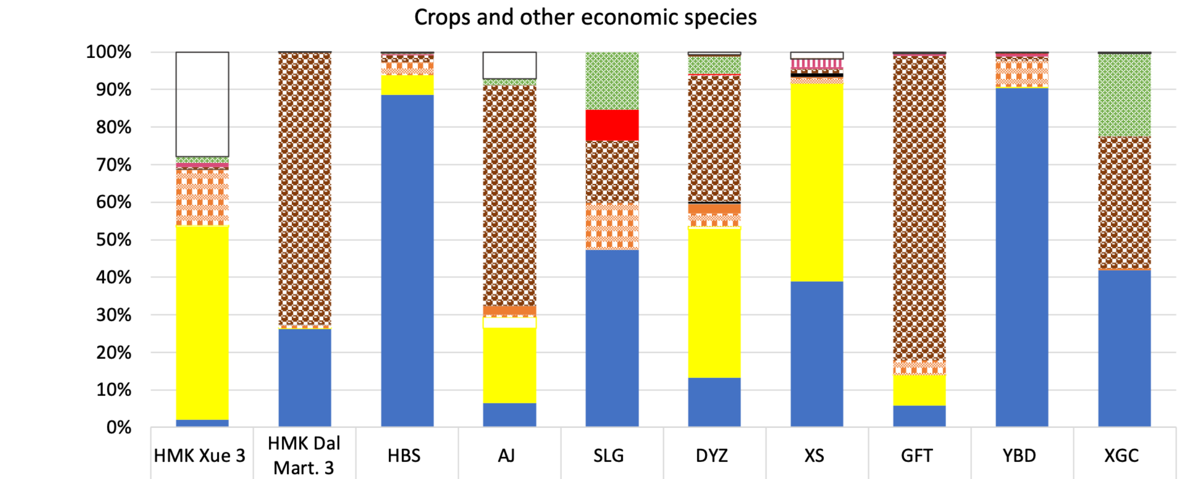
During the early 1st millennium BC in central Yunnan, mostly located around the Lake Dian, numerous sites associated with the Dian Culture have been surveyed, excavated, and due to the more recent archaeological investigation of these sites (within the last 5 years), the collection of archaeobotanical remains has been more widely practiced. These include the sites of Hebosuo, Anjiang, Dayingzhuang, Xueshan, Guangfentou, Yubeidi, and Xiaogucheng. Further sites belonging to this time period but outside the core area of Dian Culture's influence are the already mentioned site of Haimenkou, and Shilingang, located along the Mekong River.

Flotation carried out at those sites associated with the Dian Culture show a distinctive agricultural system constituted by a mixture of several different crops, including rice, millets, wheat, and possibly *Chenopodium* (fig. 8-5; table 8-1). At the time of occupation, the environmental and climatic conditions present in Central Yunnan were very similar to those of the present day, albeit highly fluctuating (see Chapter 3). Today, in Kunming annual average temperature is about 16°C, with winter mean temperature of about 10°C. Average winter precipitation is attested to 80-100mm and the region is generally frost free. The nearby water reservoir, coupled with the favourable temperature conditions allow for agricultural production all year round, and today there are three cropping per year (Zhao, 1986).

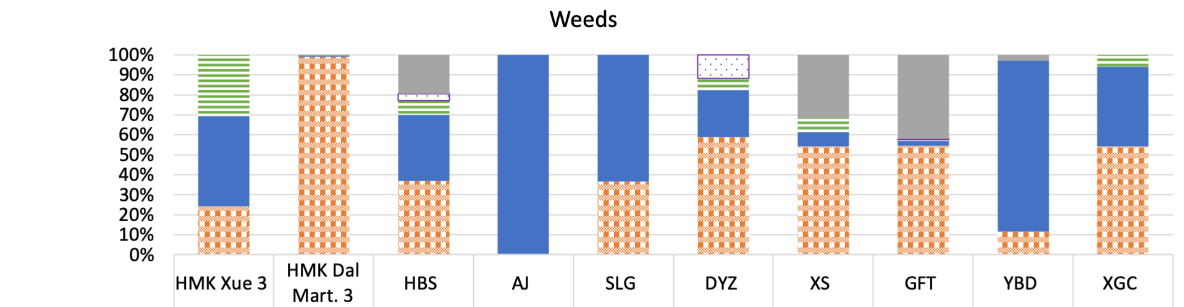
Would it have been possible to cultivate crops all year around during the 1st millennium BC? Both winter and summer varieties of wheat exist; millets can survive with minimal water (less than 125mm, see Weber et al, 2010); *Chenopodium* can also be grown at the end of the warmer months during the fall, or even during winter as it is highly tolerant to extreme conditions (Chapter 2). Therefore, it seems that a winter-summer crop rotation could have indeed been possible during the 1st millennium BC in the Dian Basin.

Rice, instead, is the dominant crop at those sites located deep within river valleys, such as Shilingang on the Mekong Basin, and Yubeidi on an affluent of the Jinsha River.

Not much data is available on faunal remains from 1st millennium BC sites in Yunnan (table 8-1). At Dayingzhuang, lacustrine resources have been reported as abundant; other sites in the Dian Basin also presumably took advantage of the nearby lake resources. At Shilingang, the same suite of animals reported from earlier sites, with remains of pig, cattle, etc., has been reported. However, their domestication status and abundance level are unclear.



	HMK Xue 3	HMK Dal Mart. 3	HBS	AJ	SLG	DYZ	XS	GFT	YBD	XGC
Indet.	17.81%	0.02%	0.26%	1.95%		0.75%	1.73%	0.31%	0.18%	0.08%
Nuts		0.02%	0.07%			0.37%	0.06%		0.03%	
Fruits	0.96%	0.01%	0.16%	0.49%	10.78%	4.68%	0.01%	0.19%	0.24%	4.08%
Zanthoxylum					5.88%	0.28%	0.05%		0.15%	
other pulses			0.07%			0.09%	2.03%			
Soybean	0.83%		0.30%				0.47%	0.46%	0.60%	
Chenopodium	0.30%	69.24%	1.74%	16.29%	11.76%	33.02%	1.07%	78.54%	1.06%	6.54%
Buckwheat	0.09%					0.47%	1.01%			
Indet. millets		0.09%				0.19%				
Broomcorn m.	0.04%	0.00%	0.23%	0.65%		2.43%	0.34%	0.06%		0.08%
Foxtail m.	9.40%	0.85%	3.12%	0.16%	8.82%	3.46%	1.41%	3.75%	6.92%	
Barley	0.30%	0.01%		0.81%		0.75%	0.05%	0.12%		
Wheat	32.69%	0.07%	5.19%	5.54%		38.91%	50.55%	7.75%	0.24%	
Rice	1.31%	25.09%	86.01%	1.79%	33.33%	13.00%	37.52%	5.65%	89.51%	7.77%



	HMK Xue 3	HMK Dal Mart. 3	HBS	AJ	SLG	DYZ	XS	GFT	YBD	XGC
Envornm. Weeds			0.56%				1.17%	1.33%	0.03%	
Echinochloa			0.10%			0.19%		0.01%		
Both dry and wet	11.10%	0.02%	0.20%			0.09%	0.26%	0.01%		4.69%
Wetland weeds	16.41%	0.02%	0.95%	72.15%	18.63%	0.37%	0.26%	0.07%	0.91%	32.54%
Dryland weeds	8.75%	4.56%	1.05%	0.16%	10.78%	0.94%	2.02%	1.73%	0.12%	44.23%

Fig. 8-5: Comparison of frequency index for sites in Yunnan with flotation, dating between c. 1000-300 BC. The site initials are used to indicate the site (HMK= Haimenkou; HBS= Hebosuo; AJ= Anjiang; SLG= Shilingang; DYZ= Dayingzhuang; XS= Xueshan; GFT= Guangfentou; YBD= Yubeidi; XGC= Xiaogucheng)[19].

[19] Total number of identified remains per site: HMK Xue 3=2297; HMK Dal Mart. 3= 10110; HBS=3046; AJ=614; SLG=102; DYZ=1070; XS=14799; GFT=6749; YBD=3309; XGC=1300.

Table 8-1. Summary of the main early sites in Yunnan with indication of geographical location (in reference to drainage system); chronological date; recovery methods of archaeobotanical materials; main archaeobotanical cultigens present at the sites; animal resources present if known/ zooarchaeological analysis present. For a full breakdown including a summary of information regarding excavation seasons and material culture for each of the sites see Appendix 5. Latin denomination indicates systematic analysis; common names indicate presence only as reported by excavation reports.

Site	River Basin/ Location	Chronological Date	Recovery method	Main cultigens present	Animal resources	References
Baiyangcun	Middle Jinsha (Yangzi)	AMS 2650-1690 cal BC	Flotation	*Oryza sativa* *Setaria italica* *Panicum miliaceum* *Glycine* cf *soja* *Cucumis* cf *melo* *Vitis* sp. *Euryale ferox*	Pig Cattle Goat/sheep Deer Tibetan bear	Yunnan, 1981 Dal Martello, et al., 2018 Dal Martello, 2019
Haidong	Qilu Lake	c. 2500-1750 BC	Hand picked	Rice	Abundant unspecified lacustrine resources	He, 1990 Xiao, 2001 Zhang & Hung, 2010 Yao, 2010 D'Alpoim Guedes & Butler, 2014
Xinguang	Upper Langcan (Mekong)	2500- 1750 cal BC	Hand picked	Rice	n/a	Yunnan, 2002 Yao, 2010 D'Alpoim Guedes & Butler, 2014
Dadunzi	Middle Jinsha (Yangzi)	AMS 2140-1630 cal BC	Flotation	*Oryza sativa* *Setaria italica* *Panicum miliaceum* Indet. Cucurbitaceae	Pig Dog Cattle Sheep/goat Chicken Muntjac	Jin, 2014

Table 8-1. Summary of the main early sites in Yunnan with indication of geographical location (in reference to drainage system); chronological date; recovery methods of archaeobotanical materials; main archaeobotanical cultigens present at the sites; animal resources present if known/ zooarchaeological analysis present. For a full breakdown including a summary of information regarding excavation seasons and material culture for each of the sites see Appendix 5. Latin denomination indicates systematic analysis; common names indicate presence only as reported by excavation reports.

Site	River Basin/ Location	Chronological Date	Recovery method	Main cultigens present	Animal resources	References
					Deer Indet. lacustrine resources	
Xingyi	Lake Qilu	c. 2000 BC- 0 AD	Flotation (unpubl.)	Acorns Rice (arcbot. report still unpubl.)	Abundant lacustrine resources (*Margarya* sp.)	Yunnan, 2017 Min Rui pers. comm. 2016
Haimenkou	Middle Jinsha (Yangzi)	AMS 1600-400 cal BC	Flotation	*Oryza sativa* *Setaria italica* *Panicum miliaceum* *Triticum aestivum* *Hordeum vulgare* *Chenopodium* sp. *Fagopyrum* sp. *Glycine max* *Cannabis* sp. *Prunus armeniaca* *Prunus amygdalus* *Vitis* sp.	*Sus domesticus* *Ovis/Capra* sp. *Canis familiaris* *Bos gaurus* *Cervus unicolor* *Axis porcinus* *Muntiacus muntjak* *Moschs berezovskii* *Sus scrofa,* *Macaca* sp., *Ursus* sp., *Volpe* sp., *Lepus* sp. Etc	Yunnan, 1958 Xue, 2010 Jin, 2013 D'Alpoim Guedes, 2014 Li & Min, 2014 Wang, 2018
Mopandi	Middle Jinsha (Yangzi)	c. 1400 BC	Hand-picked (1 visible rice	Rice	Pig Cattle Sheep/goat	Yunnan, 2003 Zhao, 2003 D'Alpoim Guedes & Butler, 2014

Table 8-1. Summary of the main early sites in Yunnan with indication of geographical location (in reference to drainage system); chronological date; recovery methods of archaeobotanical materials; main archaeobotanical cultigens present at the sites; animal resources present if known/ zooarchaeological analysis present. For a full breakdown including a summary of information regarding excavation seasons and material culture for each of the sites see Appendix 5. Latin denomination indicates systematic analysis; common names indicate presence only as reported by excavation reports.

Site	River Basin/ Location	Chronological Date	Recovery method	Main cultigens present	Animal resources	References
			rich context was chemically floated)		Dog Chicken Deer Muntjac (*Muridal* sp.)	
Nanbiqiao	Middle Langcan (Mekong)	c. 1250-970 BC	Hand picked	Rice	n/a	Kan, 1983 An, 1999
Shifodong	Middle Langcan (Mekong)	c. 1100 BC	Flotation	*Oryza sativa* *Setaria italica* *Panicum miliaceum* *Tamaridus indica*	Pig Muntjac Deer Dog Cattle? Horse? Indet. birds and fish species	Kan, 1983 Liu & Dai, 2008 Yao, 2010 Zhao, 2010 d'Alpoim Guedes & Butler, 2014
Shizhaishan	Lake Dian-southeastern bank	AMS 779-488 cal BC	unclear	Rice Foxtail millet Wheat	n/a	Yunnan 1963 Yao & Jiang 2012
Anjiang	Lake Dian-southeastern bank	AMS 770-430 cal BC	Flotation (survey test pit)	*Oryza sativa* *Setaria italica* *Triticum aestivum* *Hordeum vulgare*	n/a	Yao et al., 2015

Table 8-1. Summary of the main early sites in Yunnan with indication of geographical location (in reference to drainage system); chronological date; recovery methods of archaeobotanical materials; main archaeobotanical cultigens present at the sites; animal resources present if known/ zooarchaeological analysis present. For a full breakdown including a summary of information regarding excavation seasons and material culture for each of the sites see Appendix 5. Latin denomination indicates systematic analysis; common names indicate presence only as reported by excavation reports.

Site	River Basin/ Location	Chronological Date	Recovery method	Main cultigens present	Animal resources	References
Dayingzhuang	Lake Dian-northern bank	AMS 750-390 cal BC	Flotation	*Oryza sativa* *Setaria italica* *Panicum miliaceum* *Triticum aestivum* *Hordeum vulgare* *Chenopodium* sp. *Zanthoxylum* sp.	Indet. lacustrine resources	Dal Martello, 2019
Shilinggang	Middle Nujiang (Mekong)	AMS 723-339 cal BC	Flotation	*Oryza sativa* *Setaria italica* *Chenopodium* sp.	*Sus* sp. *Bos* sp. *Ovis/Capra* sp. *Canis familiaris* *Muntiacus* sp. Deer	Li et al., 2016 Ren, et al., 2017
Xiaogucheng	Lake Dian-southeastern Bank	c. 700-300 BC	Flotation (survey test pit)	*Oryza sativa* *Panicum miliaceum* *Setaria italica*	n/a	Yao et al., 2015
Xueshan	Upper Nanpan (Dianchi)	c. 700-300 BC	Flotation	*Oryza sativa* *Setaria italica* *Panicum miliaceum* *Triticum aestivum*	n/a	Wang, 2014

Table 8-1. Summary of the main early sites in Yunnan with indication of geographical location (in reference to drainage system); chronological date; recovery methods of archaeobotanical materials; main archaeobotanical cultigens present at the sites; animal resources present if known/ zooarchaeological analysis present. For a full breakdown including a summary of information regarding excavation seasons and material culture for each of the sites see Appendix 5. Latin denomination indicates systematic analysis; common names indicate presence only as reported by excavation reports.

Site	River Basin/ Location	Chronological Date	Recovery method	Main cultigens present	Animal resources	References
				Hordeum vulgare *Glycine max* *Fagopyrum* sp.		
Guangfentou	Lake Fuxian	c. 700-300 BC	Flotation	*Oryza sativa* *Setaria italica* *Triticum aestivum* *Hordeum vulgare* *Glycine max* *Chenopodium* sp.	n/a	Li & Liu, 2016
Yubeidi	Lake Dian-eastern bank	c. 700-300 BC	Flotation	*Oryza sativa* *Setaria italica* *Triticum aestivum* *Glycine max* *Chenopodium* sp. *Zantoxhylum* sp.	n/a	Yang, 2016
Hebosuo	Lake Dian-southeastern bank	AMS 735 cal BC- 40 AD	Flotation	*Oryza sativa* *Triticum aestivum* *Setaria italica* *Panicum miliaceum* *Glycine max*	n/a	Yang, 2016 Yao et al., 2015 Yao & Jiang, 2012

8.3.4. Short summary

It seems apparent that an agricultural, settled lifestyle was fully in place in Yunnan by at least c. 2500 BC. People settled in the lowland areas of the province, close to big water reservoirs, either rivers or lakes, which might have been beneficial for agricultural irrigation and other subsistence strategies, such as fishing, and animal husbandry, as suggested by the possible presence of domesticated pig. The early agricultural systems were based on two crops: rice and millets; however, people were also taking advantage of the variety of wild resources present locally, including local wild plants and animals, as well as lacustrine resources, through hunting and fishing. Fishing was particularly important at lacustrine sites, such as Haidong, and Xingyi.

Around the mid-2nd millennium BC, western domesticates were introduced into Yunnan. The source of these cereals is a key issue to be resolved. One possibility is that this came about through the migrations of farmers from Northwest China, which might be supported by some of the ceramic typological similarities, innovation in material culture and in the sudden increased number of houses. An alternative is that the cereals diffused from Western Tibet, through a Southern route from Himalayan India. The latter hypothesis has received recent support by the analysis of modern barley landraces genetics. On the basis of the distribution of barley genotypes a dispersal of barley into China from the Southwest, i.e. from South Asia or via the Himalaya, can be reconstructed (Lister et al., 2018; see also Chapter 2).

Neither of these hypotheses has particularly strong archaeobotanical evidence due to the currently limited amount of data available from the southern Himalayan, Tibetan and northeast Indian regions. At the site of Haimenkou wheat and barley occur together in a period that concurrently shows cultural changes and evidence of population growth, but it is not clear that population growth is connected with agricultural innovation. It is not clear where this agricultural innovation came from, or even whether the spread of wheat and barley are necessarily connected to each other in this region. According to the present evidence, there are no previous sites in Yunnan where either wheat or barley have been attested. This suggests that the crops became part of an agricultural system outside of the Yunnan province, in a place not yet identified, and then were brought to the province together, either through migration or trade, which could in turn have come from several directions. The introduction of wheat and barley, however, did not necessarily replace the cultivation of the pre-existing crops, which continue to have a role, albeit secondary, in the subsistence. Local resources, such as *Chenopodium* and wild fruits, including *Prunus* spp. fruits, continued to be extensively exploited, and this mixed agricultural system continues through the early to mid-1st millennium BC. It seems reasonable to suggest that the unstable and fluctuating climate might have had a role in encouraging the preservation of this highly mixed crop system.

8.4. Comparison of crop systems and chronological crop dispersal trajectories in broader Southwest China: data from Sichuan, Tibet, Chongqing and Guizhou

The data from the surrounding southwestern provinces is very uneven. Tibet, Chongqing, but especially Guizhou, are extremely understudied, and almost completely lack archaeobotanical research. Most of the data available comes from surveys and excavations in Sichuan (table 8-2). Even though archaeobotanical data is available, formal archaeological reports are mostly unpublished, therefore not as much information on the material culture is known from these sites (see Appendix 5).

8.4.1. 3rd to 2nd millennium BC sites

The earliest reported sites with some evidence for agricultural crops include Karuo, in Tibet, Yingpanshan, Haxiu, and Baodun, in Sichuan, and Zhongba, in Chongqing. Generally speaking, millets, both foxtail and broomcorn, are the predominant crops recovered at these sites. At Baodun and Zhongba, some rice remains have also been recovered. Rice seems to be especially prevalent at Baodun, where it accounts to over 30% of the total identified remains (fig 8-6). A variety of additional food resources have been reported; these include soybean at Yingpanshan, and *Prunus* sp., as well as some possible *Zanthoxylum* sp. at Haxiu (Zhao & Chen, 2011; d'Alpoim Guedes 2014).

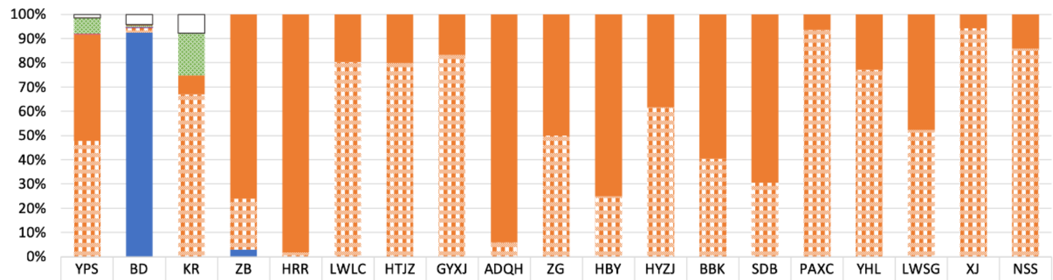
In addition to excavated sites, a recent large-scale survey on the North-eastern Tibetan Plateau (henceforth NETP) has individuated more than 50 early sites. These sites are located in modern Qinghai Province, but have been briefly included here as a reference for the southern spread of western domesticates, as well as for contextualising the spread of agriculture to the wider Tibetan Plateau region.

Flotation samples were collected from tests pits during the survey (Chen et al., 2015). 18 out of the 52 sites surveyed date to between c. 3200 BC to c. 2000 BC. These sites are all located below 2500m asl, and the archaeobotanical assemblage recovered is composed almost exclusively by foxtail and broomcorn millets (Chen et al., 2015). Similarities in material culture remains indicate that early NETP sites are results of the westward expansion of millet-based agricultural populations from the Yellow River, which are associated with the Majiayao Culture (Chen et al., 2015). The authors of the study further proposed that this westward expansion was constrained by altitudinal limits (cfr. 2500 m asl), beyond which no suitable climatic conditions existed for the cultivation of millet (Chen et al., 2015). Moreover, the archaeological material culture recovered at the site of Karuo also indicates connections with the Neolithic populations in Northwest China (D'Alpoim et al., 2013).

Overall, archaeobotanical evidence from 3rd millennium BC sites in Sichuan and on the Tibetan Plateau indicates the presence of a millet based agricultural regime. The only exception to this is the site of Baodun, where more abundant rice remains have been recovered. This site is located in the middle of the Sichuan Basin, at a lower elevation than the other sites, but more importantly, with more abundant water availability. This would have allowed for the production of rice. The abundant field weeds species associated with wetland cultivation recovered at Baodun, such as *Fimbristylis* sp., and *Scirpus* sp., indicate that rice was grown in a wet regime (D'Alpoim Guedes, 2014; D'Alpoim Guedes et al., 2013).

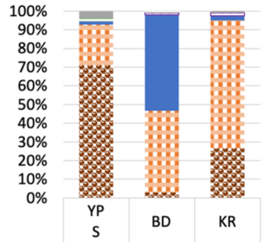
Possible pig bones have been found at Haxiu and Karuo (Zhao, 2008; Aba, et al., 2007; D'Alpoim Guedes et al., 2014), but no other information is available for faunal remains from the sites considered in this section.

Crops and other economic species



	YPS	BD	KR	ZB	HRR	LWLC	HTJZ	GYXJ	ADQH	ZG	HBY	HYZJ	BBK	SDB	PAXC	YHL	LWSG	XJ	NSS
Indet.	1%	2%	4%																
Nuts	0%	0%																	
Fruits	4%	0%	9%																
other pulses		0%																	
Soybean	0%																		
Job's tear		0%																	
Broomcorn m.	26%		4%	76%	3617%	20%	20%	17%	94%	50%	75%	38%	60%	70%	6%	23%	48%	6%	14%
Foxtail m.	28%	1%	34%	21%	64%	80%	80%	83%	6%	50%	25%	62%	40%	30%	94%	77%	52%	94%	86%
Rice		37%		3%															

Weeds



	YPS	BD	KR
Environm. Weeds	1.57%		0.40%
Both dry and wet	0.75%	0.59%	
Echinochloa		0.51%	0.81%
Wetland weeds	0.61%	30.65%	1.21%
Dryland weeds	8.80%	25.99%	33.47%
Chenopodium	28.97%	1.72%	12.90%

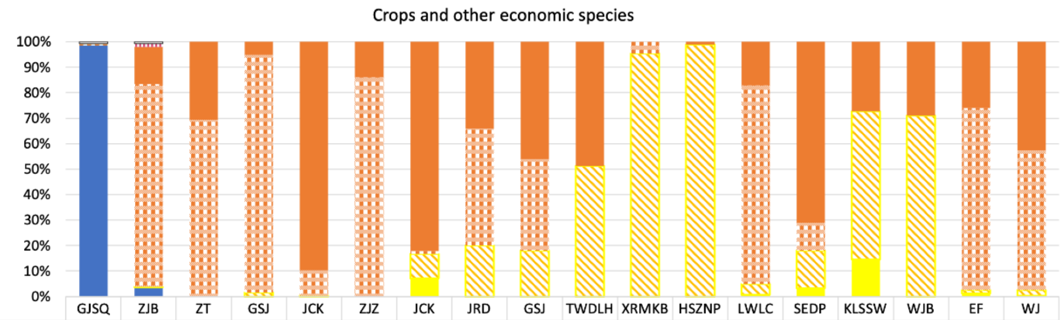
Fig. 8-6: Comparison of frequency index for sites in Southwest China with flotation, dating to the 3rd mil. BC. The site initials are used to indicate the site (YPS= Yingpangshan; BD=Baodun; KR=Karuo; ZB=Zhongba; NETP sites include: HRR=Hurere; LWLC=Luowalingchang; HTJZ=Hongtijiaozi; GYXJ=Gayixiangjing; ADQH=Andaqiha; ZG=Zhangga; HYB=Heibiya; HYZJ=Hongyazhangjia; BBK=Bennakou; SDB=Shangduoba; PAXC=Ping'anxincun; YHL=Yahulu; LWSG=Liuwanshagou; XJ=Xinjia; NSS=Nanshansi)[20].

[20] Total number of identified remains per site: YPS=8303; BD=3886; KR=248; NETP sites: HRR=1883; LWLC=425; HTJZ=480; GYXJ=149; ADQH=118; ZG=702; HYB=68; HYZJ=146; BBK=119; SDB=69; PAXC=379; YHL=361; LWSG=84; XJ=236; NSS=233. Sites with less than 30 total identified remains have been excluded from the graphs.

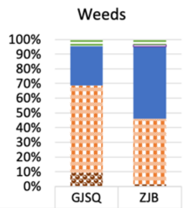
8.4.2. 2nd to early 1st millennium BC sites

Sites dating to the 2nd millennium BC include Zhongba site in Chongqing; Ashaonao, Zhongghai Guojishequ, and Zhengjiaba sites in Sichuan, and Changguogou in Tibet (table 8-2). These all appear to be settlement sites, although no available publication provide detailed information regarding the archaeological material evidence unearthed at each site. According to the available literature, these sites show cultural affinity with Northwest China populations. By at least c. 1600-1400 BC the introduction of western domesticates (wheat and barley) is attested at the sites of Ashaonao, Changguogou, Zhongghai, and Zhengjiaba, as well as from sites on the NETP (fig. 8-7). Here, 24 further sites have been dated to the 2nd millennium BC (Chen et al., 2015). Barley remains have been found at the site of Xiasunjiazhai, dating to c. 2140-1955 BC (see table 2-2 in Chapter 2 for a summary of the current dates attesting the spread of wheat and barley to China). However, at the sites surveyed, the presence of barley only becomes predominant after c. 1600 BC. This is an important chronological divide, as sites dating to before 1600 BC are all located below 2500m asl, and archaeobotanical remains at these sites are composed mostly of millets (see above). Sites dating to after 1600 BC are instead present as high as 3000m asl, and the presence of barley in the overall archaeobotanical assemblage increases proportionally at higher altitudes (Chen et al., 2015). This suggests that during the second half of the 2nd millennium BC, altitudinally differentiated subsistence strategies had developed, with low elevation sites privileging a subsistence based on millets, with the addition of wheat, *Chenopodium* and fruits at the site of Ashaonao (D'Alpoim et al., 2015), and of wheat, barley and possibly some pulses at the site of Changguogou (Fu, 2001). Higher elevation sites, instead, favoured wheat and barley, as seen from the archaeobotanical evidence from Neolithic sites on the NETP (Chen et al., 2015). At these sites, a higher quantity of sheep bones has also been reported, possibly indicating that people practiced a mixed agro-pastoral subsistence based only partially on the cultivation of crops (Chen et al., 2015). Finally, rice remains were prevalent at sites in the Sichuan Basin, such as at Zhonghai Guojishequ (fig. 8-7).

Rice remains have also been reported from two sites in Guizhou province, Jigongshan and Wujiadaping (Zhao, 2003). These sites have been dated through cultural association to the 2nd millennium BC, and they are the only two Neolithic sites in Guizhou for which archaeobotanical information is available, however, no flotation was carried out. Future work might help us understand better the development of agricultural practices in Guizhou and the connection of this province with the rest of Southwest China. No faunal remains have been reported from these sites.



	GJSQ	ZJB	ZT	GSJ	JCK	ZJZ	JCK	JRD	GSJ	TWDLH	XRMKB	HSZNP	LWLC	SEDP	KLSSW	WJB	EF	WJ
Indet.	0.65%	0.58%																
Fruits	0.26%	0.09%																
other pulses	0.01%	0.98%																
Soybean		0.02%																
Broomcorn m.	0.01%	12.60%	30.62%	5.04%	89.73%	14.04%	82.10%	34.15%	46.15%	48.77%	0.00%	1.03%	17.19%	71.13%	27.34%	29.03%	25.97%	42.70%
Foxtail m.	0.40%	68.23%	69.38%	93.28%	9.91%	85.96%	1.20%	45.73%	35.90%	0.00%	4.55%		77.89%	10.92%	0.00%	0.00%	71.43%	54.87%
Barley		0.02%	0.00%	1.68%	0.36%		9.64%	20.12%	17.95%	51.23%	95.45%	98.97%	4.21%	14.79%	58.17%	70.97%	1.30%	2.21%
Wheat	0.02%		0.00%	0.00%	0.00%		7.06%						0.70%	3.17%	14.50%	0.00%	1.30%	0.22%
Rice	96.59%	3.18%																



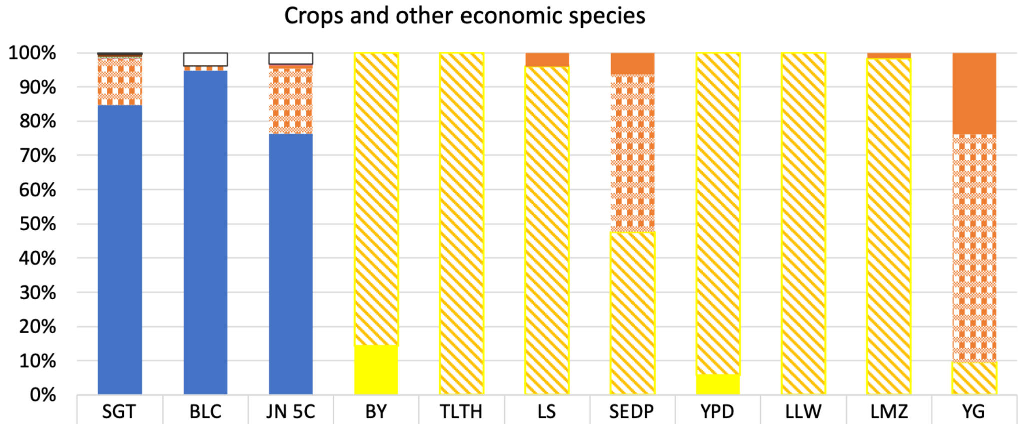
	GJSQ	ZJB
Both dry and wet	0.09%	0.51%
Echinochloa		0.20%
Wetland weeds	0.55%	7.00%
Dryland weeds	1.21%	6.35%
Chenopodium	0.20%	0.22%

Fig. 8-7: Comparison of frequency index for sites in Southwest China with flotation, dating between to the 2nd mil. BC. The site initials are used to indicate the site (GJSQ=Zhonghai Guojishequ; ZJB=Zhengjiaba; NETP sites include:ZT= Zhongtan; GSJ=Gongshijia; JCK=Jinchankou; ZJZ=Zhaojiazhuang; JRD=Jiaoridang; TWDLH=Tawendaliha; XRMKB=Xiariyamakebu; HSZNP=Hongshanzuinanpo; LWLC=Luowalinchang; SEDP=Shuang'erdongping; KLSSW=Kalashishuwan; WJB=Weijiabao; EF=Erfang; WJ=Wenjia)[21].

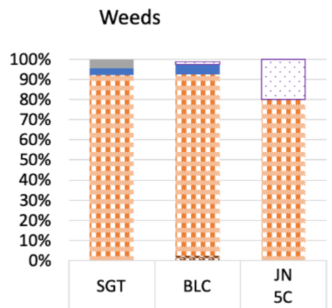
[21] Total number of identified remains per site: GJSQ=23,343; ZJB=4470; NETP sites: ZT=209; GSJ=238; JCK=1110; ZJZ=570; JKC=581; JRD=164; GSJ=39; TWDLH=324; XRMKB=44; HSZNP=97; LWLC=285; SEDP=284; KLSSW=545; WJB=31; EF=154; WJ=425.

8.4.3. 1st millennium BC sites

There is no substantial change on archaeobotanical evidence and subsistence patterns between the 2nd and 1st millennia BC in broader Southwest China. Archaeobotanical evidence from sites in the Sichuan Basin (i.e. Bolocun, Sangongtang and Jinsha 5C) show a mixed crop economy based on rice and millets, with rice more prevalent (accounting for 70-90% of the crop assemblage, see fig. 8-8). Sites located on the Tibetan Plateau instead, show a clear predominance of barley, with the exception of Shuang'erdongping and Yangou, where foxtail millet remains constitute half or more of the archaeobotanical remains recovered; millet remains decrease substantially at the rest of the NETP sites in favour of barley (fig. 8-8; Chen et al., 2015).



	SGT	BLC	JN 5C	BY	TLTH	LS	SEDP	YPD	LLW	LMZ	YG
Indet.	0.43%	3.79%	3.13%								
Nuts	0.87%	0.07%									
Fruits	0.20%	0.04%									
other pulses	0.25%										
Soybean	0.02%		0.31%								
Broomcorn m.	0.09%	0.02%	0.94%			4.07%	6.37%			1.64%	23.81%
Foxtail m.	13.30%	1.22%	18.13%				45.99%				66.67%
Barley				85.71%	100%	95.93%	47.64%	94.29%	100%	98.36%	9.52%
Wheat				14.29%				5.71%			
Rice	83.39%	94.02%	72.81%								



	SGT	BLC	JN 5C
Environ. Weeds	0.07%		
Both dry and wet		0.01%	
Echinochloa		0.01%	0.94%
Wetland weeds	0.04%	0.04%	
Dryland weeds	1.34%	0.75%	3.75%
Chenopodium		0.02%	

Fig. 8-8: Comparison of frequency indexes for sites in Yunnan with flotation, dating between c. 1000-300 BC. The site initials are used to indicate the site (SGT=Sangongtang; BLC=Boluocun; JN5C=Jinsha point 5C; NETP sites include:BY=Banyan; TLTH=Talitaliha; LS=Longshan; SEDP=Shuang'erdongping; YPD=Yingpandi; LLW=Lalingwa; LMZ=Lamuzui; YG=Yangou)[22].

[22] Total number of identified remains per site: SGT=4467; BLC=9755; JN5C= 320; NETP sites: BY=35; TLTH=34; LS=221; SEDP=424; YPD=35; LLW=42; LMZ=61; YG=63.

8.4.3. Short summary

The available archaeobotanical evidence from sites in Southwest China reveals that agricultural practices were differentiated and closely linked with local environmental constraints in each sub-region. Outside of Yunnan, and especially on the Tibetan Plateau, agricultural regimes specialised in dryland crop cultivation, differentiating in wheat and barley vs. millets-based systems according to altitudinal differences among sites.

In Yunnan, altitudinal constraints are not as felt as on the Tibetan Plateau, presumably due to differences in climate and vegetation, with Yunnan conditions being milder and more favourable to agricultural production, regardless of the high altitude. This is in part due to the specific river system and, therefore, water availability, which would have allowed for continued rice production. The mixed crop agriculture system attested through the millennia in Yunnan suggests that the most successful agricultural strategy in the area was to exploit the widest range of resources available, both domesticated and wild, both plant and animals, possibly in a crop rotation regime that took advantage of summer and winter crops.

Table: 8-2. Summary of the main early sites in Southwest China (excluding Yunnan) with indication of geographical location (in reference to drainage system); chronological date; recovery methods of archaeobotanical materials; main archaeobotanical cultigens present at the sites; animal resources present if known/ zooarchaeological analysis present. For a full breakdown including a summary of information regarding excavation seasons and material culture for each of the sites see Appendix 5. Latin denomination indicates systematic analysis; common names indicate presence only as reported by excavation reports.

Site	**River Basin/ Location**	**Chronological Date BC**	**Recovery method**	**Main cultigens present**	**Animal resources**	**References**
Yingpanshan	Upper Minjiang (Northern Sichuan)	AMS 3300-2600 cal BC	Flotation	*Setaria italica* *Panicum miliaceum* *Glycine* sp. Fruits	n/a	Zhao & Chen, 2010
Haxiu	Upper Dadunhe (Yellow R.)	c. 3300-2700 BC	Flotation (unpublished)	*Panicum miliaceum* *Setaria italica* *Prunus* sp. *Avena* sp. *Zanthoxylum* sp.	Dog Pig Deer Macaca etc	D'Alpoim Guedes, 2014 Aba, et al., 2006 Aba, et al., 2007
Karuo	Upper Mekong (Eastern Tibet)	2700- 2300 cal BC	Flotation	*Setaria italica* *Panicum miliaceum* *Fragaria/potentilla* sp *Rubus* sp.	Pig Unspecified large and small game; fish	D'Alpoim Guedes et al., 2013
Baodun	Sichuan Basin (Chengdu)	AMS 2700-2000 cal BC	Flotation	*Oryza sativa* *Setaria italica* *Coix lachryma jobi* *Vicia* sp. *Vigna* sp. *Chenopodium* sp.	n/a	D'Alpoim Guedes, 2014 D'Alpoim Guedes et al., 2014
NETP sites	NE Tibetan Plateau (Qinghai at the border with Sichuan)	AMS c. 3200- 1600 BC	Flotation	*Setaria italica* *Panicum miliaceum*	Sheep	Chen et al., 2015

Table: 8-2. Summary of the main early sites in Southwest China (excluding Yunnan) with indication of geographical location (in reference to drainage system); chronological date; recovery methods of archaeobotanical materials; main archaeobotanical cultigens present at the sites; animal resources present if known/ zooarchaeological analysis present. For a full breakdown including a summary of information regarding excavation seasons and material culture for each of the sites see Appendix 5. Latin denomination indicates systematic analysis; common names indicate presence only as reported by excavation reports.

Site	River Basin/ Location	Chronological Date BC	Recovery method	Main cultigens present	Animal resources	References
Zhongba	Three Gorges (Yangzi)	AMS 2470-200 cal BC	Flotation	*Setaria italica* *Panicum miliaceum* *Oryza sativa*	*Sus scrofa* *Nycterteutes procyonide* *Rhizomys sinensis* *Canis familiaris* *Bos p*. *Bubalus* sp. *Cervus* spp. *Vulpes* sp. *Macaca* sp. High quantity of fish remains including: Cypriniformes Siluriformes Perciformes And some giant salamander Snakes turtles	Flad, 2011
Gaopo	Sichuan Basin (Chengdu)	c. 1600-1300 BC	Flotation?	*Oryza sativa* *Panicum miliaceum* *Chenopodium* sp.	n/a	Chengdu, 2011
Ashaonao	Eastern Tibetan Plateau (Sichuan province)	c. 1400-1000 BC/ c. 400-200 BC	Flotation	*Triticum aestivum* *Hordeum vulgare* *Setaria* cf	Sheep Deer	D'Alpoim et al., 2015

Table: 8-2. Summary of the main early sites in Southwest China (excluding Yunnan) with indication of geographical location (in reference to drainage system); chronological date; recovery methods of archaeobotanical materials; main archaeobotanical cultigens present at the sites; animal resources present if known/ zooarchaeological analysis present. For a full breakdown including a summary of information regarding excavation seasons and material culture for each of the sites see Appendix 5. Latin denomination indicates systematic analysis; common names indicate presence only as reported by excavation reports.

Site	River Basin/ Location	Chronological Date BC	Recovery method	Main cultigens present	Animal resources	References
				Chenopodium sp. *Prunus* sp. *Rubus* sp.		
Zhonghai	Sichuan Basin (Chengdu)	c. 1400 BC	Flotation	*Oryza sativa* *Triticum aestivum* *Setaria italica* *Panicum miliaceum* *Chenopodium* sp.	n/a	Chengdu, 2012a
Changguogou	Southern Tibet	C14 1420-800 cal BC	Hand picked	Wheat Barley Foxtail millet (Avena; Rye) Pea Potentilla	n/a	Fu, 2001
Zhengjiaba	Jialing River	c. 1300 BC	Flotation	*Oryza sativa* *Setaria italica* *Panicum miliaceum* *Hordeum vulgare* *Glycine* sp. *Vigna* sp. *Chenopodium* sp. *Vitis* sp. Fruits (P*runus* sp.)	n/a	Yan, et al., 2013

Table: 8-2. Summary of the main early sites in Southwest China (excluding Yunnan) with indication of geographical location (in reference to drainage system); chronological date; recovery methods of archaeobotanical materials; main archaeobotanical cultigens present at the sites; animal resources present if known/ zooarchaeological analysis present. For a full breakdown including a summary of information regarding excavation seasons and material culture for each of the sites see Appendix 5. Latin denomination indicates systematic analysis; common names indicate presence only as reported by excavation reports.

Site	**River Basin/ Location**	**Chronological Date BC**	**Recovery method**	**Main cultigens present**	**Animal resources**	**References**
NETP	NE Tibetan Plateau (Qinghai at the border with Sichuan)	AMS c. 1600-1100 BC	Flotation	*Setaria italica* *Panicum miliaceum* *Hordeum vulgare* *Triticum aestivum*	Sheep Cattle Pig Fish	Chen et al., 2015
Boluocun	Sichuan Basin (Chengdu)	c. 1250-800 BC	Flotation	*Oryza sativa* *Setaria italica* *Panicum miliaceum* *Chenopodium* sp Fruits	Macaca	Chengdu, 2012b
Sangongtang	Sichuan Basin (Chengdu)	c. 1250-800 BC	Flotation	*Oryza sativa* *Setaria italica* *Panicum miliaceum* *Glycine* sp. *Vigna* sp. Fruits	n/a	Chengdu et al 2013
Jinsha 5C	Sichuan Basin (Chengdu)	c. 1250-700 BC	Flotation	*Oryza sativa* *Setaria italica* *Panicum miliaceum* *Glycine* sp.	n/a	Jiang, et al., 2011
Jinggongshan	Lower Jinsha (Yangzi)	c. 1300-800 BC	Hand picked	Rice	n/a	Zhao, 2003 Zhang & Hung, 2010
Wujiadaping	Lower Jinsha (Yangzi)	c. 1300 BC	Hand picked	Rice	n/a	Guizhou, et al., 2006; Zhao, 2003

Table: 8-2. Summary of the main early sites in Southwest China (excluding Yunnan) with indication of geographical location (in reference to drainage system); chronological date; recovery methods of archaeobotanical materials; main archaeobotanical cultigens present at the sites; animal resources present if known/ zooarchaeological analysis present. For a full breakdown including a summary of information regarding excavation seasons and material culture for each of the sites see Appendix 5. Latin denomination indicates systematic analysis; common names indicate presence only as reported by excavation reports.

Site	**River Basin/ Location**	**Chronological Date BC**	**Recovery method**	**Main cultigens present**	**Animal resources**	**References**
NETP	NE Tibetan Plateau (Qinghai, at the border with Sichuan)	AMS 1000-300 BC	Flotation	*Hordeum vulgare* *Panicum miliaceum* *Setaria italica* *Triticum aestivum*	Sheep Cattle Horse	Chen et al., 2015

8.5. Morphometric measurements of main crop species

8.5.1. Rice

Morphometric measurements of archaeological rice grains have been used to document domestication trajectories as well as highlight phenotypical changes to specific local environmental conditions (e.g. Fuller et al., 2014; Fuller et al 2010; Castillo et al, 2015). Yunnan was long considered a possible homeland for rice domestication (Chapter 2), but recent rice morphometrics, as well as the very little presence of wild rice spikelet bases from the Baiyangcun archaeobotanical assemblage (Chapter 6) indicate this crop reached Yunnan as already domesticated, therefore disproving those theories.

In the recent decade, a lot of effort has been made in tracing the domestication trajectory of this crop (see Chapter 2), and data from the Lower Yangzi River is especially representative in providing a morphometric baseline for the transition from wild to domesticated rice. When comparing rice morphometric data from early sites in Yunnan to available rice measurements across China, the domestication status of the crop becomes even more visible (fig. 8-9). In Yunnan, rice measurements fit with the size range at the end of the domestication process, further confirming that there was no independent domestication of this crop in the province.

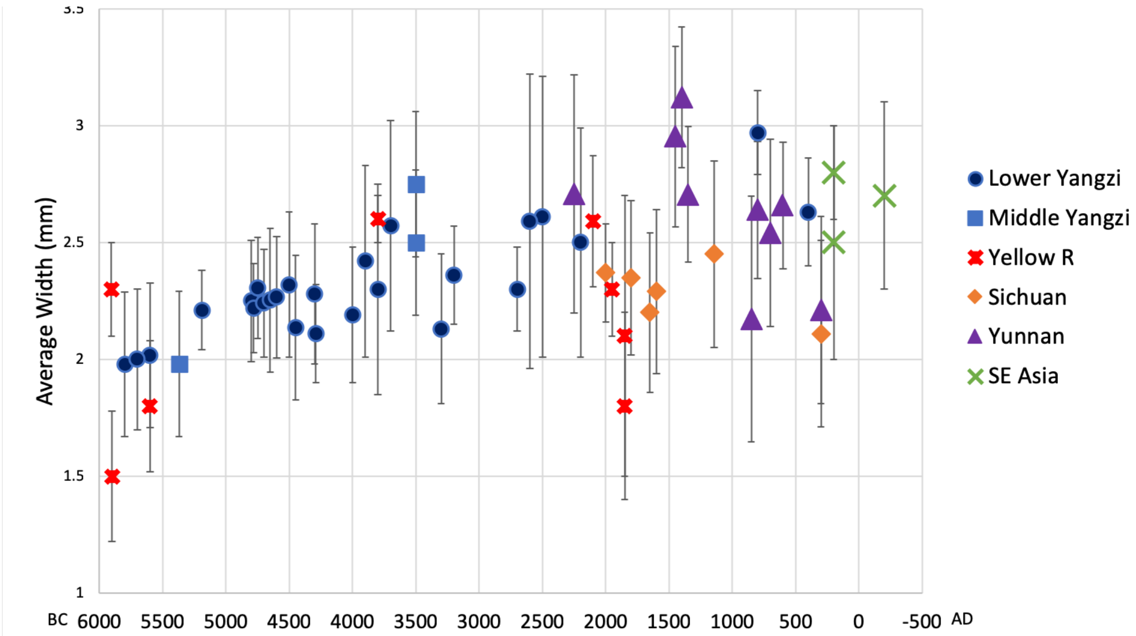


Fig. 8-9. Morphometric measurements of rice (width) from known archaeological sites in China. Data from: Crawford et al., 2006; Tang, 1999; Li ,1994; Lee & Bestel, 2007; Tang et al., 2003; Huang & Zhuang, 2000; Zheng et al., 2004; Fuller et al., 2014; Shanghai Museum, 2014; Fuller et al., 2010; Zhao, 2003; Chengdu, 2012a; Jiang et al., 2011; Chengdu, 2013; Chengdu, 2012b; D'Alpoim et al., 2009; Castillo et al., 2015; Zhao, 2011; Yang, 2016; Wang, 2014; Pei, 1998; Zhang & Wang, 1998; Liu et al., 2007; Li & Liu, 2016; Deng, 2016 unpublished.

8.5.2. Millets

Not as many morphometric measurements are available for foxtail and broomcorn millet remains from archaeological sites in China as there are for rice. The domestication trajectories of these two species are still not completely understood (Chapter 2), therefore, it is difficult to locate millet remains from Yunnan within the broader Chinese context. Measurements of archaeological seeds from both species from sites in Yunnan fit with modern domesticated seed measurement ranges (fig. 8-10; 8-11). The later date that these species appear in Yunnan, and their combined arrival with domesticated rice from central China suggests that millets arrive in Yunnan equally fully domesticated.

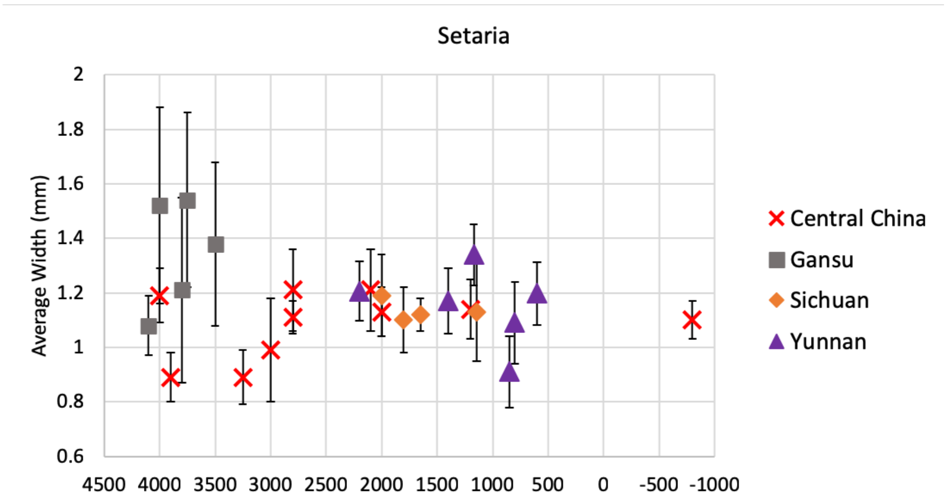


Fig. 8-10: Morphometrics measurements of archaeological foxtail millet seeds (width) from early sites in China. Data from Barton, 2009[23]; Yang, 2016; Stevens, unpublished data.

[23] Some concerns exist regarding the accuracy of the measurements for both *Setaria* and *Panicum* grains from Gansu (data from Barton, 2009); as these don't fit with modern wild and domesticated measurement ranges of the grains. Nevertheless, an increasing trend is seen through time, suggesting that Gansu could indeed be one of the possible domestication centres for millets (see Chapter 2).

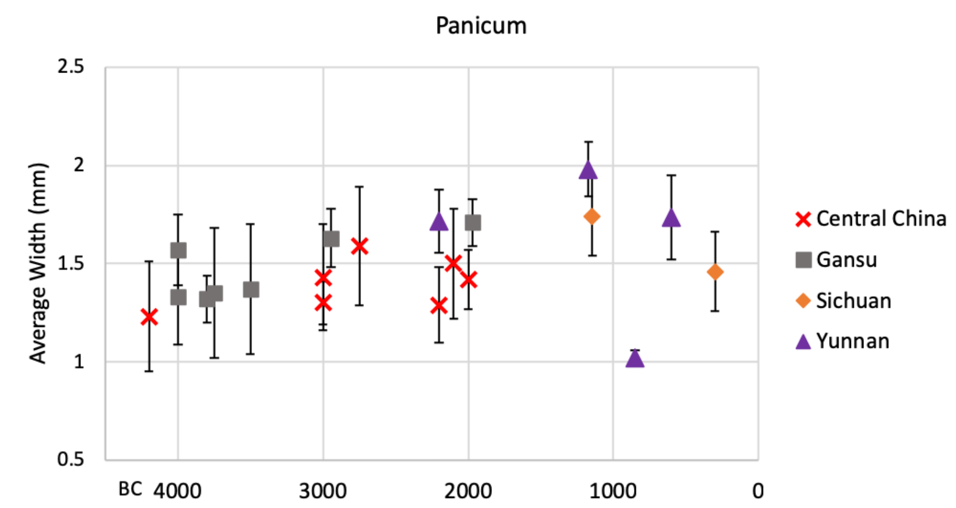


Fig. 8-11: Morphometrics measurements of archaeological broomcorn millet seeds (width) from early sites in China. Data from Barton, 2009; Yang, 2016; Chengdu, 2012; Stevens, unpublished data.

8.5.3. Soybean

Archaeobotanical remains of soybean from archaeological sites in China suggest that this crop might have been domesticated along the Yellow River Basin, among other possible centres (Chapter 2). This theory seems to find confirmation from the analysis of available morphometric measurements of early soybean in the area (fig 8-12). In Southwest China, early finds of soybean are rather sporadic. There is only one reported find of soybean from Sichuan, at the site of Yingpangshan (3300-2600 BC; Zhao, 2008), and four from Yunnan, at the sites of Baiyangcun, Haimenkou, Hebosuo and Yubeidi (Dal Martello et al., 2018; Xue, 2010; Yang, 2016). Interestingly, Baiyangcun soybean is morphologically and morphometrically wild (see Chapter 6, fig. 8-12 below), with later soybean in Yunnan gradually increasing in size. Field collections and genetic studies on soybean have recognized the remnant of a disjunct wild native population of soybean from Southwest China, located at the foot of the Tibetan Plateau, close to northwest Yunnan (Dong et al., 2011). This could indicate that at the time of occupation of Baiyangcun, local wild soybean might have been available in the area and incorporated in the subsistence.

Another possibility is that soybean was introduced in Yunnan with other crops (rice and millets) before it could reach full domestication at its domestication centre. The following continued cultivation of the crop could have caused a secondary domestication to take place in Yunnan (Fuller, 2011). However, the absence of archaeobotanical finds of soybean across the majority of Neolithic sites in Southwest China seems to favour the first possibility.

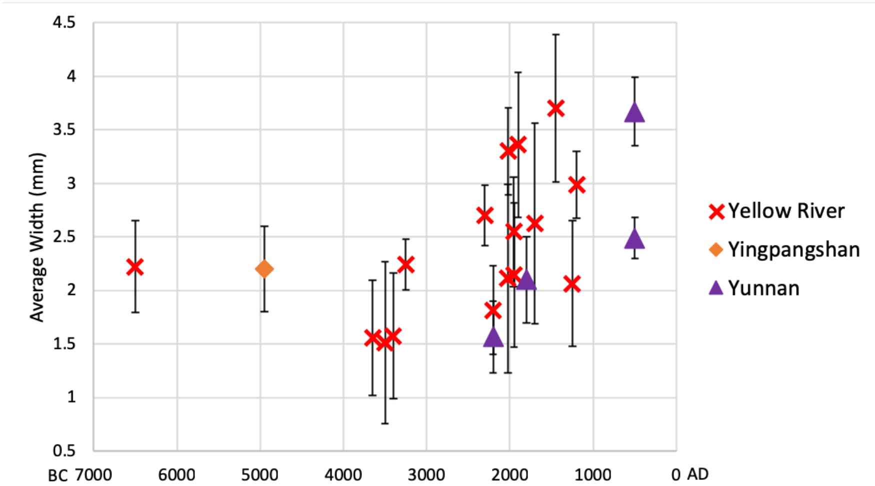


Fig. 8-12: Morphometric measurements of soybean from archaeological sites in China. Data from Lee et al., 2011; Fuller et al., 2014; Yang, 2016; Wang, 2014; Zhao & Chen, 2011.

8.6. What connections did Yunnan early farmers have with populations in Southeast Asia?

The connection between Southwest China and early sites in mainland Southeast Asia has been a topic of great interest among scholars (see Chapter 2). Whether or not Southwest China, and especially Yunnan farmers were primarily involved in the spread of agricultural crops to Southeast Asia is a question still far from being resolved. Flotation work and archaeobotanical analyses are not routinely incorporated in Southeast Asian archaeological excavations (Castillo, 2013). Well dated sites with evidence of systematic crop cultivation recovered through flotation include (see table 8-3 for complete list):

- Non Pa Wai (2470- 2200 BC/1000-700 BC, Weber, et al., 2010);
- Khok Phanom Di (2000-1400 BC, Thompson, 1996);
- Rach Nui (1845- 1385 BC, Oxenham, et al., 2015; Castillo, et al., 2018);
- Ban Chiang (1650-400 BC, Higham, et al., 2015);
- Ban Non Wat (1750 BC-500 AD, Castillo et al., 2018);
- Nil Kham Haeng (1350-500 BC, Weber et al., 2010);
- Khao Sam Kheo (400-100 cal BC, Castillo, 2013);
- Phu Khao Thong (200 cal BC- AD 20, Castillo, 2013);
- and Phromtin Thai (500 cal BC- 900 AD, D'Alpoim Guedes et al., 2018).

In addition to these, rice husks have been reported from many early sites, often incorporated in pottery temper, or as impressions on pottery remains (see table 8-3). However, even though the recovery of rice husks attests the presence of the crop at the sites, they provide neither precise information on the domestication status of the crop, nor data on the precise role it had, if any, in the economy of those sites. For these reasons, those sites are not considered in the discussion below.

It has been argued that the beginning of agriculture in mainland Southeast Asia was a "rapid and multi-directional" phenomenon (Oxenham et al., 2015:310) connected to the "greater Mekong" (Bellwood et al., 2011) sphere. This sphere of contacts was linking Vietnam, Cambodia and Thailand from at least 2500 BC and has been proposed as the context for the emergence of agriculture in Southeast Asia.

An alternative hypothesis has been linked with the so-called "Southeast Asian Interaction Sphere", a broader network of connections linking Southern China (but especially the Red River and the Lingnan region, including Chinese Guangxi and Guangdong Provinces, and Northern Vietnam) with Thailand from possibly as early as the 3rd millennium BC (Rispoli 2007: 280; Rispoli, et al., 2013). This interaction sphere could have brought agricultural crops into Southeast Asia between the 3rd and 2nd millennia BC, and it was the prime driver for the emergence of copper technology across Southeast Asia in the 2nd millennium BC (Rispoli et al., 2013).

Copper-based metal objects retrieved from early Bronze Age sites in Yunnan dating to the end of 2nd millennium BC have been seen as the result of cultural contacts, and possibly migrations of agro-pastoral communities from Northwest China (Ciarla, 2013; see also Chapter 6). Metal axes with a distinctive horn shaped decoration have been found both at Haimenkou and at many sites in Central Southeast Asia (Ciarla, 2013). However, these only date to between the 9th and 7th century BC, and are, therefore, signs of later continuous connections through time, but do not account for the initial emergence of neither metal craftsmanship nor agricultural practices in Southeast Asia (Ciarla, 2013: 221).

Earlier cultural connections between the two regions have been attested mostly through the analysis of commonalities in ceramic remains, particularly by the presence of the so-called "incised/impressed" pottery style throughout early sites both in Yunnan and mainland Southeast Asia (Rispoli, 2007; Rispoli et al., 2013). In Yunnan, incised/impressed pottery decorations characterised the ceramics recovered at the already mentioned sites of Baiyangcun, Xinguang, Dadunzi, Mopandi, Haimenkou and Shifodong as well as the majority of the rest of Neolithic sites in Yunnan (which have not been discussed here for lack of archaeobotanical remains).

Among the many designs characteristic of the incised/impressed pottery style, two specific designs have recently been highlighted as the most recognisable and representative of this cultural connections: the "meander", and the "double S" designs (fig. 8-13).

The meander design has been found at least at two sites located on the western side of Yunnan Province: Dadunzi, and Mopandi[24] (fig. 8-13). At Dadunzi, incised/impressed ceramic

[24] The potsherd represented in Rispoli et al., 2013 in fig. 12 at page 120 is mistakenly attributed to Baiyangcun; it is instead from Dadunzi- as seen in the site original excavation report published in *Kaogu Xuebao* 1977 vol. 1, in fig. 16-5 at page 66. It is not known if this specific design is present at Baiyangcun, although

remains account for about 30% of the total remains, however it is unclear which percentage is constituted by the specific meander design (Yunnan, 1997). At Mopandi, instead, incised/impressed ceramics account only for about 8% of the total ceramic remains, and the meander design accounts for less than 0.6% (Yunnan, 2003).

The double S designs has been found at the sites of Xinguang and Shifodong, on the middle Salween Basin. At Xinguang, incised/impressed decorated ceramics account for between 30-50% of the total ceramic remains, gradually decreasing through time. The double S design accounts only for about 5% of these, and it decreases gradually until disappearing in the upper levels (Yunnan, 2002).

In Southeast Asia, both meander, and double S design types have been reported at the sites of Non Pan Wai, Tha Kae, and Ban Chiang (Rispoli et al., 2013; see fig. 8-13). However, it is still unclear whether these designs represent local populations in Yunnan, or rather are evidence of multi-directional contacts between Southeast Asia and Yunnan (Rispoli, 2007; Rispoli et al., 2013), and the lack of precise radiocarbon dating at the majority of these sites in Yunnan makes it difficult to assess the chronology and direction of these connections.

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incised/impressed decorated ceramic remains from the first excavation season account for the majority of ceramic remains recovered at the site (Yunnan, 1981).

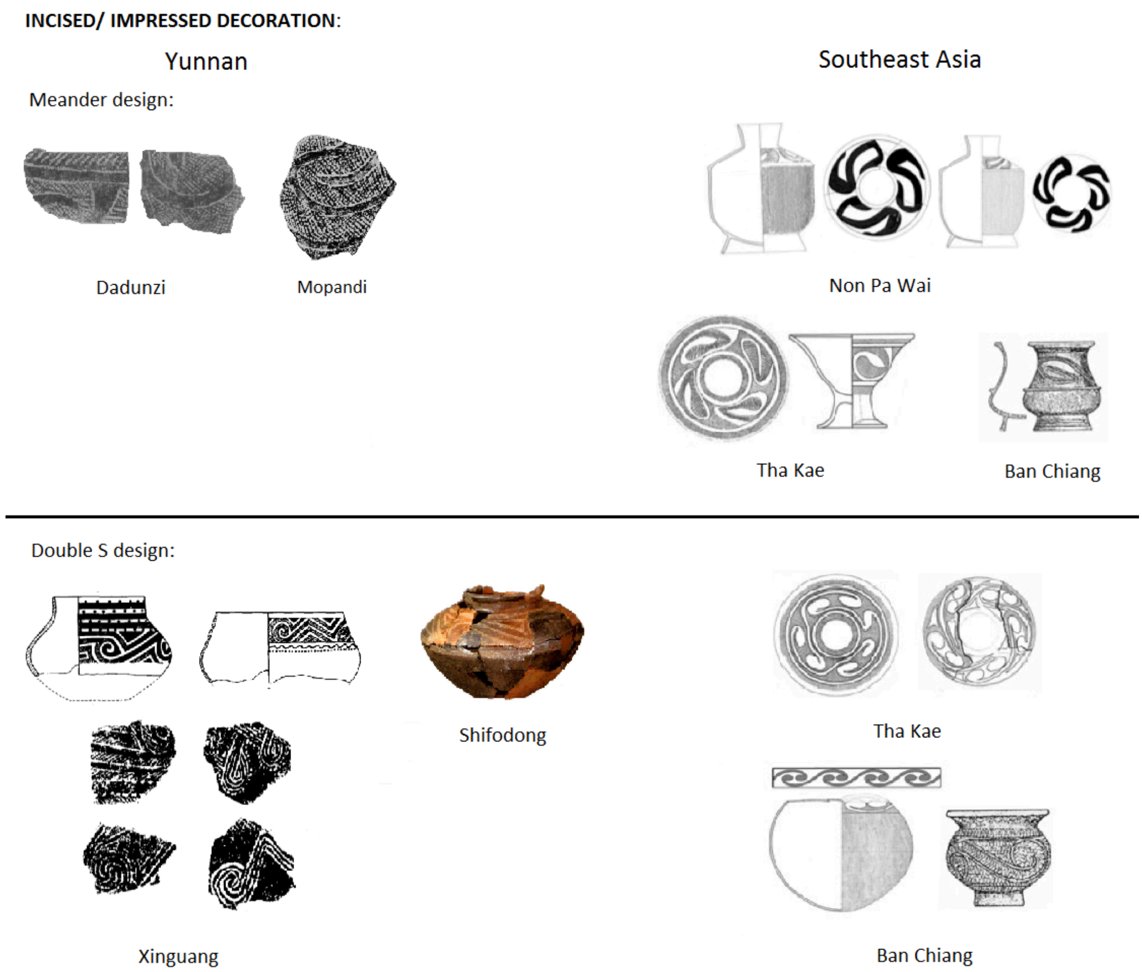


Fig. 8-13: Examples of meander (top) and double S (bottom) designs within the incised/impressed pottery style traditions from sites in Yunnan and mainland Southeast Asia. Redrawn and adapted from Yunnan, 1997; Yunnan, 2002; Yunnan, 2003; and Rispoli et al., 2013.

The archaeobotanical evidence available from early sites in mainland Southeast Asia is limited (table 8-3); it shows that the earliest agricultural systems in mainland Southeast Asia, documented only in central Thailand, were based on dryland cultivation of foxtail millet (Weber et al., 2010, see fig. 8-14C below). Foxtail millet grains dated to c. 2400 BC have been recovered at the site of Non Pa Wai (Weber et al., 2010), as well as at the slightly later sites of Non Mak La (c. 2100-1450 BC) and Nil Kham Haeng (C. 1350-800 BC; Weber et al 2010). Some scholars question the reliability of the early dates for millet cultivation at Non Pa Wai (Rispoli et al., 2013), claiming that the high level of disturbance and intrusion at the site and the very small sample dated (only one foxtail millet grain) makes the chronology questionable. However, considering the very short life span agricultural plants have (usually within the year), the direct dating on charred crop grains provides strong enough reliability, regardless of the level of disturbance and intrusion present in the samples. *Setaria italica* is also unlikely to have been mistaken for any local wild species.

At the site of Khon Phanom Di, rice remains date to about 2000-1400 BC (Higham & Thosarat, 2012). Here, rice was initially present in very low quantities, and it increases proportionally with time. Isotopic signatures on female bone remains from the same phase suggest they were migrants, therefore, possibly indicating that rice was initially imported or traded, and only with the arrival of what could have been women rice farmers, this crop became more prevalent in the economy (Higham & Thosarat, 2012). At present, it has not been possible to conclusively determine how rice was grown at Khok Phanom Di, and some authors have proposed that here rice was possibly grown in a decrue regime, through seasonal flooding of the rice fields located in swamps (Castillo, 2017; Thompson, 1996). However, this is not substantiated by archaeobotanical weedy flora, and when data is available from later sites, this is counter-indicated (see below; Castillo 2018; Castillo et al., 2016; Castillo, 2013).

There is currently no available evidence to attest wetland rice cultivation in Southeast Asia before the late 1st millennium BC (Castillo, et al., 2018; Weber et al., 2010; Kealhofer & Piperno ,1994; Mudar, 1995), instead, typical dryland rice weeds have been found associated to rice remains at the sites of Ban Non Wat, Khao Sam Kaeo, and Phu Kao Thong (see below), indicating that in this area rice was initially grown in a dryland regime (Higham, 2014; Wohlfarth, et al., 2016; Castillo et al., 2016; Castillo, 2017; Castillo, 2018).

At Ban Non Wat, in particular, *Acmella paniculata*, a typical weed of dryland rice cultivation, has been reported from samples associated with the Bronze Age (late 1st mil. BC to first early centuries AD; Castillo et al., 2018). *A. paniculata* also characterised the archaeobotanical assemblages of the sites of Khao Sam Kaeo and Phu Khao Thong (dated to the late 1st mil. BC; Castillo, 2013), attesting to the presence of dryland rice systems in the area.

At Ban Non Wat between the Bronze and Iron Age, the quantity of dryland weeds gradually decreases and it is finally substituted by wetland weeds during the Late Iron Age (250-400 AD), including *Diplacrum caricinum*, attesting to a shift from a prevalently dryland to a wetland rice regime (Castillo et al., 2018; Miller, 2014). Moreover, moat and other water reservoir constructions have been attested around the nearby settlements of Non U-Loke and Non Ban Jak dating to the Iron Age (King et al., 2014); these have been interpreted as linked with water management activites, thus further attesting to the development of wetland rice cultivation in this period (Castillo et al., 2018).

Remains of rice only have also been attested at the site of Ban Chiang (c. 1650-400 BC), with millet absent from all sites mentioned located in northeast Thailand. This could be due lack of systematic flotation sampling from Ban Chiang and at the lower levels of Ban Non Wat, but millet is also absent from later Bronze Age levels at Ban Non Wat that have been systematically sampled (Castillo et al., 2018). This suggests that early northeast Thailand subsistence systems were possibly based on a rainfed rice crop economy.

The earliest evidence for both crops found together is attested at the southern coastal Vietnam site of Rach Nui, although grains appear to be imported to the site from a nearby inland region rather than cultivated *in situ* (Castillo et al., 2017). Here, large quantities of sedges were recovered, which were possibly exploited (Castillo et al., 2017).

At the already mentioned sites of Non Mak La, Non Pa Wai, and Nil Kham Haeng, in Northeast Thailand, foxtail millet and rice remains are found together dating to the mid-2nd/ 1st millennium BC (see table 8-3; Weber et al., 2010). Here, rice remains have been found only in the later phases of occupation, initially in much lower quantities than millets, becoming more prevalent only in the 1st millennium BC. Phytoliths and soil studies at these sites have also showed that wetland rice cultivation had limited scope in the area, due to a soil mostly of limestone derived clay, clay loam or silty clay types (Pigott et al., 2006). Alternatively, it has also been proposed that rice found at Non Pa Wai and Non Mak La was imported/traded from an adjacent area rather than cultivated *in-situ* (Pigott et al., 2006: 166). Castillo suggested that at these sites rice might have initially been cultivated in similar way to foxtail millet in “opportunistic farming” practices (Castillo, 2017:344).

Table 8-3. Summary of the main early sites in mainland Southeast Asia with indication of geographical location (in reference to drainage system); chronological date; recovery methods of archaeobotanical materials; main archaeobotanical cultigens present at the sites; animal resources present if known/ zooarchaeological analysis present. For a full breakdown including a summary of information regarding excavation seasons and material culture for each of the sites see Appendix 5.

Site	**River Basin/ Location**	**Chronological Date BC**	**Recovery method**	**Main cultigens present**	**Animal resources**	**References**
Lao Pako	Nam Ngum River (Mekong)/ Laos	2600-2200	Chaff- pottery impressions	Rice		Kallen, 2004; Bowdery, 1999
Non Pa Wai	Lopburi River/ Khao Wong Prachan Valley Central Thailand	2470-2200/ 1000-700	Flotation	*Setaria italica*/ Second phase: *Setaria italica* *Oryza sativa*	*Sus scrofa* *Canis familiaris* *Cervus* spp. *Bos* sp. *Bubalus bubalis* *Bos frontalis* (gaur) *Bos indicus* Catfish-*Mystis* sp. Birds (mostly fowl) Turtles snakes & lizards	Weber et al,. 2010 Pigott et al., 2006
Non Mak La	Lopburi River/ Khao Wong Prachan Valley Central Thailand	2100-1450/ 1450-700	Flotation	*Setaria italica*/ Second phase: *Setaria italica* *Oryza sativa*		Weber et al., 2010
Khok Phanom Di	Central Coastal Thailand	2000-1400	Flotation	*Oryza sativa** *Coix* sp. *Paspalum* sp. *Eragrostis* sp. *Amaranthus* sp. *Eleocharis sp.* *Cyperus sp.* *(rice cultivation regime unclear: decrue?)	*Sus scrofa* *Macaca* sp. *Cervus* sp. *Canis* sp. *Muntiacus muntjak* *Bos* sp. *Bubalus bubalis* Birds Reptiles (including crocodile)	Thompson, 1996

Table 8-3. Summary of the main early sites in mainland Southeast Asia with indication of geographical location (in reference to drainage system); chronological date; recovery methods of archaeobotanical materials; main archaeobotanical cultigens present at the sites; animal resources present if known/ zooarchaeological analysis present. For a full breakdown including a summary of information regarding excavation seasons and material culture for each of the sites see Appendix 5.

Site	River Basin/ Location	Chronological Date BC	Recovery method	Main cultigens present	Animal resources	References
					Turtles Fish & molluscs	
Rach Nui	Vam Co Dong- Vam Co Tay- Dong Nai Rivers/ Vietnam	1845-1385	Flotation	*Oryza sativa** *Setaria italica** Large quantities of roots, tubers, and sedges (exploited) *imported	Shellfish&fish: *Geloina coaxans* *Cerithidea obtusa Neritina violacea* *Ellobium* sp. Freshwater fish; Reptiles : *Batagur* sp. Turtles: *Cuora* sp. *Cyclemys* sp. *Crocodylus porosus* *Varanus* sp. *Macaca* sp. *Sus scrofa* *Canis familiaris* (exploited for meat) Indet. birds *Cervus* sp. Pig Dog	Oxenham et al., 2015 Castillo et al., 2018
Tha Kae	Lopburi River/ Khao Wong Prachan Valley Central Thailand	1700-1100	Chaff- pottery impressions	Rice		Rispoli et al 2013
Ban Non Wat	Mun River/ NE Thailand	1750-1050 (Neolithic)/ 1050-420 (Bronze Age)/	Flotation	*Oryza sativa**	Pigs	Castillo, 2013 Higham, 2004

Table 8-3. Summary of the main early sites in mainland Southeast Asia with indication of geographical location (in reference to drainage system); chronological date; recovery methods of archaeobotanical materials; main archaeobotanical cultigens present at the sites; animal resources present if known/ zooarchaeological analysis present. For a full breakdown including a summary of information regarding excavation seasons and material culture for each of the sites see Appendix 5.

Site	**River Basin/ Location**	**Chronological Date BC**	**Recovery method**	**Main cultigens present**	**Animal resources**	**References**
		420 BC- 500 Ad (Iron Age)		*(associated with dryland weed species)		Higham & Higham, 2009 Castillo et al., 2018
Ban Chiang	Thailand	1650-1050/ 1050-400	Flotation	*Oryza sativa*	*Bos* sp *Cervus* sp. *Sus scrofa* *Canis familiaris* *Bubalus bubalis*	Yen, 1982 White, 1982 Thompson, 1996
Nil Kham Haeng	Lopburi River/ Khao Wong Prachan Valley Central Thailand	1350-800/ 800-500	Flotation	*Setaria italica* Second phase: *Setaria italica* *Oryza sativa*	Turtles	Weber et al., 2010
Lo Gach	Vietnam	1100-700	Flotation (unpubl.)	*Oryza sativa*		Castillo, pers. comm. 2018
Ban Na Di	Thailand	900-500	Hand-picked	Rice	Cattle Pig Dog Fish Turtles Crocodiles Frogs	Castillo, 2013 Higham et al., 2015
Khao Sam Kaeo	Tha Tapao River/ Thailand	AMS 400-100	Flotation	*Oryza sativa* *Setaria italica* *Vigna umbellata* *Vigna* spp. *Macrotyloma uniflorum* *Citrus* sp. *Gossypium* sp.		Castillo, 2013 Castillo & Fuller, 2010 Castillo et al., 2016

Table 8-3. Summary of the main early sites in mainland Southeast Asia with indication of geographical location (in reference to drainage system); chronological date; recovery methods of archaeobotanical materials; main archaeobotanical cultigens present at the sites; animal resources present if known/ zooarchaeological analysis present. For a full breakdown including a summary of information regarding excavation seasons and material culture for each of the sites see Appendix 5.

Site	River Basin/ Location	Chronological Date BC	Recovery method	Main cultigens present	Animal resources	References
				Sesamum indicum		
Khao Sek		c. 400-100 BC	Flotation	*Oryza sativa*		Castillo, 2018
Non Hua Raet		500-0	Handpicked	Rice		Castillo pers. comm. 2018
Ban Don Ta Phet		300-100	Handpicked	Rice Hemp Cotton	Silk?	Castillo 2012
Noen U-Loke	NE Thailand	450- AD 500	Flotation	*Oryza sativa** *(shift from dryland to wetland weeds)		Castillo et al., 2018
Phu Kao Thong	Kra Isthmus/ Thailand	AMS 200 cal BC- AD 20	Flotation	*Oryza sativa* *Setaria italica* *Vigna umbellata* *Vigna spp.* *Macrotyloma uniflorum* *Citrus* sp. *Gossypium* sp. *Sesamum indicum*		Castillo, 2013 Castillo et al., 2016
Phromtin Thai	Chao Phraya River/ Thailand	AMS 500 cal BC- AD 900	Flotation	*Oryza sativa* *Setaria italica* *Vigna* sp. Fabaceae Large quantities of cyperaceae weeds		D'Alpoim et al., 2018

8.7. Discussion

The first agricultural systems in Yunnan date to between the 3rd and 2nd millennium BC. There is no substantial archaeological evidence attesting to a widespread local presence of hunter-gatherer groups before these millennia, suggesting that the emergence of agriculture in Yunnan derived by migration inputs, however, this might be biased by the insufficient archaeological investigation carried out to date in the province.

The earliest sedentary villages have been found on the north-western area of the province starting from the mid-3rd millennium BC. A shared cultural substratum characterises the sites investigated; this is represented by wattle and daub houses and shaft pit burials for the early period (3rd to 2nd millennium BC); and by stilt houses and stone cist burial for the later period (mid-2nd to 1st millennium BC). Ceramic remains are also representative of cultural connections, with clear similarities in production techniques and decoration shared across the sites. These people engaged in prolific craft production, and by the 1st millennium BC had mastered bronze making techniques.

Pottery vessel assemblages from Neolithic sites in Yunnan are characterized by the heavy presence of vessels suitable for cooking liquid substances as well as big storing vessels, as briefly highlighted above. This is in line with the broad division made by Fuller & Rowlands (2009; 2011), according to which Yunnan belongs to the boiling and steaming cuisine tradition (as opposed to the baking/roasting tradition of the West), and distinct from traditions in South Asia. This tradition favours cooking practices that include boiling crops into making soups, and steaming various food resources, including cereals, and the production of grain-based wines. This type of cuisine has been attested in many East Asian cultures where the worshipping of the ancestors has a central role in the overall cosmology (Levi Strauss, 1978). Food offerings are frequently involved in ritual practices, in an attempt to prevent one's ancestors from coming back and haunting the living, as well as to ask for their intercession (e.g. Fuller & Rowlands 2009; Hsu, 2017; Hsu, et al., 2017; Chang, 1977).

In terms of subsistence practices, archaeobotanical assemblages retrieved through flotation at early sites in Yunnan, such as Baiyangcun and Dadunzi (both located in the middle Jinsha River Basin), show a mixed millet-rice crop regime, complemented by the exploitation of pulses, wild fruit, and nuts resources. Sites located close to lakes, such as Haidong and Xingyi, yielded large quantities of lacustrine remains (esp. *Margaya asp*.). People from those sites were depending heavily on the exploitation of the surrounding available lacustrine resources, to the extent of causing the extinction of some aquatic species (Min Rui, personal comment 2016), and could have been integrating their diet with a small degree of crop cultivation, but only the future publication of flotation results from these sites will clarify the extent and role of crop production in their overall subsistence.

Wheat is introduced to Yunnan during the 2nd millennium BC, as attested by finds at Haimenkou, but it became more widespread in cultivation only with the beginning of the 1st millennium BC, when the crop is present in almost all of the sites associated with the Dian Culture in the Dian Basin. Wheat and barley were brought into Yunnan by migrant populations, possibly from Northwest China or Western Tibet, as evidenced by the sudden increase of houses at the site of Haimenkou and sheep bone remains, pointing to an agropastoral lifestyle typical of those areas.

Buckwheat (*Fagopyrum* cf *esculentum*) was also found at the Haimenkou and Xueshan sites. This find is especially important as Yunnan is believed to be a possible centre for the domestication of this species (Ohnishi, 1998; Ohnishi, 2004; Zhao, 2008; Weisskopf & Fuller, 2014; Boivin et al., 2012; Hunt et al., 201; see Appendix 1), but the little archaeobotanical evidence available so far has prevented the understanding of its domestication process. The increasing incorporation of flotation and archaeobotanical work in the investigation of other Yunnan early sites might help shed light on the role of Yunnan in the domestication of buckwheat in the future.

Sites dating to the 1st millennium BC linked with the flourishing of the Dian Culture show a distinct multi-cropping system. This is constituted by possibly crop rotation of winter crops (such as wheat and barley), and summer crops (rice and millets), as well as by the possible exploitation of local resources, *Chenopodium* (which could be either a summer or a winter crop), and wild resources, both plants and animals. Wheat and millet crop rotation was possibly established in the previous centuries in Northwest China, including parts of the Tibetan Plateau. Lacustrine resources are also heavily present in the assemblages, indicating that a variety of subsistence strategies were implemented, including agriculture, fishing, and animal husbandry/hunting.

A rather different agricultural development took place in the other Southwestern Chinese provinces, especially in Tibet and Sichuan, where to date most of the archaeobotanical evidence has been retrieved. Here, archaeobotanical remains revealed a reliance on dryland crops, such as millets, especially for sites at lower altitudes, and barley or wheat at later sites at higher altitudes. This was not only linked to the environmental constraints derived from the high altitudes of the Tibetan Plateau, but also to close connections with Northwest China early millet farming populations, from which early agriculturalists in Tibet and Sichuan are thought to be derived. Moreover, it has recently been proposed that the specific environmental constraints of the Tibetan Plateau, and the need of early farmers to avoid frost at these altitudes, might have pushed for the development of summer varieties of wheat and barley, as indicated also in early historical Chinese texts, where differentiated sowing and harvesting times have been recorded in Central China from the late 1st millennium BC (Liu et al., 2017). This would provide a minimum age for the development of summer varieties attested, based on the available data, from at least the late 2nd millennium BC (Liu et al., 2017).

Outside of Yunnan, rice seems to occupy a minor role in the overall agricultural regime, and it is confined to sites located in the Sichuan Basin. There also seem to be no spread coming from Yunnan towards the other southwestern provinces, and distinct areas, especially Tibet and Sichuan vs. Yunnan, underwent a distinct agricultural pathway.

Ceramic remains, especially those associated with the incised/impressed pottery style tradition, attest to early cultural contacts between Yunnan and mainland Southeast Asia. However, it is unclear whether these resulted in the direct southern spread of agricultural crops, or early periods of trade and exchange. Past hypotheses on the primary role of Yunnan Austroasiatic speakers in the domestication of rice and its subsequent spread to Southeast Asia find little support with the current archaeobotanical evidence. Not only rice was not the main component of early Southeast Asian agriculture, but also, if grown locally, it could not have been grown in a wetland regime, as it seems it was the case for rice systems in Yunnan. Yunnan was also not the centre for rice domestication, and rice remains found have been classified as *japonica* type; similarly morphometric and aDNA analyses on rice remains from the sites of Ban Non Wat, Non U-Loke, Khao Sam Kaeo, and Phu Khao Thong (Castillo et al., 2010; Castillo, 2017) and Phromtin Thai (D'Alpoim Guedes et al., 2018) in Thailand determined that rice was of the *japonica* type, thus contradicting previous hypothesis of *indica* rice domestication and dispersal from Yunnan (see Chapter 2).

The linguistic inference has also been criticized in terms of uncertainty over the reconstruction of a rice-cultivation vocabulary to proto-Austroasiatic (Blench, 2005; Fuller, 2011). In fact, according to analyses by Blench and Sidwell (i.e. Blench, 2005; Sidwell & Blench, 2011), there are no terms indicating wet-field/lowland rice cultivation, instead terminology involving dry/upland hill cultivation is present, and reliance on riverine resources find stronger basis in linguistic reconstructions, as well as tuber such as taro (Blench, 2005; Sidwell & Blench, 2011, see Chapter 2). This seems to be further supported by the distribution of AA speakers in Eastern India, whose vocabulary also fit with upland hill cultivation (Fuller, 2003).

Others have inferred that rainfed rice spread to mainland Southeast Asia from Guangdong/Guangxi rather than from Yunnan (e.g. Castillo, 2017; Castillo & Fuller, 2010; Fuller et al., 2010); both rice and foxtail millet remains have been attested at the site of Gantouyan (c. 3500-1000 BC; Lu, 2009, see fig. 8-17C), as well as at earlier sites in Fujian Province, where rice is found with both foxtail and broomcorn millets by at least the mid-3rd millennium BC (i.e. Huangguashan, Pingfengshan, and Nanshan, Deng et al., 2018; Yang et al., 2019). Due to the hilly landscape present at those sites in Fujian, it has been proposed that rice might have been grown in a upland rainfed regime (Deng et al., 2018). Rice has also been found at the sites of Shixia and Laoyuan dating from the 3rd millennium BC (Yang et al., 2016; Yang et al., 2018). Although it has also been proposed that at those sites rice was cultivated in a dryland regime (Yang et al., 2016), no associated archaeobotanical weed flora or phytolith data has been retrieved in support of this hypothesis so far and further archaeobotanical research might clarify this issue.

Moreover, bronze working technology came from China to Southeast Asia, either from Yunnan (e.g. White & Hamilton, 2009) or central China (e.g. Pigott & Ciarla, 2007; Higham, 1996), or possibly through both routes (Ciarla, 2013) later than the initial spread of agricultural crops. In addition, many modern rice varieties found in Southeast Asia include waxy (sticky) forms of rice, which must have evolved secondarily, and probably diffused from China into Southeast Asia after the Neolithic (Castillo & Fuller, 2016; Fuller, 2016). Thus, the history of cultural, agricultural and possibly demic diffusion into mainland Southeast Asia from China does not appear to have been a single, chronologically and geographically defined southward dispersal, instead, more and more evidence points to a complex series of overlays across several millennia, through which agricultural and technological innovations emerged.

8.8. Conclusion

The recent accumulation of both systematic radiocarbon dating and archaeobotanical investigation on early sites in Southwest China and mainland Southeast Asia has greatly improved our previous understanding of the emergence of agricultural practices in the area. The establishment of agricultural systems and technological innovations can now be explained as the results of a multiple series and extended through time dispersals and multi-directional cultural connections.

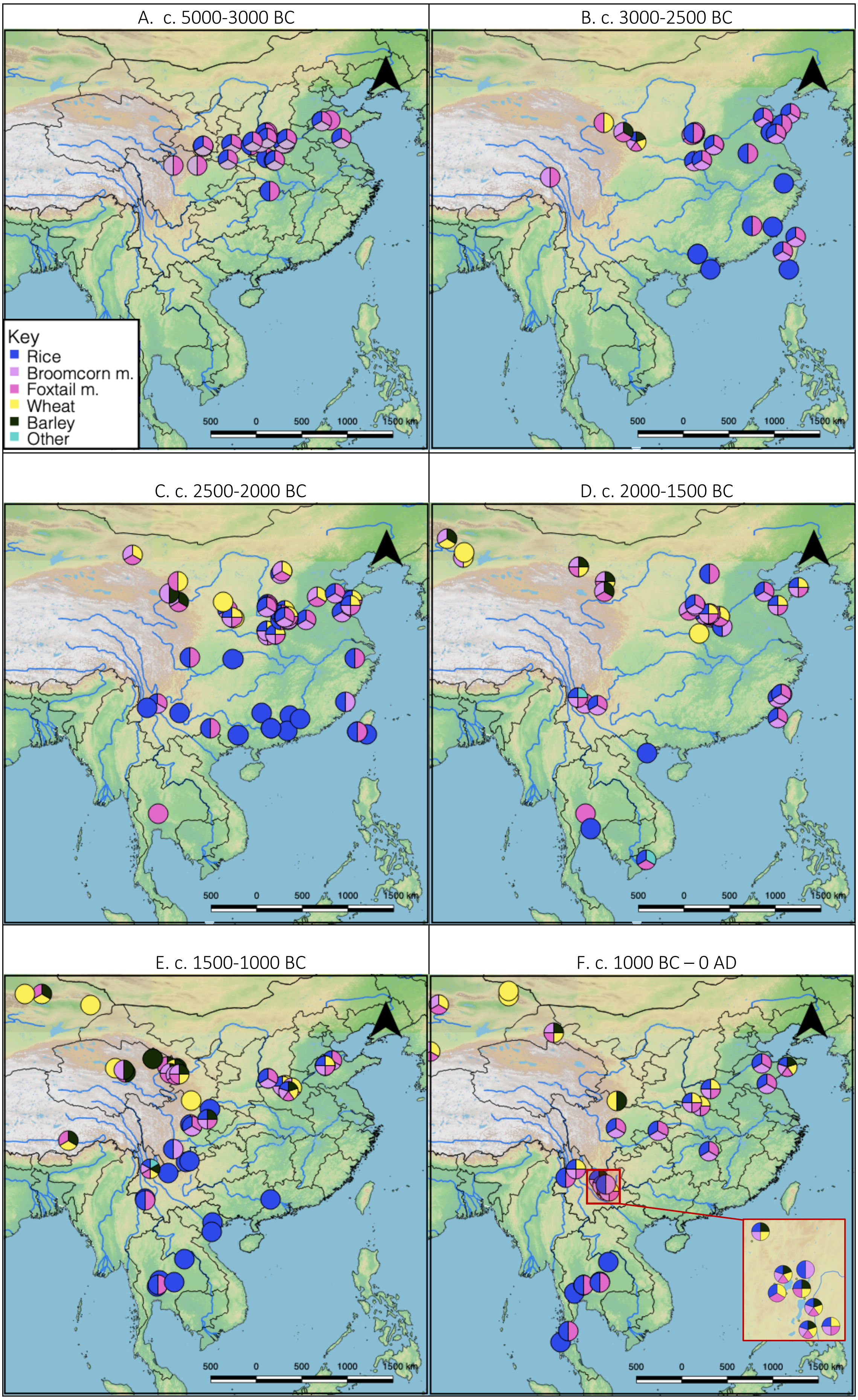
In Yunnan, a first spread is attested in the 3rd millennium BC, with the appearance of the first agricultural systems based on rice and millets. New data from Baiyangcun, generated in this thesis, contributes evidence on this. Mixed rice-millet systems had been previously found at sites along the Yellow Basin in northern China between the 5th and 4th millennia BC (fig. 8-14A). The very little attested presence of hunter-gatherers from both Sichuan and Yunnan would support the hypothesis that agriculture emerged following a first wave of agriculturalists, possibly from this area.

This is followed by subsequent agricultural changes, that could involve a second wave of migrations, either from Northwest China or the Southern Himalayan region, or both, around the mid-2nd millennium BC. Agricultural and technological innovation is strongly attested by the introduction of new crops (i.e. wheat and barley), as well as metallurgy, and development of new ceramic typologies (fig. 8-14D). It is plausible that these innovations were connected to the addition of new people to the Yunnan population. However, the Western crops might have also been introduced through trade. The potential importance of new trade connection to the west or southwest (towards the Himalayas calls for further archaeological research and archaeobotany in these regions.

Finally, the highly mixed crop system established in this millennium, became the basis for the agriculture during the Dian culture in the later 1st millennium BC, as attested by recent archaeobotanical evidence from sites in the Dian Basin (fig. 8-14F). Similarly, the history of agricultural and technological development in mainland Southeast Asia is characterised by multiple overlays. The available archaeobotanical evidence from mainland Southeast Asia contradicts previous theories of a single southward dispersal of crops driven by the spread of rice cultivation and linked with Austroasiatic speakers originating in Yunnan, both because the possible homeland of proto-Austroasiatic may lie beyond Yunnan, as well as because their subsistence was not based, as previously suggested, on wetland rice cultivation, but rather on tuber exploitation, and mostly because foxtail millet was an important component of the earliest agricultural practices involving cereals in mainland Southeast Asia (fig. 8-14-C). Foxtail millet might have been introduced following connections and exchanges along the Mekong River, that were present from at least the mid-3rd millennium BC, as attested by commonalities in incised/impressed ceramic decorations across sites in Yunnan and Southeast Asia, but it could also have been introduced through a coastal route from the Lingnan region into Vietnam, as mixed rice-millet regimes are also attested in this region starting from the 3rd millennium BC, specifically at the site of Gantouyan in Guangxi, and at the sites of Huangguashan, Pingfengshan, and Nanshan in Fujian from the mid-3rd millennium BC. In the context of this network of connections, rice could have been easily traded, and later incorporated into the local agricultural systems. However, the question of when and how rainfed cultivation of rice developed and became part of this system remains unanswered, due to many geographical gaps still present in our data, and especially the lack of reliable dating and systematic archaeobotanical investigation. The ecology of the early rice systems along the Lingnan region has also not been conclusively determined (Yang et al., 2016).

The introduction of bronze technology into mainland Southeast Asia was facilitated by the already present network of connections and was distinct by the dispersal of agricultural crops into the region, further suggesting a complex history of overlays

Fig. 8-14 (opposite page): Map showing presence/absence data of cultivated crops from sites in China and mainland Southeast Asia between the 5th and 1st millennia BC. Data from OWCAD Fuller, et al. (unpubl.). Sites are plotted according to their start date of occupation, with median date within chronological range. See Appendix 7 for full details.


A. c. 5000-3000 BC
B. c. 3000-2500 BC
C. c. 2500-2000 BC
D. c. 2000-1500 BC
E. c. 1500-1000 BC
F. c. 1000 BC – 0 AD
Key
Rice
Broomcorn m.
Foxtail m.
Wheat
Barley
Other
500 0 500 1000 1500 km

CHAPTER 9. CONCLUSIONS

The main aim of this research was to establish a solid chronological framework from which to investigate the development of agricultural practices in prehistorical Yunnan and how these compared with the surrounding regions. The new material collected through excavation from key sites in the province allowed for new precise radiocarbon dates to be obtained, and the new data derived from the archaeobotanical samples analysed in this thesis shed light on the specific development trajectories of agricultural systems in the province between the 3rd and 1st millennia BC. The meta-data analysis presented in Chapter 8 allowed for the investigation of early cultural connections with the neighbouring regions, and especially for the evaluation of past and current hypotheses of cultural, social and economic development in the area, including contributing to the current debates on rice cultivation spread within China and beyond, and testing of the validity of the language/farming dispersal hypothesis in the context of the Austroasiatic languages.

9.1. Agricultural practices in Yunnan between the 3rd-1st millennia BC

At present, the available evidence points to a possible late emergence of agricultural practices in Yunnan, and broader Southwest China, compared to other regions in the country. The attested presence of hunter-gatherers in Yunnan prior to the 3rd millennium BC is very scarce, and this would suggest little contribution of local hunter-gatherers in the transition to a settled agricultural lifestyle, and attribute it to incoming farmers. It could also suggest that competition over land control between incoming farmers and local hunter-gatherers was not the main reason for the delayed emergence of agriculture in Yunnan. However, this is biased by the scarce archaeological investigation carried out in the province. Holocene vegetation reconstructions point to a variety of food resources, both plants and animals, that would have supported local hunter-gatherer cultures prior to the emergence of agriculture in Yunnan, and where systematic studies have been carried out (i.e. at Tangzigou), these revealed that Yunnan was inhabited by at least the 8th/7th millennium BC. The preference of agriculturalists to settled along river valleys in the lowland areas of Yunnan might have meant that local hunter-gatherers moved higher up in the mountains, however, until more systematic archaeological investigation in Yunnan is undertaken, the questions of how local groups and incoming farmers interacted, and if local groups adopted agriculture following this encounter, when exactly agricultural practices began in the region remain unresolved.

Attested crops from sites dating to the mid-3rd millennium BC include both rice and millet, which form the basis of the agricultural systems of this period (contra Li, et al. 2016). Mixed millet-rice agricultural systems had developed by at least the 5th/4th millennium BC between the Yellow and Yangzi River Basin, where millet farmers incorporated rice cultivation in their agricultural system (Stevens & Fuller, 2017: 167); the differentiated ripening and harvesting times required for the two crops would not create competition for their successful production, instead, by expanding the range of resources they would rely on, it would add food security, and it has been argued that a mixed crop regime like such facilitated the spread of agriculture to those areas, including possibly Yunnan, which lied beyond the original ecological zone where the agricultural crops became domesticated (e.g. D'Alpoim Guedes, 2013).

However, mid-Holocene Yunnan valleys' environmental conditions were similar to lowland conditions in the Lower Yangzi region at time of rice domestication. During these millennia, the subtropical vegetation was widespread in all of South China, reaching beyond the Yangzi River Basin (see Chapter 3, fig. 3-7). In addition, the mountain ranges surrounding Yunnan aided in the creation of environmentally mild and favourable valleys that thanks to the high water availability from nearby rivers and lakes would have been conducive to a rich agricultural production. This would have supported the expansion of rice cultivation beyond the limits of its domestication centres. Agricultural settlements have, in fact, been attested in these lowland areas from at least the mid-3rd millennium BC; their location along the major river basins and lakes could suggest that farmers spread following river courses along the Sichuan border.

From the 3rd millennium BC onward, two main phases of agricultural development can be recognized:

1. Between the mid-3rd and mid-2nd millennium BC, cultivated crops are attested in Northern Yunnan (i.e. at Baiyangcun and Dadunzi), with mixed rice-millets cultivation forming the basis of the agricultural systems. The flourishing of agricultural practices in this millennium is further substantiated by pollen and lake sediment studies from the Erhai region, which indicate intense deforestation activities, possibly to accommodate agricultural fields, by the 3rd millennium BC (i.e. Shen et al., 2005).
2. During the mid-2nd millennium BC, wheat and barley are introduced to Yunnan. It is possible that they were introduced by incoming agropastoral populations, from Northwest or Western China, as recorded by changes in material cultural, technological innovation (appearance of bronze manufacturing), and sudden increase of houses in relation to the previous period of occupation at the site of Haimenkou. However, it is also equally possible that they came through trade and population movements from the Southern Himalayan region, as recently proposed through new direct radiocarbon dating of barley grains from the region (Liu et al., 2017).

   These Western crops, and especially wheat, become successfully incorporated into the 1st millennium Yunnan agricultural regime and a highly mixed economy based on the rotation of rice-millets-wheat as well as the exploitation of local resources characterise the agricultural systems of sites linked with the Dian Culture throughout to the end of the 1st millennium BC.

9.1.1. The ecology of agricultural systems in Yunnan between the 3rd and 1st millennia BC

Analyses of the weed flora from sites in Yunnan dating to the late 3rd millennium BC, revealed the presence of a typical wetland suite of field weeds, including the presence of *Fimbristylis* and *Scirpus* species, which characterised early rice systems along the Yangzi valley. This indicates that early rice in Yunnan was grown in a wetland regime, possibly facilitated by the vicinity of water reservoirs to the settlements, and seasonal flooding. Although agricultural fields have not been excavated during excavation at any of the sites analysed, it is posited that these were located close to the river, in the middle of the valleys, and millet fields were instead located on the surrounding hills.

Contemporaneous to the introduction of wheat and barley, a sharp drop of the monsoon and a cooling event might have pushed for a shift from a wetland to a dryland dominated agricultural regime. This has been attested by a shift in cultivation weeds, as well as by the increased presence of dryland crops, including wheat and *Chenopodium*. However, the drier environmental conditions did not equal to a push for the specialisation of the crop regime in favour of a single crop over the other, as attested by the high ubiquity of all cereal crops from the majority of the sites dating to this millennium.

Finally, the analysis on rice remains, and especially phytoliths, from this period has proved inconclusive regarding possible rice irrigation practices, which historical texts described as already developed by the 1st century AD.

9.1.2. The exploitation of local resources and the role of minor crops in Yunnan between the 3rd and 1st millennia BC

A variety of wild food resources, including fruits such as hawthorn, wild grapes, melon, foxnut, and pulses, have also been recovered in c. 40-50% of the samples analysed from the sites investigated in this thesis. This suggests that gathering was an important subsistence strategy of the time. The extremely low quantities of gathered food remains (c. 5% or less of the total archaeobotanical remains at all sites investigated) might represent differences in consumption and preservation patterns in relation to cereals. Pulses might have been grown in rotation on millet fields to restore soil fertility. Moreover, soybean remains found at Baiyangcun point to a possible local secondary domestication of the crop, not linked with the spread of cultivated millet and rice.

Beyond the gathering of local wild resources, the archaeobotanical analyses presented in this thesis have shown that a few other species were systematically exploited and can be regarded as minor crops within the economy of the sites; these include *Chenopodium* and *Cannabis*. New morphological and morphometric data gathered for this thesis will greatly foster future studies into their domestication trajectories.

High quantity of *Chenopodium* remains have been recovered from the site of Haimenkou, as well as other later sites in Yunnan, as outlined in this thesis. It has been posited that this species was not only actively exploited for food, but possibly undergoing domestication. This is supported by morphological, morphometric, and contextual analyses, including the first now available set of measurements from archaeological and modern comparative material to trace morphological changes from wild to domesticate (Chapter 6). This will provide an essential baseline for future studies into the domestication of the crop. Similarly, morphometric data on *Cannabis* (Chapter 6) will be useful for future studies on this crop. Finally, the exploitation of these resources further attests to the specific agricultural strategies of Yunnan, characterised by the differentiation of the agricultural regime, with an aim to incorporate the widest possible range of resources, rather than specialising in the intensive cultivation of a single species.

9.2. Cultural connections and agricultural spread beyond Yunnan and the Austroasiatic languages dispersal hypothesis revisited

The increased incorporation of flotation and archaeobotanical analyses from Neolithic sites both in China and mainland Southeast Asia has revealed that previous models linked with the farming/language dispersal hypothesis need to be re-evaluated in light of new archaeobotanical and chronological data. In the specific case of Yunnan and its early contacts with mainland Southeast Asia, it seems apparent that the history of cultural contacts between the two regions is more complex and stratified than previously thought. Similarities in ceramic remains attest to cultural connections, but this do not equate with a direct unidirectional dispersal of agricultural crops, instead, it seems that multi-directional exchange routes existed from at least the 3rd millennium BC, which might introduce foxtail millet to mainland Southeast Asia, but not necessarily through demic diffusion.

The data presented in this thesis also contradicts previous theories that hypothesized the emergence of agriculture in mainland Southeast Asia as result of a southward dispersal of rice farmers from Yunnan, especially in contrast with the long-held Austroasiatic languages dispersal hypothesis.

The earliest attested rice systems in each region differed in ecology; Yunnan early rice systems (dating to the mid-3nd millennium BC onward) depended on wetland cultivation, with rice grown in a similar regime to that attested in the Yangzi Basin, whereas the first rice regimes in mainland Southeast Asia (to date attested in Thailand from the mid-1st millennium BC) were based on the dryland cultivation of the crop. Recent linguistic reconstruction also points to dryland/uphill cultivation terminology in proto-Austroasiatic, with a lack for wetland cultivation terminology, further indicating that the hypothesis of immigrant rice farmers spreading (rice) agriculture from Yunnan to mainland Southwast Asia does not fit current knowledge based on systematically collected archaeobotanical evidence.

9.3. Future directions

Great geographical and chronological gaps still exist in the current data that hinders our understanding of past subsistence strategies and cultural connections dynamics in the broader area between Yunnan, broader South China and mainland Southeast Asia. This needs to be addressed with more targeted archaeological research and archaeobotanical sampling directed at bridging these gaps, such as in Southern Yunnan, Laos and broader northern mainland Southeast Asia.

The recurrent recovery of archaeobotanical remains attesting a mixed crop regime which incorporated the production of both dryland and wetland crops, has made evident the need for more efficient ways of disentangling crop ecologies, as well as finding more appropriate criteria for the categorisation of cultivation weeds. At the sites investigated for this thesis, parts of the weed assemblage was composed of weed species that are not defined by a clear cut dryland vs. wetland ecology (categorised as both wet and dry weeds); it has been difficult to pinpoint their significance in the agricultural ecology, and future research needs to address the issue of how to include them in the crop ecology analysis.

The high ubiquity but low frequency of local wild food found at all sites analysed in this thesis has also shows a preservation bias for the recovery and analysis of crops across archaeobotanical work in the area. This might obscure the importance local resources might have had in past subsistence strategies. Preliminary analysis on these local resources, specifically soybean for Baiyangcun and *Chenopodium* for Haimenkou, has revealed the potential of secondary domestication for these local resources, and future studies should address this question by providing more rigorous morphological and morphometrical analyses beyond crop remains.

In the specific case of *Chenopodium*, the preliminary results presented in this thesis have raised the importance of undergoing systematic morphological and morphometric analyses on the seeds, so to investigate this species possible domestication status. Future studies should address this issue by defining clear domestication criteria and assessing methods for *Chenopodium* species in East Asia. One further issue that was encountered while measuring *Chenopodium* seeds from Haimenkou was their high fragility, as when trying to cut them to measure the seed coat, they would shatter. This resulted in great loss of seeds and the inability to carry out more extensive measurements, therefore, future studies should also aim to find better and conservative ways to measure the seed coat of charred *Chenopodium* seeds from archaeological sites.

An issue that has not been possible to explore with the research outlined in this thesis is that linked with slash and burn practices in early Yunnan. Many questions still remain unanswered regarding the beginning and the extent of slash and burn practices, whether different groups were practicing different kind of agriculture (settled lowland vs. mobile slash and burn cultivators), and what kind of relationships they had, these all need to be addressed with more systematic archaeological surveys beyond the areas of river valleys and basins, where most of the current archaeological research in Yunnan has been focusing. This might also improve our very limited understanding of local hunter-gatherer presence and their possible interactions with incoming farmers.

Finally, more systematic flotation and radiocarbon dating needs to be undertaken at Dian Culture settlement sites, to address the question of whether social stratification, which has been attested from burial data from Dian cemetery sites, is reflected in stratified access to food resources.

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APPENDICES

Appendix 1. Major East Asian domesticates and their domestication centres

(updated from Li 1970 Northern China section, current known origin if different is outlined in table)

	LATIN NAME	COMMON NAME	NATIVE TO	REFERENCES
CEREALS	*Panicum miliaceum*	broomcorn/ Proso millet	N China/ SE Europe?/ Caucasus	Fuller et al., 2016; Fuller, 2014
	Setaria italica	foxtail millet	N China/ SE Europe?/ Caucasus	Fuller et al., 2016; Fuller, 2014
ROOT & TUBER CROPS	*Stachys affinis*	Chinese artichoke	S China- Yangzi	Simmons, 1990
LEGUMES	*Glycine max*	soybean	China, Japan, maybe Korea	Fuller et al., 2014; Stevens & Fuller, 2017; Obata & Nasu, 2011; Lee et al., 2011
EDIBLE OIL CROPS	*Glycine max*	soybean	China, Japan, maybe Korea	Fuller et al 2014; Stevens & Fuller 2017; Obata & Nasu, 2011; Lee et al., 2011
VEGETABLES	*Allium sativum*	garlic	Central Asia	Simmons, 1990
	Allium fistulosum	Schallion	China	Simmons, 1990
	Allium ramosum	Chinese chives	Central Asia	Simmons, 1990
	Brassica rapa var *chinensis*	Chinese cabbage (bok choy)	Westernt Eurasia (maybe China?)	Smartt & Simmonds, 1995
	Brassica rapa var *pekinensis*	celery cabbage	Westernt Eurasia (maybe China?)	Smartt & Simmonds, 1995
FRUIT TREE	*Prunus persica*	peach	China (Yangzi?)	Zheng et al., 2014; Weisskopf & Fuller, 2014

Appendix 1. Major East Asian domesticates and their domestication centres

(updated from Li 1970 Northern China section, current known origin if different is outlined in table)

	LATIN NAME	COMMON NAME	NATIVE TO	REFERENCES
FRUIT TREE	*Prunus salicina*	Japanese plum	N China	Simmons, 1990
	Armeniaca vulgaris	apricot	N NE China	Stevens et al., 2016; Weisskopf & Fuller, 2014
	Prunus mume	Japanese apricot	N China	Simmons, 1990
	Prunus cerasus	Pie Cherry	China	Simmons, 1990
	Pyrus pyrifolia	pear	China? Central Asia?	Silva et al., 2014
	Malus prunifolia	apple	China	Simmons, 1990
	Crataegus pinnatifida	Chinese hawthorn	N China	Simmons, 1990
	Diospyros kaki	persimmon	E Asia	Simmons, 1990
	Ziziphus jujuba	Chinese jujube	N China	Simmons, 1990

Appendix 1. Major East Asian domesticates and their domestication centres

(updated from Li 1970 Southern China section, current known origin if different is outlined in table)

	LATIN NAME	COMMON NAME	NATIVE TO	REFERENCES
ROOT & TUBER CROPS	*Dioscorea polystachya*	Chinese yam	Insular SE Asia New Guinea?	Denham, 2011; Barton, 2014
	Sagittaria trifolia	Chinese arrowhead	China	Simmons ,1990
LEGUMES	*Vigna angularis*	adzuki bean	Japan	Nasu, 2016
EDIBLE OIL CROPS	*Brassica campestris*	rapeseed (canola)	Western Eurasia (maybe China?)	Crawford, 2011
VEGETABLES	*Lilium lancifolium*	Lily	China	Simmons, 1990
	Zizania latifolia		Manchuria?	Smartt & Simmonds, 1995
	Brassica oleracea		Westernt Eurasia	Smartt & Simmonds, 1995
	Brassica juncea	Brown mustard	possibly China/ Indus Valley	Smartt & Simmonds, 1995
	Oenanthe javanica	water drop-wort	(Indomalaysia)	Li, 1970
	Brasenia schreberi	water shield	multiple: S China- Yangzi	Simmons, 1990
	Ipomea aquatica	water morning glory		Simmons, 1990
	Glebionis coronaria	edible chrysantemum		Simmons, 1990
	Allium chinensis	Chinese onion	China	Simmons, 1990
FRUIT TREE	*Citrus aurantium*	bitter orange	S China	Fuller et al., 2017
	Citrus sinensis	Sweet orange	China	Fuller et al., 2017
	Citrus reticulata	mandarin orange/ tangerine	S China	Fuller et al., 2017
	Fortunella japonica	kumquat	S China	Weisskopf & Fuller, 2014

Appendix 1. Major East Asian domesticates and their domestication centres

(updated from Li 1970 Southern China section, current known origin if different is outlined in table)

	LATIN NAME	COMMON NAME	NATIVE TO	REFERENCES
FRUIT TREE	*Clausena lansium*	wampee	S China to Yangzi	Simmons, 1990; De Bruijn, 1992
	Eriobotrya japonica	Loquat	S China	Simmons, 1990
	Myrica rubra	Chinese strawberry/ bayberry	China	Simmons ,1990
	Litchi chinensis	litchi	S China	Simmons, 1990
	Euphoria longana	longan	S China	Ke et al., 2000
	Canarium pimela	canarium	S China or SE Asia	Simmons, 1990
BEVERAGES & MASTICATORIES	*Camellia sinensis*	tea	S China	Lu et al., 2016
FIBERS	*Boehmeria nivea*	ramie	Yangzi	Fuller, Qin & Harvey, 2008
	Abutilon avicennae	Chinese jute	South China/SE Asia	Li, 1970
	Pueraria lobata	kudzu	South China/SE Asia	Simmons, 1990
OTHER INDUSTRIAL CROPS	*Camellia oleifera*	tea oil cammelia	South China/SE Asia	Li, 1970
	Sapium sebiferum	Chinese tallow / Chicken tree?	South China/SE Asia	Li, 1970
	Aleurites montana	wood-oil tree?	South China/SE Asia	Li, 1970
	Aleurites fordii	Tung tree?	South China/SE Asia	Li, 1970

Appendix 1. Major East Asian domesticates and their domestication centres

(updated from Li 1970 Southern Asia section, current known origin if different is outlined in table)

	LATIN NAME	COMMON NAME	NATIVE TO	REFERENCES
CEREALS	*Oryza sativa*	rice	China: Yangzi basin	Fuller et al., 2016
	Coix-lachryma jobi	job's tear	S China? SE Asia? Assam? Tropical Asia?	Simmons, 1990; Weber & Fuller, 2006; Arora 1977
	Echinochloa colonum (from *E. frumentacea)*	sawa millet	India	De Wet et al., 1983 Weber & Fuller, 2006
ROOTS & TUBER CROPS	*Colocasia esculentam*	taro	SE Asia	Denham, 2011; Matthews & Nguyen, 2014
	Alocasia machrorrhyzos	giant taro	Insular SE Asia New Guinea?	Denham, 2011
	Dioscorea alata	greater yam	New Guinea	Denham, 2011
	Dioscorea esculenta	yam	Insular SE Asia New Guinea?	Denham, 2011
	Eleocharis dulcis	Chinese water chestnut	S China?	Simmons, 1990
VEGETABLES	*Amaranthus tricolor*	tampala	India? SE Asia?	Simmons, 1990
	Momordica charantia	bitter gourd	Hymalayas (India/ Nepal) + Yunnan	Marr et al., 2004
	Benincasa hispida	winter melon	S China (Yunnan) maybe E India?	Matthews, 2003
	Trichosanthes cucumerina	wild snake gourd	India, China, SE Asia	
	Luffa acutangula	ridged loffah	India	Marr et al .,2005
FRUIT TREE	*Citrus maxima*	pomelo	SE Asia	Weisskopf & Fuller, 2014; Fuller et al., 2017

Appendix 1. Major East Asian domesticates and their domestication centres

(updated from Li 1970 Southern Asia section, current known origin if different is outlined in table)

	LATIN NAME	COMMON NAME	NATIVE TO	REFERENCES
BEVERAGES & MASTICATORIES	*Areca catechu*	areca palm	SE Asia	Zumbroich, 2009
SPICES & CONDIMENTS	*Piper nigrum*	pepper	multiple: SE Asia	Simmons, 1990
	Cinnamomum cassia	Chinese cinnamom	S China	Simmons, 1990
	Piper nigrum	pepper	SW India	Cappers, 2006
FIBERS	*Gossypium arboreum*	cotton tree	Indus region	Fuller ,2008; Smartt & Simmonds, 1995
	Gossypium herbaceum	Levant cotton	Africa	Fuller, 2008
	Corchorus capsularis	white jute	India	Cappers ,2006

Appendix 1. Major East Asian domesticates and their domestication centres

(updated from Li 1970 Southern Islands section, current known origin if different is outlined in table)

	LATIN NAME	COMMON NAME	NATIVE TO	REFERENCES
ROOTS & TUBER CROPS	*Colocasia esculentam*	taro	SE Asia	Denham, 2011; Matthews & Nguyen, 2014
	Alocasia machrorrhyzos	giant taro	Insular SE Asia New Guinea?	Denham, 2011
FRUIT TREE	*Artocarpus altilis*	breadfruit	SE Asia, Pacific	Denham, 2011
	Artocarpus integra	cempedak	SE Asia	Simmons, 1990
	Averrhoa carambola	starfruit	SE Asia	Simmons, 1990
	Averroha bilimbi	bilimbi	SE Asia	Simmons, 1990
	Cocos nucifera	coconut	SE Asia	Gunn et al., 2011
	Cistrus aurantifolia	lime	SE Asia	Simmons, 1990
	Gracinia mangostana	mangosteen	SE Asia	Simmons, 1990
	(Nephelium) Dimocarpus lappaceum	rambutan	SE Asia	Simmons, 1990
	Lansium domesticum	langsat/ lanzones	SE Asia	Simmons, 1990; Blench ,2008
	Durio zibethinus	durian	SE Asia	Simmons, 1990
	Eugenia javanica	Java apple	SE Asia	Panggabean, 1992; Whistler & Elevitch, 2005
	Terminalia catappa	sea-almond	India	Asouti & Fuller, 2007
OTHER SPECIAL FOOD CROPS	*Musa x paradisiaca*	banana/ plantains	SE Asia	Denham 2011; Castillo & Fuller, 2015
OTHER SPECIAL FOOD CROPS	*Saccharum officinarum*	sugarcane	Insular SE Asia New Guinea?	Denham, 2011;2014;

Appendix 1. Major East Asian domesticates and their domestication centres

(updated from Li 1970 Southern Islands section, current known origin if different is outlined in table)

	LATIN NAME	COMMON NAME	NATIVE TO	REFERENCES
				Grivet & Daniels, 2004; Daniels & Daniels, 1994
SPICES & CONDIMENTS	*Zingiber officiale*	ginger	India? SE Asia? S China	Simmons, 1990
	Curcuma domestica	turmeric	S Asia	Sopher, 1964; Kashyap & Weber 2013
	Piper nigrum	pepper	SW India	Cappers, 2006
	Myristica fragrans	nutmeg	SE Asia	Simmons, 1990
	Eugenia caryophyllus	clove	SE Asia	Simmons, 1990

Appendix 1. Major East Asian domesticates and their domestication centres: additional species

(not originally included in Li 1970)

	LATIN NAME	COMMON NAME	NATIVE TO	REFERENCES
CROPS	*Fagopyrum esculentum*	buckwheat	Yunnan or Southwest Sichuan	Ohnishi, 1998; Ohnishi, 2004; Zhao, 2008; Weisskopf & Fuller, 2014; Boivin et al., 2012
	Chenopodium album	Chenopod	possible multiple domestication: China, Himalaya, Europe?	Partap ,1990; Partap & Kapor 1987; Fogg, 1983; Smart & Simmonds, 1995
	Echinochloa crus-galli (from E. utilis Yabuno)	Barnyard millet	NE China, Japan, Korea	Weber & Fuller ,2006; Crawford, 2011
FRUIT TREE	*Cucumis melo*	melon	Probable multiple domestication: 1) Lower Yangzi; 2) Egypt; 3) Indus Valley; 4) Japan/ East Asia	Fuller, 2012; Fuller et al., 2014; Zheng & Chen, 2006; Zohary, et al., 2013; Tanaka et al., 2016
	Cucumis sativus	cucumber	Indian Subhimalayan region	Fuller, 2003
	Broussonetia papyrifera	paper mulberry	China	Crawford, 2011
	Artocarpus hetrophyllus	jackfruit	S India	Asouti & Fuller, 2008
ACORN	*Castanea molissima*	chestnut	China	Crawford, 2011

Appendix 1. Major East Asian domesticates and their domestication centres: additional species

(not originally included in Li 1970)

	LATIN NAME	COMMON NAME	NATIVE TO	REFERENCES
SPICES & CONDIMENTS	*Capsicum frutescens*	Capsicum (lajiao)	South America[1]	Ho, 1995; Piperno & Pearsall, 1998

[1] This species has been included as it was thought to be native to China (Ho 1995), but later research proved otherwise.

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 T1 (16) s2	YBB 2013 (17)	YBB 2013 (18)	YBB 2013 T1 (19)	YBB 2013 T1 (20)	YBB 2013 T2 (20) lf1	YBB 2013 T2(21)	YBB 2013 T1 (22)	YBB 2013 T1(23)	YBB 2013 T2(24) S3
		Phase	1	1	1	1	1	1	1	1	1	1
		bulk vol (L)	7	21	11	7	6	6	18	12	12	6
Cultivated Cereals	Family	Common Name										
Oryza sativa ssp. *japonica*	Poaceae	Rice grain with embryo	16	16	5	1	14	1175	182	13	4	
Oryza sativa ssp. *japonica*	Poaceae	Rice grain fragment	16	6	10	3	5	500	67	4	3	
Oryza sativa ssp. *japonica*	Poaceae	Rice embryo						59	1	1	1	
Oryza sp.	Poaceae	Charred food remains (rice)						24		1		
Oryza sativa ssp. *japonica*	Poaceae	Rice immature grain	1	4				3	1			
Oryza sativa ssp. *japonica*	Poaceae	Rice immature grain fragment	2	4					1			
Oryza sativa ssp. *japonica*	Poaceae	Rice domesticated spikelet base (ripped scar)		10	2		1		4			
Oryza sativa ssp. *japonica*	Poaceae	Rice domesticated spikelet base (semi- ripped scar)		2	1	2	3		3			
Oryza spikelet base	Poaceae	Rice wild spikelet base		2								

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 T1 (16) s2	YBB 2013 (17)	YBB 2013 (18)	YBB 2013 T1 (19)	YBB 2013 T1 (20)	YBB 2013 T2 (20) lf1	YBB 2013 T2(21)	YBB 2013 T1 (22)	YBB 2013 T1(23)	YBB 2013 T2(24) S3
		Phase	1	1	1	1	1	1	1	1	1	1
Oryza sativa ssp. *japonica*	Poaceae	Rice immature spikelet base			1							
Oryza sativa ssp. *japonica*	Poaceae	Rice indet. spikelet base										
Oryza sativa ssp. *japonica*	Poaceae	Rice husk						1	1			1
Panicum sp.	Poaceae	Small panicum millet grain							9		2	
Panicum miliaceum	Poaceae	Broomcorn millet grain	1	21	6	1	3	11	88	1	1	15
Panicum cf. *miliaceum*	Poaceae	Broomcorn millet immature grain		1					1			2
Setaria cf.	Poaceae	Millet grain									7	
Setaria italica	Poaceae	Foxtail millet grain	6	40	20		14	800	10	11	11	5
Setaria sp.	Poaceae	Charred food remains (foxtail millet)						12				
Setaria cf. *italica*	Poaceae	Foxtail millet immature grain	3	11	10		2	4	1	1		2
cf. *Setaria / Panicum*	Poaceae	Indet. millet fragments						10	8			

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 T1 (16) s2	YBB 2013 (17)	YBB 2013 (18)	YBB 2013 T1 (19)	YBB 2013 T1 (20)	YBB 2013 T2 (20) lf1	YBB 2013 T2(21)	YBB 2013 T1 (22)	YBB 2013 T1(23)	YBB 2013 T2(24) S3
		Phase	1	1	1	1	1	1	1	1	1	1
Grasses and other dryland field weeds												
cf. *Setaria/ Echinochloa*	Poaceae			4	1							
Panicum cf. subsp. *ruderale*	Poaceae	Panicum ruderale							2			
Panicum sp.	Poaceae	small wild panicum grain										2
Echinochloa sp.	Poaceae	Barnyard grass grain	8	13	1	1	3	3	6	1	17	
Echinochloa cf.	Poaceae	Barnyard grass immature grain	3		1				1	1	5	
Echinochloa sp.	Poaceae	Barnyard grass small grain										
Setaria cf. *viridis*	Poaceae	Wild foxtail millet	4	13	1		3	2			2	
Setaria cf. *verticillata*	Poaceae	Bristly foxtail millet							2		5	
Digitaria sp.	Poaceae	Crabgrass		2		2		2	5	2	42	1
Other wild/weedy grasses												
Poaceae, wild (others)	Poaceae	Wild Poaceae grass			4						2	1
cf. *Poa*	Poaceae	Bluegrass				1			1	1		
Eragrostis sp.	Poaceae	Lovegrass									1	

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 T1 (16) s2	YBB 2013 (17)	YBB 2013 (18)	YBB 2013 T1 (19)	YBB 2013 T1 (20)	YBB 2013 T2 (20) lf1	YBB 2013 T2(21)	YBB 2013 T1 (22)	YBB 2013 T1(23)	YBB 2013 T2(24) S3
		Phase	1	1	1	1	1	1	1	1	1	1
cf. *Sporobolus*	Poaceae	Smut grass										
cf. *Urochloa*	Poaceae	Signalgrass										
cf. *Paspalum*	Poaceae	Crowngrass										
cf. *Pennisetum*	Poaceae	Fountaingrass										
Sedges and other wetland weeds												
Polygonum sp.	Polygonaceae	Indet. knotweed grass										
Polygonum persicaria	Polygonaceae	Lady's thumb	1									
Cyperaceae	Cyperaceae	Indet. sedge inner nutlet							3		1	
Schoenoplectus mucronatus	Cyperaceae	Bog bulrush	1									
Fimbristylis sp.	Cyperaceae	Fimbristyle			1				8		10	1
Scirpus sp.	Cyperaceae	Bulrush							1		4	
Eleocharis sp.	Cyperaceae	Sedge rhizome tuber		1								
Cyperus sp.	Cyperaceae	Indet. Cyperus sedge										
Carex sp.	Cyperaceae	Indet. Carex sedge							1			
Juncaceae	Juncaceae	Indet. rush family	1									

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 T1 (16) s2	YBB 2013 (17)	YBB 2013 (18)	YBB 2013 T1 (19)	YBB 2013 T1 (20)	YBB 2013 T2 (20) lf1	YBB 2013 T2(21)	YBB 2013 T1 (22)	YBB 2013 T1(23)	YBB 2013 T2(24) S3
		Phase	1	1	1	1	1	1	1	1	1	1
Possible Utilized Species												
Acorn		Acorn										
Nutshell		Acorn nutshell (thin)		2								
Nutshell,		Acorn nutshell (thick)		1						1		
Juglans sp.	Junglandaceae	Walnut										
Chenopodium sp.	Chenopodiaceae				6	2	2		28		4	1
Euryale ferox	Nymphaeaceae	Foxnut		6	4			1	20	2	3	
Crataegus sp.	Rosaceae	Hawthorn							1			
Glycine cf. *max*	Fabaceae	Soybean			2				2			
Cajanus sp	Fabaceae	Wild cajanus pea		1								
Vigna sp.	Fabaceae	Indet. vigna bean		1					1			
Melia azedarach	Meliaceae	Chinaberry (endorcarp)										
Vitis sp.	Vitaceae	Wild grape										
Solanum sp.	Solonaceae	Nightshade family										
Cucurbitaceae cf	Cucurbitcaceae	Indet. cucurbit										
Cucumis cf. *melo*	Cucurbitcaceae	Melon									1	

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 T1 (16) s2	YBB 2013 (17)	YBB 2013 (18)	YBB 2013 T1 (19)	YBB 2013 T1 (20)	YBB 2013 T2 (20) lf1	YBB 2013 T2(21)	YBB 2013 T1 (22)	YBB 2013 T1(23)	YBB 2013 T2(24) S3
		Phase	1	1	1	1	1	1	1	1	1	1
Wild Species												
Portulaca cf *quadrifida/ pillosa*	Portulaceae	Chickenweed										
Cf. Urtica sp.	Urticaceae	Nettle										
Perilla sp.	Lamiaceae	Perilla										
Brassicacae indet.	Brassicaceae	Indet. mustard family										
Brassica sp.	Brassicaceae	Indet. brassica seed										
Potentilla sp.	Rosaceae	Cinquefoils										
Fabaceae	Fabaceae	Immature indet. Legume										
Fabaceae	Fabaceae	Small indet. Legume			2							
Fabaceae	Fabaceae	Thin indet. Legume										
Fabaceae	Fabaceae	Indet. Legume							5			
Fabaceae	Fabaceae	Legume (hilum)			1				1			
Euphorbia sp.	Euphorbiaceae	Euphorbia seed										
Malvaceae	Malvaceae	Indet. mallow								1		
Ipomoea sp.	Convolvulaceae	Morning glory										

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 T1 (16) s2	YBB 2013 (17)	YBB 2013 (18)	YBB 2013 T1 (19)	YBB 2013 T1 (20)	YBB 2013 T2 (20) lf1	YBB 2013 T2(21)	YBB 2013 T1 (22)	YBB 2013 T1(23)	YBB 2013 T2(24) S3
		Phase	1	1	1	1	1	1	1	1	1	1
Lamiaceae	Lamiaceae	Indet mint family										
Stachys/ Mosla cf.	Lamiaceae	Hedgenettle									25	
Verbena officinalis (uncharred)	Verbenaceae	Verbena										
Asteraceae	Asteraceae	Indet. Daisy family										
Unidentified remains												
		Indet. small seeds		5	5		3			2	3	
		Indet. reticulate testa/shell										
		Indet. fragments	10	69	43		12		26		10	
		Parenchyma fragments		24					28			
		Small bones present		x				x				
		Indet. tuber pieces							2			

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 F9	YBB2013 F10	YBB2013 F11 S1	YBB2013 F11 under Floor	YBB2013 F12(1)	YBB2013 F12(2)	YBB2013 F12 (3)	YBB2013 F13	YBB2013 F13 central	YBB2013 F14
		Phase	1	1	1	1	1	1	1	1	1	1
		bulk vol (L)	10	10	10	10	10	10	10	10	10	10
Cultivated Cereals	**Family**	**Common Name**										
Oryza sativa ssp. *japonica*	Poaceae	Rice grain with embryo	1		14	1043	13	17	21	1		11
Oryza sativa ssp. *japonica*	Poaceae	Rice grain fragment	1	7	66	225	27	12	24	10	3	34
Oryza sativa ssp. *japonica*	Poaceae	Rice embryo		2		2	2	2	1			1
Oryza sp.	Poaceae	Charred food remains (rice)										
Oryza sativa ssp. *japonica*	Poaceae	Rice immature grain						1	3	2		2
Oryza sativa ssp. *japonica*	Poaceae	Rice immature grain fragment					2	2		3	3	
Oryza sativa ssp. *japonica*	Poaceae	Rice domesticated spikelet base (ripped scar)		11		32	9	6	26	58	1	
Oryza sativa ssp. *japonica*	Poaceae	Rice domesticated spikelet base (semi- ripped scar)		2		3			5	11	1	
Oryza spikelet base	Poaceae	Rice wild spikelet base				1				2		

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 F9	YBB2013 F10	YBB2013 F11 S1	YBB2013 F11 under Floor	YBB2013 F12(1)	YBB2013 F12(2)	YBB2013 F12 (3)	YBB2013 F13	YBB2013 F13 central	YBB2013 F14
		Phase	1	1	1	1	1	1	1	1	1	1
Oryza sativa ssp. *japonica*	Poaceae	Rice immature spikelet base				7			8	1		
Oryza sativa ssp. *japonica*	Poaceae	Rice indet. spikelet base				4			2	12		
Oryza sativa ssp. *japonica*	Poaceae	Rice husk						1	1			
Panicum sp.	Poaceae	Small panicum millet grain				1	1	2	1	2		
Panicum miliaceum	Poaceae	Broomcorn millet grain				3		2	3		4	
Panicum cf. *miliaceum*	Poaceae	Broomcorn millet immature grain							1			
Setaria cf.	Poaceae	Millet grain			1					23		
Setaria italica	Poaceae	Foxtail millet grain	5	1		23	19	17	30	32	17	20
Setaria sp.	Poaceae	Charred food remains (foxtail millet)										
Setaria cf. *italica*	Poaceae	Foxtail millet immature grain		3		4	7	11	15			5
cf. *Setaria / Panicum*	Poaceae	Indet. millet fragments					6	3	4		7	

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 F9	YBB2013 F10	YBB2013 F11 S1	YBB2013 F11 under Floor	YBB2013 F12(1)	YBB2013 F12(2)	YBB2013 F12 (3)	YBB2013 F13	YBB2013 F13 central	YBB2013 F14
		Phase	1	1	1	1	1	1	1	1	1	1
Grasses and other dryland field weeds												
cf. *Setaria/ Echinochloa*	Poaceae				2		9					
Panicum cf. subsp. *ruderale*	Poaceae	Panicum ruderale										
Panicum sp.	Poaceae	small wild panicum grain										
Echinochloa sp.	Poaceae	Barnyard grass grain	4		4	232	12	12	20	29	25	22
Echinochloa cf.	Poaceae	Barnyard grass immature grain				23		11	2		14	5
Echinochloa sp.	Poaceae	Barnyard grass small grain			1					21		
Setaria cf. *viridis*	Poaceae	Wild foxtail millet			1	32	8	5		15		4
Setaria cf. *verticillata*	Poaceae	Bristly foxtail millet								29	4	
Digitaria sp.	Poaceae	Crabgrass				1	2		17	31	30	7
Other wild/weedy grasses												
Poaceae, wild (others)	Poaceae	Wild Poaceae grass					1		1			1
cf. *Poa*	Poaceae	Bluegrass						1				
Eragrostis sp.	Poaceae	Lovegrass										

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 F9	YBB2013 F10	YBB2013 F11 S1	YBB2013 F11 under Floor	YBB2013 F12(1)	YBB2013 F12(2)	YBB2013 F12 (3)	YBB2013 F13	YBB2013 F13 central	YBB2013 F14
		Phase	1	1	1	1	1	1	1	1	1	1
cf. *Sporobolus*	Poaceae	Smut grass										
cf. *Urochloa*	Poaceae	Signalgrass						1				
cf. *Paspalum*	Poaceae	Crowngrass						1			1	
cf. *Pennisetum*	Poaceae	Fountaingrass										
Sedges and other wetland weeds												
Polygonum sp.	Polygonaceae	Indet. knotweed grass										
Polygonum persicaria	Polygonaceae	Lady's thumb				18		1				
Cyperaceae	Cyperaceae	Indet. sedge inner nutlet				1						
Schoenoplectus mucronatus	Cyperaceae	Bog bulrush										
Fimbristylis sp.	Cyperaceae	Fimbristyle									1	
Scirpus sp.	Cyperaceae	Bulrush				1						1
Eleocharis sp.	Cyperaceae	Sedge rhizome tuber										
Cyperus sp.	Cyperaceae	Indet. Cyperus sedge					2					
Carex sp.	Cyperaceae	Indet. Carex sedge									1	
Juncaceae	Juncaceae	Indet. rush family										

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 F9	YBB2013 F10	YBB2013 F11 S1	YBB2013 F11 under Floor	YBB2013 F12(1)	YBB2013 F12(2)	YBB2013 F12 (3)	YBB2013 F13	YBB2013 F13 central	YBB2013 F14
		Phase	1	1	1	1	1	1	1	1	1	1
Possible Utilized Species												
Acorn		Acorn										
Nutshell		Acorn nutshell (thin)										
Nutshell,		Acorn nutshell (thick)					4	4	1	1		1
Juglans sp.	Junglandaceae	Walnut										
Chenopodium sp.	Chenopodiaceae			2	3	17	3	9	9	3	4	3
Euryale ferox	Nymphaeaceae	Foxnut					8	3	6			1
Crataegus sp.	Rosaceae	Hawthorn										
Glycine cf. *max*	Fabaceae	Soybean					2					
Cajanus sp	Fabaceae	Wild cajanus pea	1									1
Vigna sp.	Fabaceae	Indet. vigna bean								1		
Melia azedarach	Meliaceae	Chinaberry (endorcarp)										
Vitis sp.	Vitaceae	Wild grape										
Solanum sp.	Solonaceae	Nightshade family										
Cucurbitaceae cf	Cucurbitcaceae	Indet. cucurbit										
Cucumis cf. *melo*	Cucurbitcaceae	Melon										

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 F9	YBB2013 F10	YBB2013 F11 S1	YBB2013 F11 under Floor	YBB2013 F12(1)	YBB2013 F12(2)	YBB2013 F12 (3)	YBB2013 F13	YBB2013 F13 central	YBB2013 F14
		Phase	1	1	1	1	1	1	1	1	1	1
Wild Species												
Portulaca cf *quadrifida/ pillosa*	Portulaceae	Chickenweed								1		
Cf. Urtica sp.	Urticaceae	Nettle										
Perilla sp.	Lamiaceae	Perilla										
Brassicacae indet.	Brassicaceae	Indet. mustard family										
Brassica sp.	Brassicaceae	Indet. brassica seed					1					
Potentilla sp.	Rosaceae	Cinquefoils										
Fabaceae	Fabaceae	Immature indet. Legume										
Fabaceae	Fabaceae	Small indet. Legume										
Fabaceae	Fabaceae	Thin indet. Legume										
Fabaceae	Fabaceae	Indet. Legume						3				
Fabaceae	Fabaceae	Legume (hilum)										
Euphorbia sp.	Euphorbiaceae	Euphorbia seed										
Malvaceae	Malvaceae	Indet. mallow								1		
Ipomoea sp.	Convolvulaceae	Morning glory										

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 F9	YBB2013 F10	YBB2013 F11 S1	YBB2013 F11 under Floor	YBB2013 F12(1)	YBB2013 F12(2)	YBB2013 F12 (3)	YBB2013 F13	YBB2013 F13 central	YBB2013 F14
		Phase	1	1	1	1	1	1	1	1	1	1
Lamiaceae	Lamiaceae	Indet mint family								1		
Stachys/ Mosla cf.	Lamiaceae	Hedgenettle										
Verbena officinalis (uncharred)	Verbenaceae	Verbena										
Asteraceae	Asteraceae	Indet. Daisy family					1					
Unidentified remains												
		Indet. small seeds		1				5	3	5	1	7
		Indet. reticulate testa/shell										
		Indet. fragments	1	30	1ML		24	40	151		9	12
		Parenchyma fragments										
		Small bones present							1			
		Indet. tuber pieces										

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB 2013 HD8(2)	YBB 2013 HD8(3)	YBB 2013 HD10	YBB 2013 HT3	YBB 2013 HT3 D12	YBB 2013 HT3(3)	YBB 2013 HT4	YBB 2013 D58	YBB 2013 H167	YBB 2013 H168(1)
		Phase	1	1	1	1	1	1	1	1	1	1
		bulk vol (L)	10	10	10	10	10	10	10	10	10	8
Cultivated Cereals	Family	Common Name										
Oryza sativa ssp. *japonica*	Poaceae	Rice grain with embryo	139	186		3	1	2		3	4	10
Oryza sativa ssp. *japonica*	Poaceae	Rice grain fragment	25	150	5	4	4	12	2	1	4	35
Oryza sativa ssp. *japonica*	Poaceae	Rice embryo		1		1	1	1		1		2
Oryza sp.	Poaceae	Charred food remains (rice)										
Oryza sativa ssp. *japonica*	Poaceae	Rice immature grain	5	32	1							2
Oryza sativa ssp. *japonica*	Poaceae	Rice immature grain fragment		2		1	1		2			
Oryza sativa ssp. *japonica*	Poaceae	Rice domesticated spikelet base (ripped scar)								1		1
Oryza sativa ssp. *japonica*	Poaceae	Rice domesticated spikelet base (semi- ripped scar)										
Oryza spikelet base	Poaceae	Rice wild spikelet base										2

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB 2013 HD8(2)	YBB 2013 HD8(3)	YBB 2013 HD10	YBB 2013 HT3	YBB 2013 HT3 D12	YBB 2013 HT3(3)	YBB 2013 HT4	YBB 2013 D58	YBB 2013 H167	YBB 2013 H168(1)
		Phase	1	1	1	1	1	1	1	1	1	1
Oryza sativa ssp. *japonica*	Poaceae	Rice immature spikelet base										1
Oryza sativa ssp. *japonica*	Poaceae	Rice indet. spikelet base										
Oryza sativa ssp. *japonica*	Poaceae	Rice husk										
Panicum sp.	Poaceae	Small panicum millet grain	1		1	2						
Panicum miliaceum	Poaceae	Broomcorn millet grain	28	48							3	1
Panicum cf. *miliaceum*	Poaceae	Broomcorn millet immature grain		6								
Setaria cf.	Poaceae	Millet grain										
Setaria italica	Poaceae	Foxtail millet grain	11	54		7		6	7	5	15	46
Setaria sp.	Poaceae	Charred food remains (foxtail millet)										
Setaria cf. *italica*	Poaceae	Foxtail millet immature grain	5	3		3	1	3		1		14
cf. *Setaria / Panicum*	Poaceae	Indet. millet fragments	7	4		8				1		

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB 2013 HD8(2)	YBB 2013 HD8(3)	YBB 2013 HD10	YBB 2013 HT3	YBB 2013 HT3 D12	YBB 2013 HT3(3)	YBB 2013 HT4	YBB 2013 D58	YBB 2013 H167	YBB 2013 H168(1)
		Phase	1	1	1	1	1	1	1	1	1	1
Grasses and other dryland field weeds												
cf. *Setaria*/ *Echinochloa*	Poaceae							1	2			
Panicum cf. subsp. *ruderale*	Poaceae	Panicum ruderale										
Panicum sp.	Poaceae	small wild panicum grain										
Echinochloa sp.	Poaceae	Barnyard grass grain	2	12		35		7	3	2	2	12
Echinochloa cf.	Poaceae	Barnyard grass immature grain	2	2		2						
Echinochloa sp.	Poaceae	Barnyard grass small grain										
Setaria cf. *viridis*	Poaceae	Wild foxtail millet	1						4			
Setaria cf. *verticillata*	Poaceae	Bristly foxtail millet				9		1				
Digitaria sp.	Poaceae	Crabgrass	8	54		4		1	2	2	1	6
Other wild/weedy grasses												
Poaceae, wild (others)	Poaceae	Wild Poaceae grass	1	5								
cf. *Poa*	Poaceae	Bluegrass		2						1		
Eragrostis sp.	Poaceae	Lovegrass								1		

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB 2013 HD8(2)	YBB 2013 HD8(3)	YBB 2013 HD10	YBB 2013 HT3	YBB 2013 HT3 D12	YBB 2013 HT3(3)	YBB 2013 HT4	YBB 2013 D58	YBB 2013 H167	YBB 2013 H168(1)
		Phase	1	1	1	1	1	1	1	1	1	1
cf. *Sporobolus*	Poaceae	Smut grass										
cf. *Urochloa*	Poaceae	Signalgrass										
cf. *Paspalum*	Poaceae	Crowngrass		2								
cf. *Pennisetum*	Poaceae	Fountaingrass										
Sedges and other wetland weeds												
Polygonum sp.	Polygonaceae	Indet. knotweed grass										
Polygonum persicaria	Polygonaceae	Lady's thumb										
Cyperaceae	Cyperaceae	Indet. sedge inner nutlet	1	4				1				2
Schoenoplectus mucronatus	Cyperaceae	Bog bulrush					1					
Fimbristylis sp.	Cyperaceae	Fimbristyle	9	3								
Scirpus sp.	Cyperaceae	Bulrush		5		2		2				
Eleocharis sp.	Cyperaceae	Sedge rhizome tuber										
Cyperus sp.	Cyperaceae	Indet. Cyperus sedge		1								
Carex sp.	Cyperaceae	Indet. Carex sedge										
Juncaceae	Juncaceae	Indet. rush family										

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB 2013 HD8(2)	YBB 2013 HD8(3)	YBB 2013 HD10	YBB 2013 HT3	YBB 2013 HT3 D12	YBB 2013 HT3(3)	YBB 2013 HT4	YBB 2013 D58	YBB 2013 H167	YBB 2013 H168(1)
		Phase	1	1	1	1	1	1	1	1	1	1
Possible Utilized Species												
Acorn		Acorn		3								
Nutshell		Acorn nutshell (thin)				1						
Nutshell,		Acorn nutshell (thick)				1						
Juglans sp.	Junglandaceae	Walnut										
Chenopodium sp.	Chenopodiaceae		12	10						1		
Euryale ferox	Nymphaeaceae	Foxnut		4	1	1				1		2
Crataegus sp.	Rosaceae	Hawthorn										
Glycine cf. *max*	Fabaceae	Soybean	18	1		1	1					
Cajanus sp	Fabaceae	Wild cajanus pea				1						
Vigna sp.	Fabaceae	Indet. vigna bean	2									
Melia azedarach	Meliaceae	Chinaberry (endorcarp)										
Vitis sp.	Vitaceae	Wild grape	1									
Solanum sp.	Solonaceae	Nightshade family										
Cucurbitaceae cf	Cucurbitcaceae	Indet. cucurbit						1				
Cucumis cf. *melo*	Cucurbitcaceae	Melon										

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB 2013 HD8(2)	YBB 2013 HD8(3)	YBB 2013 HD10	YBB 2013 HT3	YBB 2013 HT3 D12	YBB 2013 HT3(3)	YBB 2013 HT4	YBB 2013 D58	YBB 2013 H167	YBB 2013 H168(1)
		Phase	1	1	1	1	1	1	1	1	1	1
Wild Species												
Portulaca cf *quadrifida/ pillosa*	Portulaceae	Chickenweed										
Cf. Urtica sp.	Urticaceae	Nettle										
Perilla sp.	Lamiaceae	Perilla	1	1								
Brassicacae indet.	Brassicaceae	Indet. mustard family	1									
Brassica sp.	Brassicaceae	Indet. brassica seed										
Potentilla sp.	Rosaceae	Cinquefoils										
Fabaceae	Fabaceae	Immature indet. Legume										
Fabaceae	Fabaceae	Small indet. Legume										1
Fabaceae	Fabaceae	Thin indet. Legume										
Fabaceae	Fabaceae	Indet. Legume										
Fabaceae	Fabaceae	Legume (hilum)		1								
Euphorbia sp.	Euphorbiaceae	Euphorbia seed										
Malvaceae	Malvaceae	Indet. mallow										
Ipomoea sp.	Convolvulaceae	Morning glory										

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB 2013 HD8(2)	YBB 2013 HD8(3)	YBB 2013 HD10	YBB 2013 HT3	YBB 2013 HT3 D12	YBB 2013 HT3(3)	YBB 2013 HT4	YBB 2013 D58	YBB 2013 H167	YBB 2013 H168(1)
		Phase	1	1	1	1	1	1	1	1	1	1
Lamiaceae	Lamiaceae	Indet mint family	3	2								
Stachys/ Mosla cf.	Lamiaceae	Hedgenettle										
Verbena officinalis (uncharred)	Verbenaceae	Verbena										
Asteraceae	Asteraceae	Indet. Daisy family										
Unidentified remains												
		Indet. small seeds		9	2		3				3	1
		Indet. reticulate testa/shell		1								
		Indet. fragments	3	11		15		7	8	1		
		Parenchyma fragments										
		Small bones present										
		Indet. tuber pieces										

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 H168-2	YBB2013 H178	YBB2013 H179	YBB2013 H185	YBB2013 H190	YBB2013 H193	YBB2013 H208	YBB2013 H212	YBB2013 M17	YBB2013 T1 (8) S4
		Phase	1	1	1	1	1	1	1	1	1	2
		bulk vol (L)	10	10	10	10	10	10	10	10	10	8
Cultivated Cereals	Family	Common Name										
Oryza sativa ssp. *japonica*	Poaceae	Rice grain with embryo	7	2		9	1	5	3	1		7
Oryza sativa ssp. *japonica*	Poaceae	Rice grain fragment	5	5	5	15	25	2	1	1		5
Oryza sativa ssp. *japonica*	Poaceae	Rice embryo	1				1	1		1		1
Oryza sp.	Poaceae	Charred food remains (rice)										
Oryza sativa ssp. *japonica*	Poaceae	Rice immature grain	1			1			4	1		1
Oryza sativa ssp. *japonica*	Poaceae	Rice immature grain fragment										
Oryza sativa ssp. *japonica*	Poaceae	Rice domesticated spikelet base (ripped scar)	1			1	1	1				1
Oryza sativa ssp. *japonica*	Poaceae	Rice domesticated spikelet base (semi- ripped scar)										
Oryza spikelet base	Poaceae	Rice wild spikelet base										

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 H168-2	YBB2013 H178	YBB2013 H179	YBB2013 H185	YBB2013 H190	YBB2013 H193	YBB2013 H208	YBB2013 H212	YBB2013 M17	YBB2013 T1 (8) S4
		Phase	1	1	1	1	1	1	1	1	1	2
Oryza sativa ssp. *japonica*	Poaceae	Rice immature spikelet base										
Oryza sativa ssp. *japonica*	Poaceae	Rice indet. spikelet base										
Oryza sativa ssp. *japonica*	Poaceae	Rice husk										
Panicum sp.	Poaceae	Small panicum millet grain										
Panicum miliaceum	Poaceae	Broomcorn millet grain		1				1	3	1		
Panicum cf. *miliaceum*	Poaceae	Broomcorn millet immature grain	1									1
Setaria cf.	Poaceae	Millet grain										
Setaria italica	Poaceae	Foxtail millet grain	11		1		4	5	9	2		11
Setaria sp.	Poaceae	Charred food remains (foxtail millet)										
Setaria cf. *italica*	Poaceae	Foxtail millet immature grain	3				1	1	1			3
cf. *Setaria / Panicum*	Poaceae	Indet. millet fragments					1	4	1			

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 H168-2	YBB2013 H178	YBB2013 H179	YBB2013 H185	YBB2013 H190	YBB2013 H193	YBB2013 H208	YBB2013 H212	YBB2013 M17	YBB2013 T1 (8) S4
		Phase	1	1	1	1	1	1	1	1	1	2
Grasses and other dryland field weeds												
cf. *Setaria*/ *Echinochloa*	Poaceae											
Panicum cf. subsp. *ruderale*	Poaceae	Panicum ruderale										
Panicum sp.	Poaceae	small wild panicum grain						1	1	1		
Echinochloa sp.	Poaceae	Barnyard grass grain	7	1		1		5				7
Echinochloa cf.	Poaceae	Barnyard grass immature grain										
Echinochloa sp.	Poaceae	Barnyard grass small grain										
Setaria cf. *viridis*	Poaceae	Wild foxtail millet	1									1
Setaria cf. *verticillata*	Poaceae	Bristly foxtail millet										
Digitaria sp.	Poaceae	Crabgrass	1						1			1
Other wild/weedy grasses												
Poaceae, wild (others)	Poaceae	Wild Poaceae grass										
cf. *Poa*	Poaceae	Bluegrass										
Eragrostis sp.	Poaceae	Lovegrass										

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 H168-2	YBB2013 H178	YBB2013 H179	YBB2013 H185	YBB2013 H190	YBB2013 H193	YBB2013 H208	YBB2013 H212	YBB2013 M17	YBB2013 T1 (8) S4
		Phase	1	1	1	1	1	1	1	1	1	2
cf. *Sporobolus*	Poaceae	Smut grass										
cf. *Urochloa*	Poaceae	Signalgrass										
cf. *Paspalum*	Poaceae	Crowngrass										
cf. *Pennisetum*	Poaceae	Fountaingrass										
Sedges and other wetland weeds												
Polygonum sp.	Polygonaceae	Indet. knotweed grass										
Polygonum persicaria	Polygonaceae	Lady's thumb										
Cyperaceae	Cyperaceae	Indet. sedge inner nutlet										
Schoenoplectus mucronatus	Cyperaceae	Bog bulrush										
Fimbristylis sp.	Cyperaceae	Fimbristyle										
Scirpus sp.	Cyperaceae	Bulrush										
Eleocharis sp.	Cyperaceae	Sedge rhizome tuber										
Cyperus sp.	Cyperaceae	Indet. Cyperus sedge										
Carex sp.	Cyperaceae	Indet. Carex sedge										
Juncaceae	Juncaceae	Indet. rush family										

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 H168-2	YBB2013 H178	YBB2013 H179	YBB2013 H185	YBB2013 H190	YBB2013 H193	YBB2013 H208	YBB2013 H212	YBB2013 M17	YBB2013 T1 (8) S4
		Phase	1	1	1	1	1	1	1	1	1	2
Possible Utilized Species												
Acorn		Acorn										
Nutshell		Acorn nutshell (thin)										
Nutshell,		Acorn nutshell (thick)										
Juglans sp.	Junglandaceae	Walnut										
Chenopodium sp.	Chenopodiaceae		1									1
Euryale ferox	Nymphaeaceae	Foxnut	1	1			2		3	1	1	1
Crataegus sp.	Rosaceae	Hawthorn										
Glycine cf. *max*	Fabaceae	Soybean										
Cajanus sp	Fabaceae	Wild cajanus pea										
Vigna sp.	Fabaceae	Indet. vigna bean										
Melia azedarach	Meliaceae	Chinaberry (endorcarp)										
Vitis sp.	Vitaceae	Wild grape										
Solanum sp.	Solonaceae	Nightshade family										
Cucurbitaceae cf	Cucurbitcaceae	Indet. cucurbit										
Cucumis cf. *melo*	Cucurbitcaceae	Melon										

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 H168-2	YBB2013 H178	YBB2013 H179	YBB2013 H185	YBB2013 H190	YBB2013 H193	YBB2013 H208	YBB2013 H212	YBB2013 M17	YBB2013 T1 (8) S4
		Phase	1	1	1	1	1	1	1	1	1	2
Wild Species												
Portulaca cf *quadrifida/ pillosa*	Portulaceae	Chickenweed										
Cf. Urtica sp.	Urticaceae	Nettle										
Perilla sp.	Lamiaceae	Perilla										
Brassicacae indet.	Brassicaceae	Indet. mustard family	1									1
Brassica sp.	Brassicaceae	Indet. brassica seed										
Potentilla sp.	Rosaceae	Cinquefoils										
Fabaceae	Fabaceae	Immature indet. Legume										
Fabaceae	Fabaceae	Small indet. Legume										
Fabaceae	Fabaceae	Thin indet. Legume			1							
Fabaceae	Fabaceae	Indet. Legume						1				
Fabaceae	Fabaceae	Legume (hilum)										
Euphorbia sp.	Euphorbiaceae	Euphorbia seed										
Malvaceae	Malvaceae	Indet. mallow										
Ipomoea sp.	Convolvulaceae	Morning glory										

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 H168-2	YBB2013 H178	YBB2013 H179	YBB2013 H185	YBB2013 H190	YBB2013 H193	YBB2013 H208	YBB2013 H212	YBB2013 M17	YBB2013 T1 (8) S4
		Phase	1	1	1	1	1	1	1	1	1	2
Lamiaceae	Lamiaceae	Indet mint family										
Stachys/ Mosla cf.	Lamiaceae	Hedgenettle										
Verbena officinalis (uncharred)	Verbenaceae	Verbena										
Asteraceae	Asteraceae	Indet. Daisy family										
Unidentified remains												
		Indet. small seeds						1	5	4		
		Indet. reticulate testa/shell										
		Indet. fragments	1						1			1

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 T2 (8)c S4	YBB2013 T2 (9)b S2	YBB2013 T2 (9)c S3	YBB2013 T1 (9)h under lf2	YBB2013 T1 (10)	YBB2013 T1 (11)c S5	YBB2013 T1 (12) S2	YBB2013 T1 (12)b S2	YBB2013 T1 (13) S3	YBB2013 T1 (14)c S4
		Phase	2	2	2	2	2	2	2	2	2	2
		bulk vol (L)	8	10	11	8	40	8	6	6	11	8
Cultivated Cereals	Family	Common Name										
Oryza sativa ssp. *japonica*	Poaceae	Rice grain with embryo	3	65	24	3	82	1	19	4	7	16
Oryza sativa ssp. *japonica*	Poaceae	Rice grain fragment	3	117	15	9	84	7	17	3	b	11
Oryza sativa ssp. *japonica*	Poaceae	Rice embryo	4	37	20	3	8	2	1		1	2
Oryza sp.	Poaceae	Charred food remains (rice)										
Oryza sativa ssp. *japonica*	Poaceae	Rice immature grain		34	28		15	1				
Oryza sativa ssp. *japonica*	Poaceae	Rice immature grain fragment		55			34			1		
Oryza sativa ssp. *japonica*	Poaceae	Rice domesticated spikelet base (ripped scar)	27	26	15	3	100	2	1			
Oryza sativa ssp. *japonica*	Poaceae	Rice domesticated spikelet base (semi- ripped scar)	12	11	2	2	63		2			
Oryza spikelet base	Poaceae	Rice wild spikelet base	2	5	3		6					

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 T2 (8)c S4	YBB2013 T2 (9)b S2	YBB2013 T2 (9)c S3	YBB2013 T1 (9)h under lf2	YBB2013 T1 (10)	YBB2013 T1 (11)c S5	YBB2013 T1 (12) S2	YBB2013 T1 (12)b S2	YBB2013 T1 (13) S3	YBB2013 T1 (14)c S4
		Phase	2	2	2	2	2	2	2	2	2	2
Oryza sativa ssp. *japonica*	Poaceae	Rice immature spikelet base	2	4	1		10					
Oryza sativa ssp. *japonica*	Poaceae	Rice indet. spikelet base	6	5	6	1	31					
Oryza sativa ssp. *japonica*	Poaceae	Rice husk										
Panicum sp.	Poaceae	Small panicum millet grain					20					
Panicum miliaceum	Poaceae	Broomcorn millet grain			6		2		1		1	1
Panicum cf. *miliaceum*	Poaceae	Broomcorn millet immature grain	1		3							
Setaria cf.	Poaceae	Millet grain					69					
Setaria italica	Poaceae	Foxtail millet grain	17	26	72	16	164	4	2	5	20	7
Setaria sp.	Poaceae	Charred food remains (foxtail millet)										
Setaria cf. *italica*	Poaceae	Foxtail millet immature grain	9	19	20	9	45	8			2	6
cf. *Setaria / Panicum*	Poaceae	Indet. millet fragments	17	16		11	11			2		

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 T2 (8)c S4	YBB2013 T2 (9)b S2	YBB2013 T2 (9)c S3	YBB2013 T1 (9)h under lf2	YBB2013 T1 (10)	YBB2013 T1 (11)c S5	YBB2013 T1 (12) S2	YBB2013 T1 (12)b S2	YBB2013 T1 (13) S3	YBB2013 T1 (14)c S4
		Phase	2	2	2	2	2	2	2	2	2	2
Grasses and other dryland field weeds												
cf. *Setaria*/ *Echinochloa*	Poaceae		5	6	13	5	2	1	5			
Panicum cf. subsp. *ruderale*	Poaceae	Panicum ruderale										
Panicum sp.	Poaceae	small wild panicum grain			4							
Echinochloa sp.	Poaceae	Barnyard grass grain	26	26	20		95				5	1
Echinochloa cf.	Poaceae	Barnyard grass immature grain					20					
Echinochloa sp.	Poaceae	Barnyard grass small grain		9							3	
Setaria cf. *viridis*	Poaceae	Wild foxtail millet			6		53					
Setaria cf. *verticillata*	Poaceae	Bristly foxtail millet							9		1	2
Digitaria sp.	Poaceae	Crabgrass	6	5	31	4	101	1			7	2
Other wild/weedy grasses												
Poaceae, wild (others)	Poaceae	Wild Poaceae grass			8	2	1				1	
cf. *Poa*	Poaceae	Bluegrass			1		1					
Eragrostis sp.	Poaceae	Lovegrass			1		1					

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 T2 (8)c S4	YBB2013 T2 (9)b S2	YBB2013 T2 (9)c S3	YBB2013 T1 (9)h under lf2	YBB2013 T1 (10)	YBB2013 T1 (11)c S5	YBB2013 T1 (12) S2	YBB2013 T1 (12)b S2	YBB2013 T1 (13) S3	YBB2013 T1 (14)c S4
		Phase	2	2	2	2	2	2	2	2	2	2
cf. *Sporobolus*	Poaceae	Smut grass			1							
cf. *Urochloa*	Poaceae	Signalgrass										
cf. *Paspalum*	Poaceae	Crowngrass										
cf. *Pennisetum*	Poaceae	Fountaingrass	1									
Sedges and other wetland weeds												
Polygonum sp.	Polygonaceae	Indet. knotweed grass										
Polygonum persicaria	Polygonaceae	Lady's thumb					1				1	
Cyperaceae	Cyperaceae	Indet. sedge inner nutlet										3
Schoenoplectus mucronatus	Cyperaceae	Bog bulrush									1	
Fimbristylis sp.	Cyperaceae	Fimbristyle										3
Scirpus sp.	Cyperaceae	Bulrush					1	1				2
Eleocharis sp.	Cyperaceae	Sedge rhizome tuber										
Cyperus sp.	Cyperaceae	Indet. Cyperus sedge		1			1					1
Carex sp.	Cyperaceae	Indet. Carex sedge										
Juncaceae	Juncaceae	Indet. rush family										3

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 T2 (8)c S4	YBB2013 T2 (9)b S2	YBB2013 T2 (9)c S3	YBB2013 T1 (9)h under lf2	YBB2013 T1 (10)	YBB2013 T1 (11)c S5	YBB2013 T1 (12) S2	YBB2013 T1 (12)b S2	YBB2013 T1 (13) S3	YBB2013 T1 (14)c S4
		Phase	2	2	2	2	2	2	2	2	2	2
Possible Utilized Species												
Acorn		Acorn										
Nutshell		Acorn nutshell (thin)	3		1							
Nutshell,		Acorn nutshell (thick)					3				2	
Juglans sp.	Junglandaceae	Walnut										
Chenopodium sp.	Chenopodiaceae			1	3	4	11	2	2	5	3	14
Euryale ferox	Nymphaeaceae	Foxnut				5	5					
Crataegus sp.	Rosaceae	Hawthorn										
Glycine cf. *max*	Fabaceae	Soybean					6					
Cajanus sp	Fabaceae	Wild cajanus pea	3	1			2					
Vigna sp.	Fabaceae	Indet. vigna bean					1					
Melia azedarach	Meliaceae	Chinaberry (endorcarp)	1									
Vitis sp.	Vitaceae	Wild grape										
Solanum sp.	Solonaceae	Nightshade family										
Cucurbitaceae cf	Cucurbitcaceae	Indet. cucurbit										
Cucumis cf. *melo*	Cucurbitcaceae	Melon										1

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 T2 (8)c S4	YBB2013 T2 (9)b S2	YBB2013 T2 (9)c S3	YBB2013 T1 (9)h under lf2	YBB2013 T1 (10)	YBB2013 T1 (11)c S5	YBB2013 T1 (12) S2	YBB2013 T1 (12)b S2	YBB2013 T1 (13) S3	YBB2013 T1 (14)c S4
		Phase	2	2	2	2	2	2	2	2	2	2
Wild Species												
Portulaca cf *quadrifida/ pillosa*	Portulaceae	Chickenweed										
Cf. Urtica sp.	Urticaceae	Nettle										
Perilla sp.	Lamiaceae	Perilla										
Brassicacae indet.	Brassicaceae	Indet. mustard family										
Brassica sp.	Brassicaceae	Indet. brassica seed					1					
Potentilla sp.	Rosaceae	Cinquefoils										
Fabaceae	Fabaceae	Immature indet. Legume										
Fabaceae	Fabaceae	Small indet. Legume			1		2					
Fabaceae	Fabaceae	Thin indet. Legume										
Fabaceae	Fabaceae	Indet. Legume										
Fabaceae	Fabaceae	Legume (hilum)					1					
Euphorbia sp.	Euphorbiaceae	Euphorbia seed										
Malvaceae	Malvaceae	Indet. mallow										
Ipomoea sp.	Convolvulaceae	Morning glory										

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 T2 (8)c S4	YBB2013 T2 (9)b S2	YBB2013 T2 (9)c S3	YBB2013 T1 (9)h under lf2	YBB2013 T1 (10)	YBB2013 T1 (11)c S5	YBB2013 T1 (12) S2	YBB2013 T1 (12)b S2	YBB2013 T1 (13) S3	YBB2013 T1 (14)c S4
		Phase	2	2	2	2	2	2	2	2	2	2
Lamiaceae	Lamiaceae	Indet mint family										
Stachys/ Mosla cf.	Lamiaceae	Hedgenettle									1	
Verbena officinalis (uncharred)	Verbenaceae	Verbena										
Asteraceae	Asteraceae	Indet. daisy family									1	
Unidentified remains												
		Indet. small seeds			1	7		4	1	2	2	1
		Indet. reticulate testa/shell										
		Indet. fragments		85	125		31	23	13		13	6
		Small bones present	x		x							

Appendix 2. BAIYANGCUN
Macro-botanical remains.

Cultivated Cereals	Family	Common Name	YBB2013 T1 (15) S2	YBB2013 HD1(1)	YBB2013 HD2(2)	YBB2013 HD5	YBB2013 HD6(2)	YBB2013 HD6(3)	YBB2013 HD6(4)	YBB2013 F6	YBB2013 F7 East	YBB2013 F7 West
		Phase	2	2	2	2	2	2	2	2	2	2
		bulk vol (L)	**8**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**
Oryza sativa ssp. *japonica*	Poaceae	Rice grain with embryo	28	18	11	2	10	68	3	3	9	2
Oryza sativa ssp. *japonica*	Poaceae	Rice grain fragment	17	13	11	2	20	46	25	10	19	2
Oryza sativa ssp. *japonica*	Poaceae	Rice embryo		9			2	10			4	1
Oryza sp.	Poaceae	Charred food remains (rice)										
Oryza sativa ssp. *japonica*	Poaceae	Rice immature grain					6	1	1			
Oryza sativa ssp. *japonica*	Poaceae	Rice immature grain fragment	4					3			15	
Oryza sativa ssp. *japonica*	Poaceae	Rice domesticated spikelet base (ripped scar)	1	1		1	4	4		60	37	33
Oryza sativa ssp. *japonica*	Poaceae	Rice domesticated spikelet base (semi- ripped scar)								17	8	6
Oryza spikelet base	Poaceae	Rice wild spikelet base									4	3

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 T1 (15) S2	YBB2013 HD1(1)	YBB2013 HD2(2)	YBB2013 HD5	YBB2013 HD6(2)	YBB2013 HD6(3)	YBB2013 HD6(4)	YBB2013 F6	YBB2013 F7 East	YBB2013 F7 West
		Phase	2	2	2	2	2	2	2	2	2	2
Oryza sativa ssp. *japonica*	Poaceae	Rice immature spikelet base								3	6	
Oryza sativa ssp. *japonica*	Poaceae	Rice indet. spikelet base								1	4	1
Oryza sativa ssp. *japonica*	Poaceae	Rice husk										
Panicum sp.	Poaceae	Small panicum millet grain		1					1			
Panicum miliaceum	Poaceae	Broomcorn millet grain					11	7	8			
Panicum cf. *miliaceum*	Poaceae	Broomcorn millet immature grain		1								
Setaria cf.	Poaceae	Millet grain										15
Setaria italica	Poaceae	Foxtail millet grain	4	41	23	6	56	75	37	6	41	10
Setaria sp.	Poaceae	Charred food remains (foxtail millet)										
Setaria cf. *italica*	Poaceae	Foxtail millet immature grain		11	11		9	4	6		2	
cf. *Setaria / Panicum*	Poaceae	Indet. millet fragments			1			2		52	10	1

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 T1 (15) S2	YBB2013 HD1(1)	YBB2013 HD2(2)	YBB2013 HD5	YBB2013 HD6(2)	YBB2013 HD6(3)	YBB2013 HD6(4)	YBB2013 F6	YBB2013 F7 East	YBB2013 F7 West
		Phase	2	2	2	2	2	2	2	2	2	2
Grasses and other dryland field weeds												
cf. *Setaria/ Echinochloa*	Poaceae			6					3	19	5	
Panicum cf. subsp. *ruderale*	Poaceae	Panicum ruderale										
Panicum sp.	Poaceae	small wild panicum grain										
Echinochloa sp.	Poaceae	Barnyard grass grain	4	28	13	1	10	108	14	22	32	6
Echinochloa cf.	Poaceae	Barnyard grass immature grain	2	11				16				
Echinochloa sp.	Poaceae	Barnyard grass small grain										20
Setaria cf. *viridis*	Poaceae	Wild foxtail millet		2							5	2
Setaria cf. *verticillata*	Poaceae	Bristly foxtail millet										
Digitaria sp.	Poaceae	Crabgrass			1			5		4	17	3
Other wild/weedy grasses												
Poaceae, wild (others)	Poaceae	Wild Poaceae grass						1				
cf. *Poa*	Poaceae	Bluegrass										
Eragrostis sp.	Poaceae	Lovegrass										

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 T1 (15) S2	YBB2013 HD1(1)	YBB2013 HD2(2)	YBB2013 HD5	YBB2013 HD6(2)	YBB2013 HD6(3)	YBB2013 HD6(4)	YBB2013 F6	YBB2013 F7 East	YBB2013 F7 West
		Phase	2	2	2	2	2	2	2	2	2	2
cf. *Sporobolus*	Poaceae	Smut grass										
cf. *Urochloa*	Poaceae	Signalgrass										
cf. *Paspalum*	Poaceae	Crowngrass									2	
cf. *Pennisetum*	Poaceae	Fountaingrass										
Sedges and other wetland weeds												
Polygonum sp.	Polygonaceae	Indet. knotweed grass										
Polygonum persicaria	Polygonaceae	Lady's thumb										
Cyperaceae	Cyperaceae	Indet. sedge inner nutlet										1
Schoenoplectus mucronatus	Cyperaceae	Bog bulrush						4				
Fimbristylis sp.	Cyperaceae	Fimbristyle										
Scirpus sp.	Cyperaceae	Bulrush									1	
Eleocharis sp.	Cyperaceae	Sedge rhizome tuber										
Cyperus sp.	Cyperaceae	Indet. Cyperus sedge										
Carex sp.	Cyperaceae	Indet. Carex sedge										1
Juncaceae	Juncaceae	Indet. rush family										

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 T1 (15) S2	YBB2013 HD1(1)	YBB2013 HD2(2)	YBB2013 HD5	YBB2013 HD6(2)	YBB2013 HD6(3)	YBB2013 HD6(4)	YBB2013 F6	YBB2013 F7 East	YBB2013 F7 West
		Phase	2	2	2	2	2	2	2	2	2	2
Possible Utilized Species												
Acorn		Acorn		10							1	
Nutshell		Acorn nutshell (thin)									1	
Nutshell,		Acorn nutshell (thick)		2						1	7	
Juglans sp.	Junglandaceae	Walnut									1	
Chenopodium sp.	Chenopodiaceae		8		6					2	16	2
Euryale ferox	Nymphaeaceae	Foxnut		2								
Crataegus sp.	Rosaceae	Hawthorn										
Glycine cf. *max*	Fabaceae	Soybean								2		
Cajanus sp	Fabaceae	Wild cajanus pea		1	1						1	
Vigna sp.	Fabaceae	Indet. vigna bean									1	1
Melia azedarach	Meliaceae	Chinaberry (endorcarp)										
Vitis sp.	Vitaceae	Wild grape										
Solanum sp.	Solonaceae	Nightshade family									1	
Cucurbitaceae cf	Cucurbitcaceae	Indet. cucurbit										
Cucumis cf. *melo*	Cucurbitcaceae	Melon										

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 T1 (15) S2	YBB2013 HD1(1)	YBB2013 HD2(2)	YBB2013 HD5	YBB2013 HD6(2)	YBB2013 HD6(3)	YBB2013 HD6(4)	YBB2013 F6	YBB2013 F7 East	YBB2013 F7 West
		Phase	2	2	2	2	2	2	2	2	2	2
Wild Species												
Portulaca cf *quadrifida/ pillosa*	Portulaceae	Chickenweed										
Cf. Urtica sp.	Urticaceae	Nettle										
Perilla sp.	Lamiaceae	Perilla										
Brassicacae indet.	Brassicaceae	Indet. mustard family										
Brassica sp.	Brassicaceae	Indet. brassica seed										
Potentilla sp.	Rosaceae	Cinquefoils										
Fabaceae	Fabaceae	Immature indet. Legume		1								
Fabaceae	Fabaceae	Small indet. Legume										
Fabaceae	Fabaceae	Thin indet. Legume										
Fabaceae	Fabaceae	Indet. Legume										1
Fabaceae	Fabaceae	Legume (hilum)										
Euphorbia sp.	Euphorbiaceae	Euphorbia seed										
Malvaceae	Malvaceae	Indet. mallow										
Ipomoea sp.	Convolvulaceae	Morning glory										

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 T1 (15) S2	YBB2013 HD1(1)	YBB2013 HD2(2)	YBB2013 HD5	YBB2013 HD6(2)	YBB2013 HD6(3)	YBB2013 HD6(4)	YBB2013 F6	YBB2013 F7 East	YBB2013 F7 West
		Phase	2	2	2	2	2	2	2	2	2	2
Lamiaceae	Lamiaceae	Indet mint family										
Stachys/ Mosla cf.	Lamiaceae	Hedgenettle									1	
Verbena officinalis (uncharred)	Verbenaceae	Verbena										
Asteraceae	Asteraceae	Indet. daisy family										
Unidentified remains												
		Indet. small seeds		1	2	2		1	1	2		
		Indet. reticulate testa/shell										
		Indet. fragments		47	12	6	3	15	6	2	4	9
		Small bones present									x	

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 F7(1)	YBB2013 F7(2)	YBB2013 H84	YBB2013 H89	YBB2013 H99	YBB2013 H103	YBB2013 H117	YBB2013 H118	YBB2013 H121	YBB2013 H123
		Phase	2	2	2	2	2	2	2	2	2	2
		bulk vol (L)	10	10	10	10	10	10	10	10	10	10
Cultivated Cereals	**Family**	**Common Name**										
Oryza sativa ssp. *japonica*	Poaceae	Rice grain with embryo	7	3	7	7	3	9	20	33	11	50
Oryza sativa ssp. *japonica*	Poaceae	Rice grain fragment	18	15	7	6	15	12	30	6	40	23
Oryza sativa ssp. *japonica*	Poaceae	Rice embryo		16	4	11	4	4	4	1	6	3
Oryza sp.	Poaceae	Charred food remains (rice)										
Oryza sativa ssp. *japonica*	Poaceae	Rice immature grain	3	1	1	4				11		
Oryza sativa ssp. *japonica*	Poaceae	Rice immature grain fragment	4	6	3		2	4	3	14		3
Oryza sativa ssp. *japonica*	Poaceae	Rice domesticated spikelet base (ripped scar)		185	2	2	1	1	2	83	3	2
Oryza sativa ssp. *japonica*	Poaceae	Rice domesticated spikelet base (semi- ripped scar)		115								
Oryza spikelet base	Poaceae	Rice wild spikelet base		30						28		

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 F7(1)	YBB2013 F7(2)	YBB2013 H84	YBB2013 H89	YBB2013 H99	YBB2013 H103	YBB2013 H117	YBB2013 H118	YBB2013 H121	YBB2013 H123
		Phase	2	2	2	2	2	2	2	2	2	2
Oryza sativa ssp. *japonica*	Poaceae	Rice immature spikelet base		33						23	2	
Oryza sativa ssp. *japonica*	Poaceae	Rice indet. spikelet base		39								
Oryza sativa ssp. *japonica*	Poaceae	Rice husk		1			1			1		
Panicum sp.	Poaceae	Small panicum millet grain			1	9			3			
Panicum miliaceum	Poaceae	Broomcorn millet grain		3				8		3		1
Panicum cf. *miliaceum*	Poaceae	Broomcorn millet immature grain			1					7		
Setaria cf.	Poaceae	Millet grain										
Setaria italica	Poaceae	Foxtail millet grain	14	12	25	33	22	45	15	536	3	102
Setaria sp.	Poaceae	Charred food remains (foxtail millet)				6						
Setaria cf. *italica*	Poaceae	Foxtail millet immature grain	7		1		3	13	1	49		6
cf. *Setaria / Panicum*	Poaceae	Indet. millet fragments					5	2	4	130		

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 F7(1)	YBB2013 F7(2)	YBB2013 H84	YBB2013 H89	YBB2013 H99	YBB2013 H103	YBB2013 H117	YBB2013 H118	YBB2013 H121	YBB2013 H123
		Phase	2	2	2	2	2	2	2	2	2	2
Grasses and other dryland field weeds												
cf. *Setaria*/ *Echinochloa*	Poaceae		6							22		4
Panicum cf. subsp. *ruderale*	Poaceae	Panicum ruderale										
Panicum sp.	Poaceae	small wild panicum grain				2	1					
Echinochloa sp.	Poaceae	Barnyard grass grain	25	36	11	24	1	21	13	45	3	51
Echinochloa cf.	Poaceae	Barnyard grass immature grain		17	2		2	13	6			
Echinochloa sp.	Poaceae	Barnyard grass small grain		14								
Setaria cf. *viridis*	Poaceae	Wild foxtail millet	3					5		28		
Setaria cf. *verticillata*	Poaceae	Bristly foxtail millet								6		38
Digitaria sp.	Poaceae	Crabgrass	11	7	2	2		6	9	7		24
Other wild/weedy grasses												
Poaceae, wild (others)	Poaceae	Wild Poaceae grass			2				2			
cf. *Poa*	Poaceae	Bluegrass				1			1			
Eragrostis sp.	Poaceae	Lovegrass		1								3

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 F7(1)	YBB2013 F7(2)	YBB2013 H84	YBB2013 H89	YBB2013 H99	YBB2013 H103	YBB2013 H117	YBB2013 H118	YBB2013 H121	YBB2013 H123
		Phase	2	2	2	2	2	2	2	2	2	2
cf. *Sporobolus*	Poaceae	Smut grass										
cf. *Urochloa*	Poaceae	Signalgrass										
cf. *Paspalum*	Poaceae	Crowngrass										
cf. *Pennisetum*	Poaceae	Fountaingrass										
Sedges and other wetland weeds												
Polygonum sp.	Polygonaceae	Indet. knotweed grass										
Polygonum persicaria	Polygonaceae	Lady's thumb										2
Cyperaceae	Cyperaceae	Indet. sedge inner nutlet										
Schoenoplectus mucronatus	Cyperaceae	Bog bulrush	1			1				1		
Fimbristylis sp.	Cyperaceae	Fimbristyle								1		2
Scirpus sp.	Cyperaceae	Bulrush										2
Eleocharis sp.	Cyperaceae	Sedge rhizome tuber										
Cyperus sp.	Cyperaceae	Indet. Cyperus sedge	1							1		3
Carex sp.	Cyperaceae	Indet. Carex sedge										
Juncaceae	Juncaceae	Indet. rush family										

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 F7(1)	YBB2013 F7(2)	YBB2013 H84	YBB2013 H89	YBB2013 H99	YBB2013 H103	YBB2013 H117	YBB2013 H118	YBB2013 H121	YBB2013 H123
		Phase	2	2	2	2	2	2	2	2	2	2
Possible Utilized Species												
Acorn		Acorn					6	1				
Nutshell		Acorn nutshell (thin)								1		3
Nutshell,		Acorn nutshell (thick)					1		1	5		8
Juglans sp.	Junglandaceae	Walnut										
Chenopodium sp.	Chenopodiaceae					2	2	2	4	3	3	17
Euryale ferox	Nymphaeaceae	Foxnut		7				1		3		3
Crataegus sp.	Rosaceae	Hawthorn										
Glycine cf. *max*	Fabaceae	Soybean								8		6
Cajanus sp	Fabaceae	Wild cajanus pea				1		2		17		
Vigna sp.	Fabaceae	Indet. vigna bean										
Melia azedarach	Meliaceae	Chinaberry (endorcarp)										
Vitis sp.	Vitaceae	Wild grape										
Solanum sp.	Solonaceae	Nightshade family										
Cucurbitaceae cf	Cucurbitcaceae	Indet. cucurbit										
Cucumis cf. *melo*	Cucurbitcaceae	Melon										

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 F7(1)	YBB2013 F7(2)	YBB2013 H84	YBB2013 H89	YBB2013 H99	YBB2013 H103	YBB2013 H117	YBB2013 H118	YBB2013 H121	YBB2013 H123
		Phase	2	2	2	2	2	2	2	2	2	2
Wild Species												
Portulaca cf *quadrifida/ pillosa*	Portulaceae	Chickenweed										
Cf. Urtica sp.	Urticaceae	Nettle										
Perilla sp.	Lamiaceae	Perilla										
Brassicacae indet.	Brassicaceae	Indet. mustard family	3				2	2				
Brassica sp.	Brassicaceae	Indet. brassica seed										
Potentilla sp.	Rosaceae	Cinquefoils										
Fabaceae	Fabaceae	Immature indet. Legume	2					1				
Fabaceae	Fabaceae	Small indet. Legume	1	2					1			1
Fabaceae	Fabaceae	Thin indet. Legume								1		
Fabaceae	Fabaceae	Indet. Legume										
Fabaceae	Fabaceae	Legume (hilum)										
Euphorbia sp.	Euphorbiaceae	Euphorbia seed			1							
Malvaceae	Malvaceae	Indet. mallow										
Ipomoea sp.	Convolvulaceae	Morning glory										

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 F7(1)	YBB2013 F7(2)	YBB2013 H84	YBB2013 H89	YBB2013 H99	YBB2013 H103	YBB2013 H117	YBB2013 H118	YBB2013 H121	YBB2013 H123
		Phase	2	2	2	2	2	2	2	2	2	2
Lamiaceae	Lamiaceae	Indet mint family										
Stachys/ Mosla cf.	Lamiaceae	Hedgenettle										2
Verbena officinalis (uncharred)	Verbenaceae	Verbena										
Asteraceae	Asteraceae	Indet. daisy family										
Unidentified remains												
		Indet. small seeds			1	3	2		4		1	
		Indet. reticulate testa/shell									1	
		Indet. fragments		2	12	9		15	4	34	3	50
		Parenchyma fragments										5
		Small bones present				1						x
		Tree bud								1		

Appendix 2. BAIYANGCUN
Macro-botanical remains.

Cultivated Cereals	Family	Common Name	YBB2013 H125	YBB2013 H129	YBB2013 H132	YBB2013 H134	YBB2013 H136	YBB2013 H147	YBB2013 H236	YBB2013 H237	YBB2013 T2 (3)d S2	YBB2013 T2 (4)b S2
		Phase	3	3	3	3	3	3	3	3	3	3
		bulk vol (L)	10	10	10	10	10	10	10	10	7	7
Oryza sativa ssp. *japonica*	Poaceae	Rice grain with embryo	26	28	17	13	41	5	3	9		1
Oryza sativa ssp. *japonica*	Poaceae	Rice grain fragment	25	35	15	8	35	10	5	8	1	6
Oryza sativa ssp. *japonica*	Poaceae	Rice embryo	1	1	1		9					
Oryza sp.	Poaceae	Charred food remains (rice)						3				
Oryza sativa ssp. *japonica*	Poaceae	Rice immature grain	5		7		3	3				
Oryza sativa ssp. *japonica*	Poaceae	Rice immature grain fragment		7		1						
Oryza sativa ssp. *japonica*	Poaceae	Rice domesticated spikelet base (ripped scar)	18	4	4	2	26			4		
Oryza sativa ssp. *japonica*	Poaceae	Rice domesticated spikelet base (semi- ripped scar)										
Oryza spikelet base	Poaceae	Rice wild spikelet base								1		

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 H125	YBB2013 H129	YBB2013 H132	YBB2013 H134	YBB2013 H136	YBB2013 H147	YBB2013 H236	YBB2013 H237	YBB2013 T2 (3)d S2	YBB2013 T2 (4)b S2
		Phase	3	3	3	3	3	3	3	3	3	3
Oryza sativa ssp. *japonica*	Poaceae	Rice immature spikelet base	1	3	4		6					
Oryza sativa ssp. *japonica*	Poaceae	Rice indet. spikelet base										
Oryza sativa ssp. *japonica*	Poaceae	Rice husk						1				
Panicum sp.	Poaceae	Small panicum millet grain					2					
Panicum miliaceum	Poaceae	Broomcorn millet grain			9	4		3	1	4	1	
Panicum cf. *miliaceum*	Poaceae	Broomcorn millet immature grain										
Setaria cf.	Poaceae	Millet grain										
Setaria italica	Poaceae	Foxtail millet grain	18	23	52	90	4	9		9		4
Setaria sp.	Poaceae	Charred food remains (foxtail millet)							4			
Setaria cf. *italica*	Poaceae	Foxtail millet immature grain		9	7	43		4	3			2
cf. *Setaria / Panicum*	Poaceae	Indet. millet fragments		9	7							

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 H125	YBB2013 H129	YBB2013 H132	YBB2013 H134	YBB2013 H136	YBB2013 H147	YBB2013 H236	YBB2013 H237	YBB2013 T2 (3)d S2	YBB2013 T2 (4)b S2
		Phase	3	3	3	3	3	3	3	3	3	3
Grasses and other dryland field weeds												
cf. *Setaria/ Echinochloa*	Poaceae		9	3								
Panicum cf. subsp. *ruderale*	Poaceae	Panicum ruderale										
Panicum sp.	Poaceae	small wild panicum grain				1		1	1			
Echinochloa sp.	Poaceae	Barnyard grass grain	13	15	26	36	8	2	13	11		
Echinochloa cf.	Poaceae	Barnyard grass immature grain				10	2	2				
Echinochloa sp.	Poaceae	Barnyard grass small grain										
Setaria cf. *viridis*	Poaceae	Wild foxtail millet										
Setaria cf. *verticillata*	Poaceae	Bristly foxtail millet										
Digitaria sp.	Poaceae	Crabgrass			1	8	2	3		1		
Other wild/weedy grasses												
Poaceae, wild (others)	Poaceae	Wild Poaceae grass						1				
cf. *Poa*	Poaceae	Bluegrass										2
Eragrostis sp.	Poaceae	Lovegrass										

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 H125	YBB2013 H129	YBB2013 H132	YBB2013 H134	YBB2013 H136	YBB2013 H147	YBB2013 H236	YBB2013 H237	YBB2013 T2 (3)d S2	YBB2013 T2 (4)b S2
		Phase	3	3	3	3	3	3	3	3	3	3
cf. *Sporobolus*	Poaceae	Smut grass										
cf. *Urochloa*	Poaceae	Signalgrass										
cf. *Paspalum*	Poaceae	Crowngrass										
cf. *Pennisetum*	Poaceae	Fountaingrass										
Sedges and other wetland weeds												
Polygonum sp.	Polygonaceae	Indet. knotweed grass									1	
Polygonum persicaria	Polygonaceae	Lady's thumb									2	
Cyperaceae	Cyperaceae	Indet. sedge inner nutlet										1
Schoenoplectus mucronatus	Cyperaceae	Bog bulrush						1			15	
Fimbristylis sp.	Cyperaceae	Fimbristyle						1			14	
Scirpus sp.	Cyperaceae	Bulrush				1						
Eleocharis sp.	Cyperaceae	Sedge rhizome tuber										
Cyperus sp.	Cyperaceae	Indet. Cyperus sedge										
Carex sp.	Cyperaceae	Indet. Carex sedge									2	
Juncaceae	Juncaceae	Indet. rush family				1						

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 H125	YBB2013 H129	YBB2013 H132	YBB2013 H134	YBB2013 H136	YBB2013 H147	YBB2013 H236	YBB2013 H237	YBB2013 T2 (3)d S2	YBB2013 T2 (4)b S2
		Phase	3	3	3	3	3	3	3	3	3	3
Possible Utilized Species												
Acorn		Acorn										
Nutshell		Acorn nutshell (thin)									1	
Nutshell,		Acorn nutshell (thick)										
Juglans sp.	Junglandaceae	Walnut										
Chenopodium sp.	Chenopodiaceae		1	14	1		3		1		3	
Euryale ferox	Nymphaeaceae	Foxnut										
Crataegus sp.	Rosaceae	Hawthorn										
Glycine cf. *max*	Fabaceae	Soybean				1						
Cajanus sp	Fabaceae	Wild cajanus pea				1						
Vigna sp.	Fabaceae	Indet. vigna bean										
Melia azedarach	Meliaceae	Chinaberry (endorcarp)										
Vitis sp.	Vitaceae	Wild grape										
Solanum sp.	Solonaceae	Nightshade family										
Cucurbitaceae cf	Cucurbitcaceae	Indet. cucurbit										
Cucumis cf. *melo*	Cucurbitcaceae	Melon										

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 H125	YBB2013 H129	YBB2013 H132	YBB2013 H134	YBB2013 H136	YBB2013 H147	YBB2013 H236	YBB2013 H237	YBB2013 T2 (3)d S2	YBB2013 T2 (4)b S2
		Phase	3	3	3	3	3	3	3	3	3	3
Wild Species												
Portulaca cf *quadrifida/ pillosa*	Portulaceae	Chickenweed										
Cf. Urtica sp.	Urticaceae	Nettle				1						
Perilla sp.	Lamiaceae	Perilla										
Brassicacae indet.	Brassicaceae	Indet. mustard family										
Brassica sp.	Brassicaceae	Indet. brassica seed										
Potentilla sp.	Rosaceae	Cinquefoils									10	
Fabaceae	Fabaceae	Immature indet. Legume										
Fabaceae	Fabaceae	Small indet. Legume				1						
Fabaceae	Fabaceae	Thin indet. Legume										
Fabaceae	Fabaceae	Indet. Legume										
Fabaceae	Fabaceae	Legume (hilum)										
Euphorbia sp.	Euphorbiaceae	Euphorbia seed										
Malvaceae	Malvaceae	Indet. mallow										
Ipomoea sp.	Convolvulaceae	Morning glory										

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 H125	YBB2013 H129	YBB2013 H132	YBB2013 H134	YBB2013 H136	YBB2013 H147	YBB2013 H236	YBB2013 H237	YBB2013 T2 (3)d S2	YBB2013 T2 (4)b S2
		Phase	3	3	3	3	3	3	3	3	3	3
Lamiaceae	Lamiaceae	Indet mint family										
Stachys/ Mosla cf.	Lamiaceae	Hedgenettle										
Verbena officinalis (uncharred)	Verbenaceae	Verbena									17	
Asteraceae	Asteraceae	Indet. daisy family										
Unidentified remains												
		Indet. small seeds			3	4		4	1	1		1
		Indet. reticulate testa/shell										
		Indet. fragments	1		7	3		1			10	
		Parenchyma fragments						4				

Appendix 2. BAIYANGCUN
Macro-botanical remains.

Cultivated Cereals	Family	Common Name	YBB2013 (5)	YBB2013 T2 (6)	YBB2013 T2 (7)b S3	YBB2013 T1 (7)f S4	YBB2013 F5(1)	YBB2013 F5 (2)	YBB2013 F5 D3	YBB2013 T2 (3)c H19	YBB2013 H23(1)	YBB2013 H23(3)
		Phase	3	3	3	3	3	3	3	3	3	3
		bulk vol (L)	**16**	**15**	**9**	**7**	**10**	**10**	**10**	**10**	**10**	**10**
Oryza sativa ssp. *japonica*	Poaceae	Rice grain with embryo	1	3	4	1	6	10				
Oryza sativa ssp. *japonica*	Poaceae	Rice grain fragment	11	15	5	8	2	22	1	1	1	1
Oryza sativa ssp. *japonica*	Poaceae	Rice embryo	1	1				2				
Oryza sp.	Poaceae	Charred food remains (rice)										
Oryza sativa ssp. *japonica*	Poaceae	Rice immature grain			1			9				
Oryza sativa ssp. *japonica*	Poaceae	Rice immature grain fragment		1	8			13		2		
Oryza sativa ssp. *japonica*	Poaceae	Rice domesticated spikelet base (ripped scar)		19	108		52		1		3	
Oryza sativa ssp. *japonica*	Poaceae	Rice domesticated spikelet base (semi- ripped scar)		7			20		2		1	
Oryza spikelet base	Poaceae	Rice wild spikelet base										

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 (5)	YBB2013 T2 (6)	YBB2013 T2 (7)b S3	YBB2013 T1 (7)f S4	YBB2013 F5(1)	YBB2013 F5 (2)	YBB2013 F5 D3	YBB2013 T2 (3)c H19	YBB2013 H23(1)	YBB2013 H23(3)
		Phase	3	3	3	3	3	3	3	3	3	3
Oryza sativa ssp. *japonica*	Poaceae	Rice immature spikelet base		18	3		4					
Oryza sativa ssp. *japonica*	Poaceae	Rice indet. spikelet base		2			7					
Oryza sativa ssp. *japonica*	Poaceae	Rice husk				1						
Panicum sp.	Poaceae	Small panicum millet grain		2	3	1		1				
Panicum miliaceum	Poaceae	Broomcorn millet grain	2	1								
Panicum cf. *miliaceum*	Poaceae	Broomcorn millet immature grain										
Setaria cf.	Poaceae	Millet grain		1								
Setaria italica	Poaceae	Foxtail millet grain	7	10	10	20	26	32	1			1
Setaria sp.	Poaceae	Charred food remains (foxtail millet)										
Setaria cf. *italica*	Poaceae	Foxtail millet immature grain	6	11	4	7		9				
cf. *Setaria / Panicum*	Poaceae	Indet. millet fragments				4	2					

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 (5)	YBB2013 T2 (6)	YBB2013 T2 (7)b S3	YBB2013 T1 (7)f S4	YBB2013 F5(1)	YBB2013 F5 (2)	YBB2013 F5 D3	YBB2013 T2 (3)c H19	YBB2013 H23(1)	YBB2013 H23(3)
		Phase	3	3	3	3	3	3	3	3	3	3
Grasses and other dryland field weeds												
cf. *Setaria*/ *Echinochloa*	Poaceae					6						
Panicum cf. subsp. *ruderale*	Poaceae	Panicum ruderale										
Panicum sp.	Poaceae	small wild panicum grain		1								
Echinochloa sp.	Poaceae	Barnyard grass grain	4		21		7	45				
Echinochloa cf.	Poaceae	Barnyard grass immature grain						2	1			
Echinochloa sp.	Poaceae	Barnyard grass small grain		10		21	1					
Setaria cf. *viridis*	Poaceae	Wild foxtail millet	1				9	1				
Setaria cf. *verticillata*	Poaceae	Bristly foxtail millet	1		1	2						
Digitaria sp.	Poaceae	Crabgrass	1	17	5		1	14				
Other wild/weedy grasses												
Poaceae, wild (others)	Poaceae	Wild Poaceae grass	1			1	1	1				
cf. *Poa*	Poaceae	Bluegrass			1							
Eragrostis sp.	Poaceae	Lovegrass										

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 (5)	YBB2013 T2 (6)	YBB2013 T2 (7)b S3	YBB2013 T1 (7)f S4	YBB2013 F5(1)	YBB2013 F5 (2)	YBB2013 F5 D3	YBB2013 T2 (3)c H19	YBB2013 H23(1)	YBB2013 H23(3)
		Phase	3	3	3	3	3	3	3	3	3	3
cf. *Sporobolus*	Poaceae	Smut grass										
cf. *Urochloa*	Poaceae	Signalgrass										
cf. *Paspalum*	Poaceae	Crowngrass					1					
cf. *Pennisetum*	Poaceae	Fountaingrass						1				
Sedges and other wetland weeds												
Polygonum sp.	Polygonaceae	Indet. knotweed grass										
Polygonum persicaria	Polygonaceae	Lady's thumb										
Cyperaceae	Cyperaceae	Indet. sedge inner nutlet										
Schoenoplectus mucronatus	Cyperaceae	Bog bulrush	1									
Fimbristylis sp.	Cyperaceae	Fimbristyle										
Scirpus sp.	Cyperaceae	Bulrush										
Eleocharis sp.	Cyperaceae	Sedge rhizome tuber										
Cyperus sp.	Cyperaceae	Indet. Cyperus sedge										
Carex sp.	Cyperaceae	Indet. Carex sedge	1									
Juncaceae	Juncaceae	Indet. rush family										

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 (5)	YBB2013 T2 (6)	YBB2013 T2 (7)b S3	YBB2013 T1 (7)f S4	YBB2013 F5(1)	YBB2013 F5 (2)	YBB2013 F5 D3	YBB2013 T2 (3)c H19	YBB2013 H23(1)	YBB2013 H23(3)
		Phase	3	3	3	3	3	3	3	3	3	3
Possible Utilized Species												
Acorn		Acorn										
Nutshell		Acorn nutshell (thin)										
Nutshell,		Acorn nutshell (thick)	1	7	1	1						
Juglans sp.	Junglandaceae	Walnut										
Chenopodium sp.	Chenopodiaceae		7	13	12			1			4	
Euryale ferox	Nymphaeaceae	Foxnut	1	10	14	5						
Crataegus sp.	Rosaceae	Hawthorn										
Glycine cf. *max*	Fabaceae	Soybean		1		1						
Cajanus sp	Fabaceae	Wild cajanus pea					2			1		
Vigna sp.	Fabaceae	Indet. vigna bean	1		1							
Melia azedarach	Meliaceae	Chinaberry (endorcarp)										
Vitis sp.	Vitaceae	Wild grape										
Solanum sp.	Solonaceae	Nightshade family					2			1		
Cucurbitaceae cf	Cucurbitcaceae	Indet. cucurbit										
Cucumis cf. *melo*	Cucurbitcaceae	Melon								1		

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 (5)	YBB2013 T2 (6)	YBB2013 T2 (7)b S3	YBB2013 T1 (7)f S4	YBB2013 F5(1)	YBB2013 F5 (2)	YBB2013 F5 D3	YBB2013 T2 (3)c H19	YBB2013 H23(1)	YBB2013 H23(3)
		Phase	3	3	3	3	3	3	3	3	3	3
Wild Species												
Portulaca cf *quadrifida/ pillosa*	Portulaceae	Chickenweed										
Cf. Urtica sp.	Urticaceae	Nettle		1								
Perilla sp.	Lamiaceae	Perilla										
Brassicacae indet.	Brassicaceae	Indet. mustard family					1		3			
Brassica sp.	Brassicaceae	Indet. brassica seed	1									
Potentilla sp.	Rosaceae	Cinquefoils										
Fabaceae	Fabaceae	Immature indet. Legume						1				
Fabaceae	Fabaceae	Small indet. Legume										
Fabaceae	Fabaceae	Thin indet. Legume										
Fabaceae	Fabaceae	Indet. Legume										
Fabaceae	Fabaceae	Legume (hilum)										
Euphorbia sp.	Euphorbiaceae	Euphorbia seed										
Malvaceae	Malvaceae	Indet. mallow										
Ipomoea sp.	Convolvulaceae	Morning glory		1								

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 (5)	YBB2013 T2 (6)	YBB2013 T2 (7)b S3	YBB2013 T1 (7)f S4	YBB2013 F5(1)	YBB2013 F5 (2)	YBB2013 F5 D3	YBB2013 T2 (3)c H19	YBB2013 H23(1)	YBB2013 H23(3)
		Phase	3	3	3	3	3	3	3	3	3	3
Lamiaceae	Lamiaceae	Indet mint family										
Stachys/ Mosla cf.	Lamiaceae	Hedgenettle										
Verbena officinalis (uncharred)	Verbenaceae	Verbena										
Asteraceae	Asteraceae	Indet. daisy family								1		
Unidentified remains												
		Indet. small seeds		1	7		1				6	
		Indet. reticulate testa/shell										
		Indet. fragments	5	30	3	3	70					3

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 H39	YBB2013 H44(2)	YBB2013 H46	YBB2013 H47(1)	YBB2013 H47(2)	YBB2013 H47(3)	YBB2013 H50	YBB2013 H56	YBB2013 H57	YBB2013 H58
		Phase	3	3	3	3	3	3	3	3	3	3
		bulk vol (L)	10	10	10	10	10	10	10	10	10	10
Cultivated Cereals	Family	Common Name										
Oryza sativa ssp. *japonica*	Poaceae	Rice grain with embryo						2	21	1	1	
Oryza sativa ssp. *japonica*	Poaceae	Rice grain fragment	1	1	1		1	2	47	2		1
Oryza sativa ssp. *japonica*	Poaceae	Rice embryo						1				
Oryza sp.	Poaceae	Charred food remains (rice)										
Oryza sativa ssp. *japonica*	Poaceae	Rice immature grain							2		1	
Oryza sativa ssp. *japonica*	Poaceae	Rice immature grain fragment			1	1						
Oryza sativa ssp. *japonica*	Poaceae	Rice domesticated spikelet base (ripped scar)			2							
Oryza sativa ssp. *japonica*	Poaceae	Rice domesticated spikelet base (semi- ripped scar)	1									
Oryza spikelet base	Poaceae	Rice wild spikelet base										

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 H39	YBB2013 H44(2)	YBB2013 H46	YBB2013 H47(1)	YBB2013 H47(2)	YBB2013 H47(3)	YBB2013 H50	YBB2013 H56	YBB2013 H57	YBB2013 H58
		Phase	3	3	3	3	3	3	3	3	3	3
Oryza sativa ssp. *japonica*	Poaceae	Rice immature spikelet base										
Oryza sativa ssp. *japonica*	Poaceae	Rice indet. spikelet base						1	2			
Oryza sativa ssp. *japonica*	Poaceae	Rice husk										
Panicum sp.	Poaceae	Small panicum millet grain										
Panicum miliaceum	Poaceae	Broomcorn millet grain										
Panicum cf. *miliaceum*	Poaceae	Broomcorn millet immature grain										
Setaria cf.	Poaceae	Millet grain				1						
Setaria italica	Poaceae	Foxtail millet grain						5			1	
Setaria sp.	Poaceae	Charred food remains (foxtail millet)										
Setaria cf. *italica*	Poaceae	Foxtail millet immature grain									1	
cf. *Setaria / Panicum*	Poaceae	Indet. millet fragments										

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 H39	YBB2013 H44(2)	YBB2013 H46	YBB2013 H47(1)	YBB2013 H47(2)	YBB2013 H47(3)	YBB2013 H50	YBB2013 H56	YBB2013 H57	YBB2013 H58
		Phase	3	3	3	3	3	3	3	3	3	3
Grasses and other dryland field weeds												
cf. *Setaria/ Echinochloa*	Poaceae											
Panicum cf. subsp. *ruderale*	Poaceae	Panicum ruderale										
Panicum sp.	Poaceae	small wild panicum grain										
Echinochloa sp.	Poaceae	Barnyard grass grain		1		1		1				2
Echinochloa cf.	Poaceae	Barnyard grass immature grain										
Echinochloa sp.	Poaceae	Barnyard grass small grain										1
Setaria cf. *viridis*	Poaceae	Wild foxtail millet										
Setaria cf. *verticillata*	Poaceae	Bristly foxtail millet										
Digitaria sp.	Poaceae	Crabgrass		1								
Other wild/weedy grasses												
Poaceae, wild (others)	Poaceae	Wild Poaceae grass										
cf. *Poa*	Poaceae	Bluegrass										
Eragrostis sp.	Poaceae	Lovegrass										

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 H39	YBB2013 H44(2)	YBB2013 H46	YBB2013 H47(1)	YBB2013 H47(2)	YBB2013 H47(3)	YBB2013 H50	YBB2013 H56	YBB2013 H57	YBB2013 H58
		Phase	3	3	3	3	3	3	3	3	3	3
cf. *Sporobolus*	Poaceae	Smut grass										
cf. *Urochloa*	Poaceae	Signalgrass										
cf. *Paspalum*	Poaceae	Crowngrass										
cf. *Pennisetum*	Poaceae	Fountaingrass						1				
Sedges and other wetland weeds												
Polygonum sp.	Polygonaceae	Indet. knotweed grass										
Polygonum persicaria	Polygonaceae	Lady's thumb										
Cyperaceae	Cyperaceae	Indet. sedge inner nutlet										
Schoenoplectus mucronatus	Cyperaceae	Bog bulrush								1		
Fimbristylis sp.	Cyperaceae	Fimbristyle						1				
Scirpus sp.	Cyperaceae	Bulrush										
Eleocharis sp.	Cyperaceae	Sedge rhizome tuber										
Cyperus sp.	Cyperaceae	Indet. Cyperus sedge										
Carex sp.	Cyperaceae	Indet. Carex sedge										
Juncaceae	Juncaceae	Indet. rush family										

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 H39	YBB2013 H44(2)	YBB2013 H46	YBB2013 H47(1)	YBB2013 H47(2)	YBB2013 H47(3)	YBB2013 H50	YBB2013 H56	YBB2013 H57	YBB2013 H58
		Phase	3	3	3	3	3	3	3	3	3	3
Possible Utilized Species												
Acorn		Acorn										
Nutshell		Acorn nutshell (thin)										
Nutshell,		Acorn nutshell (thick)						1				
Juglans sp.	Junglandaceae	Walnut										
Chenopodium sp.	Chenopodiaceae			1		1		2	2		1	
Euryale ferox	Nymphaeaceae	Foxnut			1	2				1		
Crataegus sp.	Rosaceae	Hawthorn										
Glycine cf. *max*	Fabaceae	Soybean						7				1
Cajanus sp	Fabaceae	Wild cajanus pea	1									
Vigna sp.	Fabaceae	Indet. vigna bean										
Melia azedarach	Meliaceae	Chinaberry (endorcarp)										
Vitis sp.	Vitaceae	Wild grape										
Solanum sp.	Solonaceae	Nightshade family										
Cucurbitaceae cf	Cucurbitcaceae	Indet. cucurbit										
Cucumis cf. *melo*	Cucurbitcaceae	Melon										

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 H39	YBB2013 H44(2)	YBB2013 H46	YBB2013 H47(1)	YBB2013 H47(2)	YBB2013 H47(3)	YBB2013 H50	YBB2013 H56	YBB2013 H57	YBB2013 H58
		Phase	3	3	3	3	3	3	3	3	3	3
Wild Species												
Portulaca cf *quadrifida/ pillosa*	Portulaceae	Chickenweed										
Cf. Urtica sp.	Urticaceae	Nettle										
Perilla sp.	Lamiaceae	Perilla										
Brassicacae indet.	Brassicaceae	Indet. mustard family						1				
Brassica sp.	Brassicaceae	Indet. brassica seed										
Potentilla sp.	Rosaceae	Cinquefoils										
Fabaceae	Fabaceae	Immature indet. Legume										
Fabaceae	Fabaceae	Small indet. Legume										
Fabaceae	Fabaceae	Thin indet. Legume										
Fabaceae	Fabaceae	Indet. Legume										
Fabaceae	Fabaceae	Legume (hilum)										
Euphorbia sp.	Euphorbiaceae	Euphorbia seed										
Malvaceae	Malvaceae	Indet. mallow										
Ipomoea sp.	Convolvulaceae	Morning glory										

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 H39	YBB2013 H44(2)	YBB2013 H46	YBB2013 H47(1)	YBB2013 H47(2)	YBB2013 H47(3)	YBB2013 H50	YBB2013 H56	YBB2013 H57	YBB2013 H58
		Phase	3	3	3	3	3	3	3	3	3	3
Lamiaceae	Lamiaceae	Indet mint family										
Stachys/ Mosla cf.	Lamiaceae	Hedgenettle										
Verbena officinalis (uncharred)	Verbenaceae	Verbena										
Asteraceae	Asteraceae	Indet. daisy family										
Unidentified remains												
		Indet. small seeds							2		1	
		Indet. reticulate testa/shell										
		Indet. fragments				3		3				

Appendix 2. BAIYANGCUN
Macro-botanical remains.

Cultivated Cereals	Family	Common Name	YBB2013 H60 (2)	YBB2013 H61(1)	YBB2013 H61(2)	YBB2013 H63	YBB2013 H63(1)	YBB2013 H65	YBB2013 H67	YBB2013 H68	YBB2013 H69	YBB2013 H70
		Phase	3	3	3	3	3	3	3	3	3	3
		bulk vol (L)	10	10	10	10	10	10	10	10	10	10
Oryza sativa ssp. *japonica*	Poaceae	Rice grain with embryo		2	7	6			4	4	1	1
Oryza sativa ssp. *japonica*	Poaceae	Rice grain fragment	1	3	8	3	1	1	3	7	2	4
Oryza sativa ssp. *japonica*	Poaceae	Rice embryo				1	1		5			3
Oryza sp.	Poaceae	Charred food remains (rice)										
Oryza sativa ssp. *japonica*	Poaceae	Rice immature grain							1			
Oryza sativa ssp. *japonica*	Poaceae	Rice immature grain fragment			2					1		1
Oryza sativa ssp. *japonica*	Poaceae	Rice domesticated spikelet base (ripped scar)		1	6		9	15	121	28	3	18
Oryza sativa ssp. *japonica*	Poaceae	Rice domesticated spikelet base (semi- ripped scar)				2				11		
Oryza spikelet base	Poaceae	Rice wild spikelet base										

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 H60 (2)	YBB2013 H61(1)	YBB2013 H61(2)	YBB2013 H63	YBB2013 H63(1)	YBB2013 H65	YBB2013 H67	YBB2013 H68	YBB2013 H69	YBB2013 H70
		Phase	3	3	3	3	3	3	3	3	3	3
Oryza sativa ssp. *japonica*	Poaceae	Rice immature spikelet base			2				3			3
Oryza sativa ssp. *japonica*	Poaceae	Rice indet. spikelet base								6		
Oryza sativa ssp. *japonica*	Poaceae	Rice husk										
Panicum sp.	Poaceae	Small panicum millet grain				1			1			
Panicum miliaceum	Poaceae	Broomcorn millet grain							4			2
Panicum cf. *miliaceum*	Poaceae	Broomcorn millet immature grain										
Setaria cf.	Poaceae	Millet grain	1									
Setaria italica	Poaceae	Foxtail millet grain		25	24	3	4	3		13	21	20
Setaria sp.	Poaceae	Charred food remains (foxtail millet)										
Setaria cf. *italica*	Poaceae	Foxtail millet immature grain			14	2		1	6	13	1	6
cf. *Setaria / Panicum*	Poaceae	Indet. millet fragments		3		1	4					1

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 H60 (2)	YBB2013 H61(1)	YBB2013 H61(2)	YBB2013 H63	YBB2013 H63(1)	YBB2013 H65	YBB2013 H67	YBB2013 H68	YBB2013 H69	YBB2013 H70
		Phase	3	3	3	3	3	3	3	3	3	3
Grasses and other dryland field weeds												
cf. *Setaria/ Echinochloa*	Poaceae									1		
Panicum cf. subsp. *ruderale*	Poaceae	Panicum ruderale										
Panicum sp.	Poaceae	small wild panicum grain										
Echinochloa sp.	Poaceae	Barnyard grass grain		2	6	5	3	1	18	24	7	16
Echinochloa cf.	Poaceae	Barnyard grass immature grain				1	5					
Echinochloa sp.	Poaceae	Barnyard grass small grain										
Setaria cf. *viridis*	Poaceae	Wild foxtail millet								4		
Setaria cf. *verticillata*	Poaceae	Bristly foxtail millet	1									
Digitaria sp.	Poaceae	Crabgrass		1					10	10	1	4
Other wild/weedy grasses												
Poaceae, wild (others)	Poaceae	Wild Poaceae grass							1			
cf. *Poa*	Poaceae	Bluegrass										
Eragrostis sp.	Poaceae	Lovegrass										

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 H60 (2)	YBB2013 H61(1)	YBB2013 H61(2)	YBB2013 H63	YBB2013 H63(1)	YBB2013 H65	YBB2013 H67	YBB2013 H68	YBB2013 H69	YBB2013 H70
		Phase	3	3	3	3	3	3	3	3	3	3
cf. *Sporobolus*	Poaceae	Smut grass										
cf. *Urochloa*	Poaceae	Signalgrass										
cf. *Paspalum*	Poaceae	Crowngrass										
cf. *Pennisetum*	Poaceae	Fountaingrass										
Sedges and other wetland weeds												
Polygonum sp.	Polygonaceae	Indet. knotweed grass				1						
Polygonum persicaria	Polygonaceae	Lady's thumb										
Cyperaceae	Cyperaceae	Indet. sedge inner nutlet							1			
Schoenoplectus mucronatus	Cyperaceae	Bog bulrush										1
Fimbristylis sp.	Cyperaceae	Fimbristyle										
Scirpus sp.	Cyperaceae	Bulrush										
Eleocharis sp.	Cyperaceae	Sedge rhizome tuber										
Cyperus sp.	Cyperaceae	Indet. Cyperus sedge										
Carex sp.	Cyperaceae	Indet. Carex sedge										
Juncaceae	Juncaceae	Indet. rush family										

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 H60 (2)	YBB2013 H61(1)	YBB2013 H61(2)	YBB2013 H63	YBB2013 H63(1)	YBB2013 H65	YBB2013 H67	YBB2013 H68	YBB2013 H69	YBB2013 H70
		Phase	3	3	3	3	3	3	3	3	3	3
Possible Utilized Species												
Acorn		Acorn								1		
Nutshell		Acorn nutshell (thin)										
Nutshell,		Acorn nutshell (thick)							2		2	3
Juglans sp.	Junglandaceae	Walnut										
Chenopodium sp.	Chenopodiaceae		1	33	25		4		3		6	7
Euryale ferox	Nymphaeaceae	Foxnut			x				17			
Crataegus sp.	Rosaceae	Hawthorn										
Glycine cf. *max*	Fabaceae	Soybean		1	3		1		1			
Cajanus sp	Fabaceae	Wild cajanus pea		1	1	2	1		1	3	2	6
Vigna sp.	Fabaceae	Indet. vigna bean									1	1
Melia azedarach	Meliaceae	Chinaberry (endorcarp)										
Vitis sp.	Vitaceae	Wild grape										
Solanum sp.	Solonaceae	Nightshade family										
Cucurbitaceae cf	Cucurbitcaceae	Indet. cucurbit										
Cucumis cf. *melo*	Cucurbitcaceae	Melon										

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 H60 (2)	YBB2013 H61(1)	YBB2013 H61(2)	YBB2013 H63	YBB2013 H63(1)	YBB2013 H65	YBB2013 H67	YBB2013 H68	YBB2013 H69	YBB2013 H70
		Phase	3	3	3	3	3	3	3	3	3	3
Wild Species												
Portulaca cf *quadrifida/ pillosa*	Portulaceae	Chickenweed	1									
Cf. Urtica sp.	Urticaceae	Nettle										
Perilla sp.	Lamiaceae	Perilla										
Brassicacae indet.	Brassicaceae	Indet. mustard family							1			
Brassica sp.	Brassicaceae	Indet. brassica seed										2
Potentilla sp.	Rosaceae	Cinquefoils										
Fabaceae	Fabaceae	Immature indet. Legume		2								1
Fabaceae	Fabaceae	Small indet. Legume										1
Fabaceae	Fabaceae	Thin indet. Legume										
Fabaceae	Fabaceae	Indet. Legume							1		1	
Fabaceae	Fabaceae	Legume (hilum)										
Euphorbia sp.	Euphorbiaceae	Euphorbia seed			1							
Malvaceae	Malvaceae	Indet. mallow									1	
Ipomoea sp.	Convolvulaceae	Morning glory										

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 H60 (2)	YBB2013 H61(1)	YBB2013 H61(2)	YBB2013 H63	YBB2013 H63(1)	YBB2013 H65	YBB2013 H67	YBB2013 H68	YBB2013 H69	YBB2013 H70
		Phase	3	3	3	3	3	3	3	3	3	3
Lamiaceae	Lamiaceae	Indet mint family										
Stachys/ Mosla cf.	Lamiaceae	Hedgenettle										
Verbena officinalis (uncharred)	Verbenaceae	Verbena							1			
Asteraceae	Asteraceae	Indet. daisy family								1		
Unidentified remains												
		Indet. small seeds			4				4	6	4	2
		Indet. reticulate testa/shell										
		Indet. fragments	1	3	1	3	1		43		4	3

Appendix 2. BAIYANGCUN
Macro-botanical remains.

Cultivated Cereals	Family	Common Name	YBB2013 H72	YBB2013 H73	YBB2013 H74	YBB2013 W3 tiantu	YBB2013 W3 upper filling	YBB2013 W5
		Phase	3	3	3	3	3	3
		bulk vol (L)	10	10	10	5	5	10
Oryza sativa ssp. *japonica*	Poaceae	Rice grain with embryo	5	1	10	1	1	
Oryza sativa ssp. *japonica*	Poaceae	Rice grain fragment	6	4	1	1	2	2
Oryza sativa ssp. *japonica*	Poaceae	Rice embryo	8	6				
Oryza sp.	Poaceae	Charred food remains (rice)						
Oryza sativa ssp. *japonica*	Poaceae	Rice immature grain	5					
Oryza sativa ssp. *japonica*	Poaceae	Rice immature grain fragment	1			2		1
Oryza sativa ssp. *japonica*	Poaceae	Rice domesticated spikelet base (ripped scar)	53	77	1	14	6	4
Oryza sativa ssp. *japonica*	Poaceae	Rice domesticated spikelet base (semi- ripped scar)		29			1	
Oryza spikelet base	Poaceae	Rice wild spikelet base						

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 H72	YBB2013 H73	YBB2013 H74	YBB2013 W3 tiantu	YBB2013 W3 upper filling	YBB2013 W5
		Phase	3	3	3	3	3	3
Oryza sativa ssp. *japonica*	Poaceae	Rice immature spikelet base	3	4	1	2		4
Oryza sativa ssp. *japonica*	Poaceae	Rice indet. spikelet base		1				
Oryza sativa ssp. *japonica*	Poaceae	Rice husk						
Panicum sp.	Poaceae	Small panicum millet grain						
Panicum miliaceum	Poaceae	Broomcorn millet grain	2	2	1			
Panicum cf. *miliaceum*	Poaceae	Broomcorn millet immature grain				2		
Setaria cf.	Poaceae	Millet grain						2
Setaria italica	Poaceae	Foxtail millet grain	49	12	8			
Setaria sp.	Poaceae	Charred food remains (foxtail millet)						
Setaria cf. *italica*	Poaceae	Foxtail millet immature grain	12	6				
cf. *Setaria / Panicum*	Poaceae	Indet. millet fragments	1		1	1		1

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 H72	YBB2013 H73	YBB2013 H74	YBB2013 W3 tiantu	YBB2013 W3 upper filling	YBB2013 W5
		Phase	3	3	3	3	3	3
Grasses and other dryland field weeds								
cf. *Setaria/ Echinochloa*	Poaceae							
Panicum cf. subsp. *ruderale*	Poaceae	Panicum ruderale						
Panicum sp.	Poaceae	small wild panicum grain						
Echinochloa sp.	Poaceae	Barnyard grass grain	23	15	8			
Echinochloa cf.	Poaceae	Barnyard grass immature grain						
Echinochloa sp.	Poaceae	Barnyard grass small grain						
Setaria cf. *viridis*	Poaceae	Wild foxtail millet		5			1	
Setaria cf. *verticillata*	Poaceae	Bristly foxtail millet						
Digitaria sp.	Poaceae	Crabgrass	7	7	3			
Other wild/weedy grasses								
Poaceae, wild (others)	Poaceae	Wild Poaceae grass	1					
cf. *Poa*	Poaceae	Bluegrass						
Eragrostis sp.	Poaceae	Lovegrass						

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 H72	YBB2013 H73	YBB2013 H74	YBB2013 W3 tiantu	YBB2013 W3 upper filling	YBB2013 W5
		Phase	3	3	3	3	3	3
cf. *Sporobolus*	Poaceae	Smut grass						
cf. *Urochloa*	Poaceae	Signalgrass						
cf. *Paspalum*	Poaceae	Crowngrass						
cf. *Pennisetum*	Poaceae	Fountaingrass	2					
Sedges and other wetland weeds								
Polygonum sp.	Polygonaceae	Indet. knotweed grass	1					
Polygonum persicaria	Polygonaceae	Lady's thumb						
Cyperaceae	Cyperaceae	Indet. sedge inner nutlet	2				1	
Schoenoplectus mucronatus	Cyperaceae	Bog bulrush						
Fimbristylis sp.	Cyperaceae	Fimbristyle						
Scirpus sp.	Cyperaceae	Bulrush	1					
Eleocharis sp.	Cyperaceae	Sedge rhizome tuber						
Cyperus sp.	Cyperaceae	Indet. Cyperus sedge						
Carex sp.	Cyperaceae	Indet. Carex sedge						
Juncaceae	Juncaceae	Indet. rush family						

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 H72	YBB2013 H73	YBB2013 H74	YBB2013 W3 tiantu	YBB2013 W3 upper filling	YBB2013 W5
		Phase	3	3	3	3	3	3
Possible Utilized Species								
Acorn		Acorn						
Nutshell		Acorn nutshell (thin)						
Nutshell,		Acorn nutshell (thick)	7				1	
Juglans sp.	Junglandaceae	Walnut						
Chenopodium sp.	Chenopodiaceae		11	1	10	1	2	1
Euryale ferox	Nymphaeaceae	Foxnut	1				1	1
Crataegus sp.	Rosaceae	Hawthorn						
Glycine cf. *max*	Fabaceae	Soybean	2		2			
Cajanus sp	Fabaceae	Wild cajanus pea	8		1	1		
Vigna sp.	Fabaceae	Indet. vigna bean	1					
Melia azedarach	Meliaceae	Chinaberry (endorcarp)						
Vitis sp.	Vitaceae	Wild grape						
Solanum sp.	Solonaceae	Nightshade family						
Cucurbitaceae cf	Cucurbitcaceae	Indet. cucurbit						
Cucumis cf. *melo*	Cucurbitcaceae	Melon						

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 H72	YBB2013 H73	YBB2013 H74	YBB2013 W3 tiantu	YBB2013 W3 upper filling	YBB2013 W5
		Phase	3	3	3	3	3	3
Wild Species								
Portulaca cf *quadrifida/ pillosa*	Portulaceae	Chickenweed						
Cf. Urtica sp.	Urticaceae	Nettle						
Perilla sp.	Lamiaceae	Perilla		1				
Brassicacae indet.	Brassicaceae	Indet. mustard family	1					
Brassica sp.	Brassicaceae	Indet. brassica seed	2					
Potentilla sp.	Rosaceae	Cinquefoils						1
Fabaceae	Fabaceae	Immature indet. Legume	1					
Fabaceae	Fabaceae	Small indet. Legume	1					
Fabaceae	Fabaceae	Thin indet. Legume		1				
Fabaceae	Fabaceae	Indet. Legume	2					1
Fabaceae	Fabaceae	Legume (hilum)						
Euphorbia sp.	Euphorbiaceae	Euphorbia seed						
Malvaceae	Malvaceae	Indet. mallow						
Ipomoea sp.	Convolvulaceae	Morning glory						

Appendix 2. BAIYANGCUN
Macro-botanical remains.

			YBB2013 H72	YBB2013 H73	YBB2013 H74	YBB2013 W3 tiantu	YBB2013 W3 upper filling	YBB2013 W5
		Phase	3	3	3	3	3	3
Lamiaceae	Lamiaceae	Indet mint family						
Stachys/ Mosla cf.	Lamiaceae	Hedgenettle						
Verbena officinalis (uncharred)	Verbenaceae	Verbena						
Asteraceae	Asteraceae	Indet. daisy family						
Unidentified remains								
		Indet. small seeds		4	2			
		Indet. reticulate testa/shell						
		Indet. fragments	7	2	3	2	2	
		Small bones present				x		

Appendix 2. HAIMENKOU Macro-botanical remains.

			2008JHDT 1003(8)	2008JHAT 1907(7)	2008JHAT 2004(6)	2008JHDT 1003(7)	2008JHDT 1803(7)	2008JHAT 2003(6)s5	2008JHDT 1204(6)	2008JHDT 1304 z1	2008JHDT 1304(5)	2008JHDT 1004(4)
		Phase	1	2	2	2	2	2	2	3	3	3
bulk vol (L)			5	5	5	5	5	5	5	5	5	5
flot vol (ml)						50		500ml			90	
flot weigth (g)			211.22		66.93	39.27	33.65	50		315	53.25	7.08
Cultivated Cereals	Family	Common Name										
Oryza sativa ssp. *japonica*	Poaceae	Rice grain with embryo	1015		1	388		9	17		2500	
Oryza sativa ssp. *japonica*	Poaceae	Rice grain fragment	87	2		49	2					
Oryza sativa ssp. *japonica*	Poaceae	Rice embryo	1			6		1				
Oryza sativa	Poaceae	Rice culm	14	2	17	1		1				
Oryza sativa ssp. *japonica*	Poaceae	Rice immature grain with embryo	1			20						
Oryza sativa ssp. *japonica*	Poaceae	Rice immature grain fragment	33									
Oryza sativa ssp. *japonica*	Poaceae	Rice domesticated spikelet base (ripped scar)	47						4		36	
Oryza sativa ssp. *japonica*	Poaceae	Rice wild spikelet base (smooth scar)										

Appendix 2. HAIMENKOU Macro-botanical remains.

			2008JHDT 1003(8)	2008JHAT 1907(7)	2008JHAT 2004(6)	2008JHDT 1003(7)	2008JHDT 1803(7)	2008JHAT 2003(6)s5	2008JHDT 1204(6)	2008JHDT 1304 z1	2008JHDT 1304(5)	2008JHDT 1004(4)
		Phase	1	2	2	2	2	2	2	3	3	3
Oryza sativa ssp. *japonica*	Poaceae	Rice immature spikelet base										
Oryza sativa ssp. *japonica*	Poaceae	Rice indet. spikelet base	10			6						1
Oryza sativa ssp. *japonica*	Poaceae	Rice husk				25						
Hordeum vulgare	Poaceae	Barley						1	1		1	
Tritivum aestivum	Poaceae	Wheat			1			1	237	1	4	1
Tritivum aestivum	Poaceae	wheat glume base				1		1	5		1	
Panicum miliaceum	Poaceae	Broomcorn millet grain	45			7	35		8			
Panicum cf *miliaceum*	Poaceae	Broomcorn millet immature grain										
Setaria italica	Poaceae	Foxtail millet grain	6600	30	3500	381	1		72	2	22	
Setaria cf. *italica*	Poaceae	Foxtail millet immature grain	128		16				4			
Cf *Setaria*	Poaceae				288			7		1	61	
indet millet frags.	Poaceae	Indet. millet grains	21			2					9	

Appendix 2. HAIMENKOU Macro-botanical remains.

			2008JHDT 1003(8)	2008JHAT 1907(7)	2008JHAT 2004(6)	2008JHDT 1003(7)	2008JHDT 1803(7)	2008JHAT 2003(6)s5	2008JHDT 1204(6)	2008JHDT 1304 z1	2008JHDT 1304(5)	2008JHDT 1004(4)
		Phase	1	2	2	2	2	2	2	3	3	3
Chenopodium sp.	Chenopodiaceae	Chenopodium	135	2	189			22	125		7000	
Fagopyrum cf *esculentum*	Polygonaceae	Buckwheat	1					2				
Grasses and dryland weeds												
Echinochloa sp.	Poaceae	Barnyard grass grain				38			1			
Echinochloa sp.	Poaceae	Barnyard grass (immature grain)										
Echinochloa sp.	Poaceae	Barnyard grass (small)										
Setaria cf *viridis*	Poaceae	Wild foxtail millet	87			1						
Setaria cf *verticillata*	Poaceae	Bristly foxtail				18			5			
Digitaria sp.	Poaceae	Crabgrass				6			2		3	
Cf *Setaria/ Echinochloa*	Poaceae	small immature millet										
Other wild/weedy grasses												
Perilla sp.	Lamiaceae				130						455	
Poaceae	Poaceae	wild Poaceae	2								1	

Appendix 2. HAIMENKOU Macro-botanical remains.

			2008JHDT 1003(8)	2008JHAT 1907(7)	2008JHAT 2004(6)	2008JHDT 1003(7)	2008JHDT 1803(7)	2008JHAT 2003(6)s5	2008JHDT 1204(6)	2008JHDT 1304 z1	2008JHDT 1304(5)	2008JHDT 1004(4)
		Phase	1	2	2	2	2	2	2	3	3	3
Sedges and other wetland weeds												
Polygonum persicaria	Polygonaceae	Lady's thumb			4	3		5				
Carex sp.	Cyperaceae				8							
Cyperus sp.	Cyperaceae	Sedge	1		14			1				1
Juncaceae	Juncaceae	Rush family							1			
Possible Utilized Species												
Acorn		Acorn								1		
Nutshell, fine: cf. acorn		Acorn							1			
Nutshell, thick		Acorn	1						1	1		
Cannabis sp.	Cannabaceae	Hemp			2			1	450			
Euryale ferox	Nymphaeaceae	Foxnut							1			
Rubus sp.	Rosaceae				6							
Prunus cf *armeniaca*	Rosaceae	Plum							3			
Prunus cf *mume*	Rosaceae	Apricot							4			
Prunus cf *persica*	Rosaceae	Peach						3				
Glycine cf *max*	Fabaceae	Soybean			2				1			
Cucurbitaceae cf	Cucurbitcaceae				1					1		
Wild Species												
Fabaceae indet.	Fabaceae										1	

Appendix 2. HAIMENKOU Macro-botanical remains.

			2008JHDT 1003(8)	2008JHAT 1907(7)	2008JHAT 2004(6)	2008JHDT 1003(7)	2008JHDT 1803(7)	2008JHAT 2003(6)s5	2008JHDT 1204(6)	2008JHDT 1304 z1	2008JHDT 1304(5)	2008JHDT 1004(4)
		Phase	1	2	2	2	2	2	2	3	3	3
Bombax sp.	Bombaceae					22			1			
Lamiaceae	Lamiaceae										1	
Galeopsis sp.	Lamiaceae									1		
Leonurus sp.	Lamiaceae				4							
Verbena officinalis	Verbenaceae	Verbena	1						1			
Butomus sp.	Butomaceae		3		1				1			
Najas sp.	Hydrocharitaceae				1							2
Asteraceae	Asteraceae				4							
Unidentified remains												
Indet. small seeds			2	3	6	2	2	6	2	1	1	
Indet. reticulate testa/shell									4			
Indet. fragments				2						1		

Appendix 2. DAYINGZHUANG Macro-botanical remains.

			2017 YHD TN2E2(3)	2017 YHD TN2E2-GJZ 3:2	2017 YHD TN2E2(4)	2017 YHD TN2E2-GJZ 4:2	2017 YHD TN2E2-Z1	2017 YHD F1-1	2017 YHD HDM 2	2017 YHD HDM3	2017 YHD H3	2017 YHD H8
		Phase	2	2	2	2	2	2	2	2	2	2
		bulk vol (L)	80	20	40	20	20	20	20	20	20	20
		intrusion			small roots				modern seeds	modern seeds		
Cultivated Cereals	**Family**	**Common Name**										
Oryza sativa ssp. *japonica*	Poaceae	Rice grain with embryo	1	3				1			1	7
Oryza sativa ssp. *japonica*	Poaceae	Rice grain fragment	1		1	1		3		1		5
Oryza sativa ssp. *Japonica*	Poaceae	Rice embryo										
Oryza sativa ssp. *japonica*	Poaceae	Rice immature grain										
Oryza sativa ssp. *japonica*	Poaceae	Rice domesticated spikelet base (ripped scar)										
Oryza sativa ssp. *japonica*	Poaceae	Rice immature spikelet base										
Hordeum vulgare	Poaceae	Barley grain-naked										

Appendix 2. DAYINGZHUANG Macro-botanical remains.

			2017 YHD TN2E2(3)	2017 YHD TN2E2-GJZ 3:2	2017 YHD TN2E2(4)	2017 YHD TN2E2-GJZ 4:2	2017 YHD TN2E2-Z1	2017 YHD F1-1	2017 YHD HDM 2	2017 YHD HDM3	2017 YHD H3	2017 YHD H8
		Phase	2	2	2	2	2	2	2	2	2	2
Hordeum vulgare	Poaceae	Barley grain-naked immature						1				
Hordeum vulgare	Poaceae	Barley grain-hulled	1			1						1
Hordeum vulgare	Poaceae	Barley rachis										
Triticum aestivum	Poaceae	Wheat grain	10		9	1		12	1	6	2	2
Triticum aestivum	Poaceae	Wheat grain fragments	2	1	2							
Triticum aestivum	Poaceae	Wheat immature grain										1
Triticum aestivum	Poaceae	Wheat rachis										
Triticum aestivum	Poaceae	Wheat grain with husk										
Panicum miliaceum	Poaceae	Broomcorn millet grain						1				5
Setaria italica	Poaceae	Foxtail millet grain						2				
Setaria italica	Poaceae	Foxtail millet immature grain										
cf *Setaria*	Poaceae	Millet grain										6

Appendix 2. DAYINGZHUANG Macro-botanical remains.

			2017 YHD TN2E2(3)	2017 YHD TN2E2-GJZ 3:2	2017 YHD TN2E2(4)	2017 YHD TN2E2-GJZ 4:2	2017 YHD TN2E2-Z1	2017 YHD F1-1	2017 YHD HDM 2	2017 YHD HDM3	2017 YHD H3	2017 YHD H8
		Phase	2	2	2	2	2	2	2	2	2	2
Cf *Setaria/ Panicum*	Poaceae	Indet. Millet grain										
Chenopodium sp.	Chenopodiaceae	Chenopodium	8	4	2		2	58		4	1	99
cf *Fagopyrum*	Polygonaceae									2		
Grasses and other dryland field weeds												
Echinochloa sp	Poaceae	Barnyard grass										
Pennisetum cf	Poaceae											
Sedges and other wetland field weeds												
Rumex cf	Polygonaceae							1				
Schoenoplectus sp	Cyperaceae											
Possible utilized species												
Acorn		Acorn										
cf *Castanea*	Fagaceae	Chestnut										
Euryale ferox	Nymphaeaceae	Foxnut	3	1							25	2
Fabaceae	Fabaceae	Indet. Pulse										
Vicia cf	Fabaceae											
Zanthoxylum sp.	Rutaceae	Sichuan pepper										1
Solanum sp.	Solanaceae											

Appendix 2. DAYINGZHUANG Macro-botanical remains.

			2017 YHD TN2E2(3)	2017 YHD TN2E2-GJZ 3:2	2017 YHD TN2E2(4)	2017 YHD TN2E2-GJZ 4:2	2017 YHD TN2E2-Z1	2017 YHD F1-1	2017 YHD HDM 2	2017 YHD HDM3	2017 YHD H3	2017 YHD H8
		Phase	2	2	2	2	2	2	2	2	2	2
Wild Species												
Portulaca sp.	Portulaceae				1							
Ilex sp.	Aquifoliaceae		1									
Rutaceae	Rutaceae	Indet. Rutaceae										
Euphorbiacee	Euphorbiacee											
Apiaceae	Apiaceae											
Alisma cf *orientale*	Alismataceae											
Uncharred remains- modern												
Rumex cf	Polygonaceae								1	2		
Malva sp.	Malvaceae	Malva										
Asteraceae	Asteraceae	Indet. Daisy family								4		
Unidentified remains												
		Indet. small seeds	2		1	1						
		Indet. fragments	4		1			6	1			
		Small bones			x							

Appendix 2. DAYINGZHUANG Macro-botanical remains.

Cultivated Cereals	Family	Common Name	2017 YHD H9	2017 Y HD H10	2017YHD H11	2017YHD H15	2017YHD H16	2017YHD H18	2017YHD TN2E2(5)	2017YHD TN2E2-GJZ 5	2017YHD *Hedao* 1	2017YHD *Hedao* 2
		Phase	2	2	2	2	2	2	2	2	2	2
		bulk vol (L)	**20**	**20**	**20**	**20**	**20**	**20**	**100**	**20**	**20**	**20**
		intrusion			modern seeds							
Oryza sativa ssp. *japonica*	Poaceae	Rice grain with embryo		1	2	2	1	2	10		4	1
Oryza sativa ssp. *japonica*	Poaceae	Rice grain fragment	2				1		25	1	3	
Oryza sativa ssp. *Japonica*	Poaceae	Rice embryo										
Oryza sativa ssp. *japonica*	Poaceae	Rice immature grain							3	1	3	
Oryza sativa ssp. *japonica*	Poaceae	Rice domesticated spikelet base (ripped scar)							3	6		
Oryza sativa ssp. *japonica*	Poaceae	Rice immature spikelet base								1		
Hordeum vulgare	Poaceae	Barley grain-naked			1							
Hordeum vulgare	Poaceae	Barley grain-naked immature										

Appendix 2. DAYINGZHUANG Macro-botanical remains.

			2017 YHD H9	2017 Y HD H10	2017YHD H11	2017YHD H15	2017YHD H16	2017YHD H18	2017YHD TN2E2(5)	2017YHD TN2E2-GJZ 5	2017YHD *Hedao* 1	2017YHD *Hedao* 2
		Phase	2	2	2	2	2	2	2	2	2	2
Hordeum vulgare	Poaceae	Barley grain-hulled				1					1	
Hordeum vulgare	Poaceae	Barley rachis			1							
Triticum aestivum	Poaceae	Wheat grain	2	7	8	3	1	1	22		194	2
Triticum aestivum	Poaceae	Wheat grain fragments				2		1	2	1	95	
Triticum aestivum	Poaceae	Wheat immature grain										
Triticum aestivum	Poaceae	Wheat rachis			1							
Triticum aestivum	Poaceae	Wheat grain with husk									18	
Panicum miliaceum	Poaceae	Broomcorn millet grain				2					14	
Setaria italica	Poaceae	Foxtail millet grain							4			
Setaria italica	Poaceae	Foxtail millet immature grain			1							
cf *Setaria*	Poaceae	Millet grain	5	2	2							
Cf *Setaria/ Panicum*	Poaceae	Indet. Millets grain										
Chenopodium sp.	Chenopodiaceae	Chenopodium	24	1	99	2	1	7	21	5	5	
cf *Fagopyrum*	Polygonaceae								1			

Appendix 2. DAYINGZHUANG Macro-botanical remains.

			2017 YHD H9	2017 Y HD H10	2017YHD H11	2017YHD H15	2017YHD H16	2017YHD H18	2017YHD TN2E2(5)	2017YHD TN2E2-GJZ 5	2017YHD *Hedao* 1	2017YHD *Hedao* 2
		Phase	2	2	2	2	2	2	2	2	2	2
Grasses and other dryland field weeds												
Echinochloa sp	Poaceae	Barnyard grass				1				1		
Pennisetum cf	Poaceae											
Sedges and other wetland field weeds												
Rumex cf	Polygonaceae											
Schoenoplectus sp	Cyperaceae				1							
Possible utilized species												
Acorn		Acorn			3				3			
cf *Castanea*	Fagaceae	Chestnut							1			
Euryale ferox	Nymphaeaceae	Foxnut	1	3					1			
Fabaceae	Fabaceae	Indet. Pulse							1			
Vicia cf	Fabaceae				1				1			
Zanthoxylum sp.	Rutaceae	Sichuan pepper			2							
Solanum sp.	Solanaceae								1			
Wild Species												
Portulaca sp.	Portulaceae				1							
Ilex sp.	Aquifoliaceae											
Rutaceae	Rutaceae	Indet. Rutaceae							3			

Appendix 2. DAYINGZHUANG Macro-botanical remains.

		2017 YHD H9	2017 Y HD H10	2017YHD H11	2017YHD H15	2017YHD H16	2017YHD H18	2017YHD TN2E2(5)	2017YHD TN2E2-GJZ 5	2017YHD *Hedao* 1	2017YHD *Hedao* 2
	Phase	2	2	2	2	2	2	2	2	2	2
Euphorbiacee	Euphorbiacee			1							
Apiaceae	Apiaceae							1			
Alisma cf *orientale*	Alismataceae										
Uncharred remains- modern											
Rumex cf	Polygonaceae										
Malva sp.	Malvaceae			1							
Asteraceae	Asteraceae			3							
Unidentified remains											
	Indet. small seeds			2				4			
	Indet. fragments	4		2	8	1	4	17	3		
	Parenchyma fragments							2			

Appendix 2. DAYINGZHUANG Macro-botanical remains.

			2017 YHD *jicao 4*	2017 YHD F2-2	2017 YHD F2 living floor	2017 YHD H24	2017 YHD H27	2017 YHD H28	2017 YHD H29	2017 YHD H30	2017 YHD H33	2017 YHD H34
		Phase	1	1	1	1	1	1	1	1	1	1
		bulk vol (L)	20	20	20	20	20	20	20	20	20	20
Cultivated Cereals	Family	Common Name										
Oryza sativa ssp. *japonica*	Poaceae	Rice grain with embryo	2				1	4	2	2	4	1
Oryza sativa ssp. *japonica*	Poaceae	Rice grain fragment				3					2	7
Oryza sativa ssp. *Japonica*	Poaceae	Rice embryo		1								
Oryza sativa ssp. *japonica*	Poaceae	Rice immature grain										
Oryza sativa ssp. *japonica*	Poaceae	Rice domesticated spikelet base (ripped scar)	11	2								
Oryza sativa ssp. *japonica*	Poaceae	Rice immature spikelet base										
Hordeum vulgare	Poaceae	Barley grain-naked										
Hordeum vulgare	Poaceae	Barley grain-naked immature										
Hordeum vulgare	Poaceae	Barley grain-hulled										

Appendix 2. DAYINGZHUANG Macro-botanical remains.

			2017 YHD *jicao 4*	2017 YHD F2-2	2017 YHD F2 living floor	2017 YHD H24	2017 YHD H27	2017 YHD H28	2017 YHD H29	2017 YHD H30	2017 YHD H33	2017 YHD H34
		Phase	1	1	1	1	1	1	1	1	1	1
Hordeum vulgare	Poaceae	Barley rachis										
Triticum aestivum	Poaceae	Wheat grain	1			2	4					
Triticum aestivum	Poaceae	Wheat grain fragments										
Triticum aestivum	Poaceae	Wheat immature grain										
Triticum aestivum	Poaceae	Wheat rachis										
Triticum aestivum	Poaceae	Wheat grain with husk										
Panicum miliaceum	Poaceae	Broomcorn millet grain						1	2	1		
Setaria italica	Poaceae	Foxtail millet grain	3					1		3	5	
Setaria italica	Poaceae	Foxtail millet immature grain	3									
cf *Setaria*	Poaceae	Millet grain										
Cf *Setaria/ Panicum*	Poaceae	Indet. Millets grain		2								
Chenopodium sp.	Chenopodiaceae	Chenopodium	7		1	2						
cf *Fagopyrum*	Polygonaceae	Buckwheat										
Grasses and other dryland field weeds												
Echinochloa sp	Poaceae	Barnyard grass										
Pennisetum cf	Poaceae		1								1	

Appendix 2. DAYINGZHUANG Macro-botanical remains.

			2017 YHD *jicao 4*	2017 YHD F2-2	2017 YHD F2 living floor	2017 YHD H24	2017 YHD H27	2017 YHD H28	2017 YHD H29	2017 YHD H30	2017 YHD H33	2017 YHD H34
		Phase	1	1	1	1	1	1	1	1	1	1
Sedges and other wetland field weeds												
Rumex cf	Polygonaceae				1							
Schoenoplectus sp	Cyperaceae											
Possible utilized species												
Acorn		Acorn										
cf *Castanea*	Fagaceae	Chestnut										
Euryale ferox	Nymphaeaceae	Foxnut		1	1	2	1	2				
Fabaceae	Fabaceae	Indet. Pulse									1	
Vicia cf	Fabaceae										1	
Zanthoxylum sp.	Rutaceae	Sichuan pepper										
Solanum sp.	Solanaceae											
Wild Species												
Portulaca sp.	Portulaceae											
Ilex sp.	Aquifoliaceae											
Rutaceae	Rutaceae	Indet. Rutaceae										
Euphorbiacee	Euphorbiacee											
Apiaceae	Apiaceae											
Alisma cf *orientale*	Alismataceae						1					
Unidentified remains												
		Indet. small seeds				1				1		

Appendix 2. DAYINGZHUANG Macro-botanical remains.

	2017 YHD *jicao 4*	2017 YHD F2-2	2017 YHD F2 living floor	2017 YHD H24	2017 YHD H27	2017 YHD H28	2017 YHD H29	2017 YHD H30	2017 YHD H33	2017 YHD H34
Phase	1	1	1	1	1	1	1	1	1	1
Indet. fragments	2		1		5	4				
Parenchyma fragments					1				1	

Appendix 2B. DAYINGZHUANG Phytoliths: weights.

Phytolith slide number	Samples ID	Sieved soil weight g	Dry pot weight g	Dry pot + phytolith weight g	Mounted phytolith weight mg
1	34	1.26	6.82003	7.10618	2.39
2	32	1.26	6.78933	6.79419	2.41
3	30	1.32	6.29828	6.30318	2.32
4	26	1.34	6.82545	6.95833	2.84
5	24	1.19	6.69667	6.87281	2.48
6	22	1.25	6.91875	6.94076	2.39
7	20	1.27	6.971596	6.97956	2.49
8	18	1.29	6.92578	6.94179	2.44
9	16	1.21	6.78533	6.94351	2.32
11	10	1.55	6.72102	6.81199	2.42
12	3	1.49	6.80252	6.81044	2.37

Appendix 2B. DAYINGZHUANG Phytoliths: counts.

Sample ID	3	10	16	18	20	22
SINGLE-CELL						
SC rows counted	21	2	2.5	3.5	2.5	3
Elongate (Smooth):	13	122	103	23	69	24
Elongate (Sinuate)	1	29	3	6	1	1
Elongate (Echinate)	7	23	19	42	39	32
Elongate (Dendritic):		25	23	9	3	26
Elongate (Rods)			3			
Stomata		4			1	
Hair - long			7	2	1	
Hair - segmented		4				
Hair - acicular	1	5	1			
Hair - uncifrom		1		1		1
Hair base						
Bulliform:	8	63	17	9	11	8
Cuneiform bulliform	1	15		21	7	8
Oryza-type cuneiform bulliform		7		3	18	2
Oryza-type double peaked cell		6				
Crenates:		38				
Polylobate		4	1			
Bilobes:	3	4	17	32	18	44
Setaria-type bilobe		6	1	12	9	4
Oryza-type bilobe		19	1	7	4	4
1/2 bilobe		2	1			1
Cross - mirror image type		17			2	4
Cross - Bambusoidaea type			3	1		1
Cross - other	4	10		8	1	11
Rondels:	12	1	43	54	38	40
Stipa-Type Rondel	2	2		4	6	3
Saddles:	3		20	36	28	43
Collapsed saddle		3	4	2	5	6
Trapeziform short cell	7			1	2	3
Papillae	4	1	5			2
Sedge achene cell		2	3	4	10	4
Hat shaped		4	5	5	5	8
Reniform		2				
Scutiform						
Oval		1	1			2
Oblong	1					1
Conical	1	1	4	6		4
Conical with pointed apex	1				3	2
Globular smooth					3	6
Globular echinate						
Golbular rugulose		3				1
Pitted sheet	2			15	11	2
Reticulate sheet						
Sheet - other	20	60	17	19	33	16
Scalloped - cucurbitaceae				2		
Scalloped - other		5		4	2	
Tabluar		2				
Trapeziform sinuate		2		1		
Elongate - dicot/wood		1				

Appendix 2B. DAYINGZHUANG Phytoliths: counts.

Sample ID	3	10	16	18	20	22
Tracheids		1	3	4		
Sclereid						
Irregular block	28	2	44	16	10	15
Jigsaw puzzle (stellate)				14	8	4
Irregular (other)	35					
MULTI-CELL						
MC rows counted	**4**	**4**	**4**	**7**	**2**	**7**
Leaf/culm indet. - Palisade layer		1	7	8	4	12
Leaf/culm rondels						
Leaf/culm bilobes	1		1			2
Leaf/culm saddles		36				
Leaf/culm globular smooth						
Leaf/culm globular rugulose						
Leaf/culm globular echinate						
Leaf/culm cross		2	1			
Leaf/culm sedge						
Leaf/culm square cell				1		1
Leaf/culm Oryza						
Leaf/culm Setaria						
Leaf jigsaw - upper epidermis			2			1
Awn			1			
Unident husk	8		40	45	34	34
Indet dendritic husk						
Oryza husk			31	45	64	45
Oryza double peaked cells	1	3	5	7		1
Oryza single peak cell			5	3	9	4
Wheat Husk			4	6	1	8
Barley Husk		2				1
Setaria-Type Husk			3	6		2
Panicum-Type husk						
Millet type 1 - rounded processes		3				
Millet type 2 - square processes						
Cyperaceae (cones)		1				
Polyhedral hair base			1			
Verrucate		1				
Scrobiculate						
Rugulate						
Striate		7	1			
Tabular						
Mesophyll - spongy layer			1			
Indet multicell			1			
Indet dicot			2	1		3
Silica aggregate				2	5	6
Diatoms	4		5	1	1	5
Starch		5	2			
Sponge spicules		3				
Indet silica forms	2	1				
Parenchyma				1		

Appendix 2B. DAYINGZHUANG Phytoliths: counts.

Sample ID	24	26	30	32	34
SINGLE-CELL					
SC rows counted	9	21	22	16	5.5
Elongate (Smooth):	31	26	36	27	48
Elongate (Sinuate)	3	1		1	1
Elongate (Echinate)	47	41	33	26	39
Elongate (Dendritic):	17	45	1	1	7
Elongate (Rods)					
Stomata	3	3	1		1
Hair - long	1	1			
Hair - segmented	1		1		
Hair - acicular	1				
Hair - uncifrom	1				
Hair base					2
Bulliform:	5		7	11	12
Cuneiform bulliform	26	7	22	9	12
Oryza-type cuneiform bulliform	3	3	6	3	7
Oryza-type double peaked cell					
Crenates:					
Polylobate					
Bilobes:	30	22	11	12	7
Setaria-type bilobe	2	2	2	2	
Oryza-type bilobe	5	4			
1/2 bilobe					
Cross - mirror image type	6	4	3		
Cross - Bambusoidaea type					
Cross - other		6			7
Rondels:	54	39	38	37	45
Stipa-Type Rondel					
Saddles:	35	31	21	22	37
Collapsed saddle		2			
Trapeziform short cell		1	1		3
Papillae					
Sedge achene cell	11	20	8	3	6
Hat shaped	13	10	2		
Reniform					
Scutiform					
Oval					6
Oblong					
Conical		5	5	1	14
Conical with pointed apex			4	3	1
Globular smooth	1		3	3	2
Globular echinate					
Golbular rugulose					
Pitted sheet	2	1	2		1
Reticulate sheet					
Sheet - other	21	22	29	7	25
Scalloped - cucurbitaceae					
Scalloped - other	3				1
Tabluar					
Trapeziform sinuate					

Appendix 2B. DAYINGZHUANG Phytoliths: counts.

Sample ID	24	26	30	32	34
Elongate - dicot/wood					
Tracheids		3			1
Sclereid					
Irregular block	6	11	5	4	4
Jigsaw puzzle (stellate)	2	10	4	2	1
Irregular (other)					
MULTI-CELL					
MC rows counted	12	25	22	16	18
Leaf/culm indet. - Palisade layer		13	3	3	4
Leaf/culm rondels					
Leaf/culm bilobes					
Leaf/culm saddles					
Leaf/culm globular smooth				3	
Leaf/culm globular rugulose					
Leaf/culm globular echinate					
Leaf/culm cross					
Leaf/culm sedge					
Leaf/culm square cell			3	1	5
Leaf/culm Oryza					
Leaf/culm Setaria					
Leaf jigsaw - upper epidermis					
Awn					
Unident husk		8	6	4	29
Indet dendritic husk	1				
Oryza husk	33	28	6	5	17
Oryza double peaked cells	31	6	3	2	
Oryza single peak cell	35	3	11	4	6
Wheat Husk		2		1	
Barley Husk		1			
Setaria-Type Husk	1				
Panicum-Type husk					
Millet type 1 - rounded processes	2	4			1
Millet type 2 - square processes					
Cyperaceae (cones)					
Polyhedral hair base					
Verrucate					
Scrobiculate					
Rugulate					
Striate					
Tabular					
Mesophyll - spongy layer					
Indet multicell					
Indet dicot		1	1	2	1
Silica aggregate		2	1		1
Diatoms		6	5		3
Starch					
Sponge spicules					
Indet silica forms					
Parenchyma					

Appendix 2B. DAYINGZHUANG Phytoliths: number per gram.

Sample:	3	10	16	18	20	22
SINGLE-CELL						
Elongate (Smooth):	67	71010	111434	1604	3336	2829
Elongate (Sinuate)	5	16879	3246	419	48	118
Elongate (Echinate)	36	13387	20556	2930	1886	3772
Elongate (Dendritic):	0	14551	28990	628	145	3065
Elongate (Rods)	0	0	129826	0	0	0
Stomata	0	2328	0	0	48	0
Hair - long	0	0	7573	140	48	0
Hair - segmented	0	2328	0	0	0	0
Hair - acicular	5	2910	1082	0	0	0
Hair - uncifrom	0	582	0	70	0	118
Hair base	0	0	0	0	0	0
Bulliform:	41	36669	18392	628	532	943
Cuneiform bulliform	5	8731	0	1465	338	943
Oryza-type cuneiform bulliform	0	4074	0	209	870	236
Oryza-type double peaked cell	0	3492	0	0	0	0
Crenates:	0	22118	0	0	0	0
Polylobate	0	2328	1082	0	0	0
Bilobes:	15	2328	18392	2232	870	5187
Setaria-type bilobe	0	3492	1082	837	435	472
Oryza-type bilobe	0	11059	1082	488	193	472
1/2 bilobe	0	1164	1082	0	0	118
Cross - mirror image type	0	9895	0	0	97	472
Cross - Bambusoidaea type	0	0	3246	70	0	118
Cross - other	21	5820	0	558	48	1297
Rondels:	62	582	46521	3767	1837	4715
Stipa-Type Rondel	10	1164	0	279	290	354
Saddles:	15	0	21638	2511	1354	5069
Collapsed saddle	0	1746	4328	140	242	707
Trapeziform short cell	36	0	0	70	97	354
Papillae	21	582	5409	0	0	236
Sedge achene cell	0	1164	3246	279	484	472
	0	2328	5409	349	242	943
Reniform	0	1164	0	0	0	0
Scutiform	0	0	0	0	0	0
Oval	0	582	1082	0	0	236
Oblong	5	0	0	0	0	118
Conical	5	582	4328	419	0	472
Conical with pointed apex	5	0	0	0	145	236
Globular smooth	0	0	0	0	145	707
Globular echinate	0	0	0	0	0	0
Golbular rugulose	0	1746	0	0	0	118
Pitted sheet	10	0	0	1046	532	236
Reticulate sheet	0	0	0	0	0	0
Sheet - other	103	34923	18392	1325	1596	1886
Scalloped - cucurbitaceae	0	0	0	140	0	0
Scalloped - other	0	2910	0	279	97	0
Tabluar	0	1164	0	0	0	0
Trapeziform sinuate	0	1164	0	70	0	0

Appendix 2B. DAYINGZHUANG Phytoliths: number per gram.

Sample:	3	10	16	18	20	22
Elongate - dicot/wood	0	582	0	0	0	0
Tracheids	0	582	3246	279	0	0
Sclereid	0	0	0	0	0	0
Irregular block	144	1164	47603	1116	484	1768
Jigsaw puzzle (stellate)	0	0	0	977	387	472
Irregular (other)	179	0	0	0	0	0
MULTI-CELL						
Leaf/culm indet. - Palisade layer	0	291	113597	13393	3316	606
Leaf/culm rondels	0	0	0	0	0	0
Leaf/culm bilobes	27	0	16228	0	0	101
Leaf/culm saddles	0	10477	0	0	0	0
Leaf/culm globular smooth	0	0	0	0	0	0
Leaf/culm globular rugulose	0	0	0	0	0	0
Leaf/culm globular echinate	0	0	0	0	0	0
Leaf/culm cross	0	582	16228	0	0	0
Leaf/culm sedge	0	0	0	0	0	0
Leaf/culm square cell	0	0	0	1674	0	51
Leaf/culm Oryza	0	0	0	0	0	0
Leaf/culm Setaria	0	0	0	0	0	0
Leaf jigsaw - upper epidermis	0	0	32456	0	0	51
Awn	0	0	16228	0	0	0
Unident husk	215	0	649129	75337	28183	1718
Unindet dendritic husk	0	0	0	0	0	0
Oryza husk	0	0	503075	75337	53051	2273
Oryza double peaked cells	27	873	81141	11719	0	51
Oryza single peak	0	0	81141	5022	7460	202
Wheat Husk	0	0	64913	10045	829	404
Barley Husk	0	582	0	0	0	51
Setaria-Type Husk	0	0	48685	10045	0	101
Panicum-Type husk	0	0	0	0	0	0
Millet type 1 - rounded processes	0	873	0	0	0	0
Millet type 2 - square processes	0	0	0	0	0	0
Cyperaceae (cones)	0	291	0	0	0	0
Polyhedral hair base	0	0	16228	0	0	0
Verrucate	0	291	0	0	0	0
Scrobiculate	0	0	0	0	0	0
Rugulate	0	0	0	0	0	0
Striate	0	2037	16228	0	0	0
Tabular	0	0	0	0	0	0
Mesophyll - spongy layer	0	0	16228	0	0	0
Indet multicell	0	0	16228	0	0	0
Indet dicot	0	0	32456	1674	0	152
Silica aggregate	0	0	0	3348	4145	303
Diatoms	108	0	81141	1674	829	253
Starch	0	1455	32456	0	0	0
Sponge spicules	0	873	0	0	0	0
Indet silica forms	54	291	0	0	0	0

Appendix 2B. DAYINGZHUANG Phytoliths: number per gram.

Sample:	3	10	16	18	20	22
Parenchyma	0	0	0	1674	0	0
Total % phytoliths per gram	0.531476510067114	5.86896774193548	13.0727272727273	0.627086614173228	0.627086614173228	1.760792

Sample:	24	26	30	32	34
SINGLE-CELL					
Elongate (Smooth):	9869	2075	126	130	39806
Elongate (Sinuate)	955	80	0	5	829
Elongate (Echinate)	14963	3272	115	125	32342
Elongate (Dendritic):	5412	3591	3	5	5805
Elongate (Rods)	0	0	0	0	0
Stomata	955	239	3	0	829
Hair - long	318	80	0	0	0
Hair - segmented	318	0	3	0	0
Hair - acicular	318	0	0	0	0
Hair - uncifrom	318	0	0	0	0
Hair base	0	0	0	0	1659
Bulliform:	1592	0	24	53	9951
Cuneiform bulliform	8278	559	77	43	9951
Oryza-type cuneiform bulliform	955	239	21	14	5805
Oryza-type double peaked cell	0	0	0	0	0
Crenates:	0	0	0	0	0
Polylobate	0	0	0	0	0
Bilobes:	9551	1756	38	58	5805
Setaria-type bilobe	637	160	7	10	0
Oryza-type bilobe	1592	319	0	0	0
1/2 bilobe	0	0	0	0	0
Cross - mirror image type	1910	319	10	0	0
Cross - Bambusoidaea type	0	0	0	0	0
Cross - other	0	479	0	0	5805
Rondels:	17192	3113	133	178	37318
Stipa-Type Rondel	0	0	0	0	0
Saddles:	11143	2474	73	106	30684
Collapsed saddle	0	160	0	0	0
Trapeziform short cell	0	80	3	0	2488
Papillae	0	0	0	0	0
Sedge achene cell	3502	1596	28	14	4976
Hat shaped	4139	798	7	0	0
Reniform	0	0	0	0	0
Scutiform	0	0	0	0	0
Oval	0	0	0	0	4976
Oblong	0	0	0	0	0
Conical	0	399	17	5	11610
Conical with pointed apex	0	0	14	14	829
Globular smooth	318	0	10	14	1659
Globular echinate	0	0	0	0	0

Appendix 2B. DAYINGZHUANG Phytoliths: number per gram.

Sample:	24	26	30	32	34
Globular rugulose	0	0	0	0	0
Pitted sheet	637	80	7	0	829
Reticulate sheet	0	0	0	0	0
Sheet - other	6686	1756	101	34	20732
Scalloped - cucurbitaceae	0	0	0	0	0
Scalloped - other	955	0	0	0	829
Tabluar	0	0	0	0	0
Trapeziform sinuate	0	0	0	0	0
Elongate - dicot/wood	0	0	0	0	0
Tracheids	0	239	0	0	829
Sclereid	0	0	0	0	0
Irregular block	1910	878	17	19	3317
Jigsaw puzzle (stellate)	637	798	14	10	829
Irregular (other)	0	0	0	0	0
MULTI-CELL					
Leaf/culm indet. - Palisade layer	0	872	10	14	1014
Leaf/culm rondels	0	0	0	0	0
Leaf/culm bilobes	0	0	0	0	0
Leaf/culm saddles	0	0	0	0	0
Leaf/culm globular smooth	0	0	0	14	0
Leaf/culm globular rugulose	0	0	0	0	0
Leaf/culm globular echinate	0	0	0	0	0
Leaf/culm cross	0	0	0	0	0
Leaf/culm sedge	0	0	0	0	0
Leaf/culm square cell	0	0	10	5	1267
Leaf/culm Oryza	0	0	0	0	0
Leaf/culm Setaria	0	0	0	0	0
Leaf jigsaw - upper epidermis	0	0	0	0	0
Awn	0	0	0	0	0
Unident husk	0	536	21	19	7348
Unindet dendritic husk	239	0	0	0	0
Oryza husk	7880	1877	21	24	4308
Oryza double peaked cells	7402	402	10	10	0
Oryza single peak	8357	201	38	19	1520
Wheat Husk	0	134	0	5	0
Barley Husk	0	67	0	0	0
Setaria-Type Husk	239	0	0	0	0
Panicum-Type husk	0	0	0	0	0
Millet type 1 - rounded processes	478	268	0	0	253
Millet type 2 - square processes	0	0	0	0	0
Cyperaceae (cones)	0	0	0	0	0
Polyhedral hair base	0	0	0	0	0
Verrucate	0	0	0	0	0
Scrobiculate	0	0	0	0	0
Rugulate	0	0	0	0	0
Striate	0	0	0	0	0

Appendix 2B. DAYINGZHUANG Phytoliths: number per gram.

Sample:	24	26	30	32	34
Tabular	0	0	0	0	0
Mesophyll - spongy layer	0	0	0	0	0
Indet multicell	0	0	0	0	0
Indet dicot	0	67	3	10	253
Silica aggregate	0	134	3	0	253
Diatoms	0	402	17	0	760
Starch	0	0	0	0	0
Sponge spicules	0	0	0	0	0
Indet silica forms	0	0	0	0	0
Parenchyma	0	0	0	0	0
Total % phytoliths per gram	14.8042016806723	9.91641791044776	0.371212121212121	0.385714285714286	22.7103174603175

Appendix 2B. DAYINGZHUANG Phytoliths: % per gram.

Sample:	34	32	30	26	24
Layer	5	5	5	5	4
SINGLE-CELL					
Elongate (Smooth):	15.46	13.57	12.68	6.80	7.61
Elongate (Sinuate)	0.32	0.50	0.00	0.26	0.74
Elongate (Echinate)	12.56	13.07	11.62	10.73	11.54
Elongate (Dendritic):	2.25	0.50	0.35	11.78	4.17
Elongate (Rods)	0.00	0.00	0.00	0.00	0.00
Stomata	0.32	0.00	0.35	0.79	0.74
Hair - long	0.00	0.00	0.00	0.26	0.25
Hair - segmented	0.00	0.00	0.35	0.00	0.25
Hair - acicular	0.00	0.00	0.00	0.00	0.25
Hair - uncifrom	0.00	0.00	0.00	0.00	0.25
Hair base	0.64	0.00	0.00	0.00	0.00
Bulliform:	3.87	5.53	2.46	0.00	1.23
Cuneiform bulliform	3.87	4.52	7.75	1.83	6.38
Oryza-type cuneiform bulliform	2.25	1.51	2.11	0.79	0.74
Oryza-type double peaked cell	0.00	0.00	0.00	0.00	0.00
Crenates:	0.00	0.00	0.00	0.00	0.00
Polylobate	0.00	0.00	0.00	0.00	0.00
Bilobes:	2.25	6.03	3.87	5.76	7.37
Setaria-type bilobe	0.00	1.01	0.70	0.52	0.49
Oryza-type bilobe	0.00	0.00	0.00	1.05	1.23
1/2 bilobe	0.00	0.00	0.00	0.00	0.00
Cross - mirror image type	0.00	0.00	1.06	1.05	1.47
Cross - Bambusoidaea type	0.00	0.00	0.00	0.00	0.00
Cross - other	2.25	0.00	0.00	1.57	0.00
Rondels:	14.49	18.59	13.38	10.21	13.26
Stipa-Type Rondel	0.00	0.00	0.00	0.00	0.00
Saddles:	11.92	11.06	7.39	8.11	8.59
Collapsed saddle	0.00	0.00	0.00	0.52	0.00
Trapeziform short cell	0.97	0.00	0.35	0.26	0.00
Papillae	0.00	0.00	0.00	0.00	0.00
Sedge achene cell	1.93	1.51	2.82	5.23	2.70
Hat shaped	0.00	0.00	0.70	2.62	3.19
Reniform	0.00	0.00	0.00	0.00	0.00
Scutiform	0.00	0.00	0.00	0.00	0.00
Oval	1.93	0.00	0.00	0.00	0.00
Oblong	0.00	0.00	0.00	0.00	0.00
Conical	4.51	0.50	1.76	1.31	0.00
Trichomes	0.32	1.51	1.41	0.00	0.00
Globular smooth	0.64	1.51	1.06	0.00	0.25
Golbular rugulose	0.00	0.00	0.00	0.00	0.00
Pitted sheet	0.32	0.00	0.70	0.26	0.49
Reticulate sheet	0.00	0.00	0.00	0.00	0.00
Sheet - other	8.05	3.52	10.21	5.76	5.16
Scalloped - cucurbitaceae	0.00	0.00	0.00	0.00	0.00
Scalloped - other	0.32	0.00	0.00	0.00	0.74
Tabluar	0.00	0.00	0.00	0.00	0.00
Trapeziform sinuate	0.00	0.00	0.00	0.00	0.00
Elongate - dicot/wood	0.00	0.00	0.00	0.00	0.00

Appendix 2B. DAYINGZHUANG Phytoliths: % per gram.

Sample:	34	32	30	26	24
Tracheids	0.32	0.00	0.00	0.79	0.00
Irregular block	1.29	2.01	1.76	2.88	1.47
Jigsaw puzzle (stellate)	0.32	1.01	1.41	2.62	0.49
Irregular (other)	0.00	0.00	0.00	0.00	0.00
MULTI-CELL					
Leaf/culm indet. - Palisade layer	0.39	1.51	1.06	2.86	0.00
Leaf/culm rondels	0.00	0.00	0.00	0.00	0.00
Leaf/culm bilobes	0.00	0.00	0.00	0.00	0.00
Leaf/culm saddles	0.00	0.00	0.00	0.00	0.00
Leaf/culm globular smooth	0.00	1.51	0.00	0.00	0.00
Leaf/culm globular rugulose	0.00	0.00	0.00	0.00	0.00
Leaf/culm globular echinate	0.00	0.00	0.00	0.00	0.00
Leaf/culm cross	0.00	0.00	0.00	0.00	0.00
Leaf/culm sedge	0.00	0.00	0.00	0.00	0.00
Leaf/culm square ? polyhedral	0.49	0.50	1.06	0.00	0.00
Leaf jigsaw - upper epidermis	0.00	0.00	0.00	0.00	0.00
Awn	0.00	0.00	0.00	0.00	0.00
Unident husk	2.85	2.01	2.11	1.76	0.00
Unindet dendritic husk	0.00	0.00	0.00	0.00	0.18
Oryza husk	1.67	2.51	2.11	6.15	6.08
Oryza double peaked cells	0.00	1.01	1.06	1.32	5.71
Oryza single peak	0.59	2.01	3.87	0.66	6.45
Wheat Husk	0.00	0.50	0.00	0.44	0.00
Barley Husk	0.00	0.00	0.00	0.22	0.00
Setaria-Type Husk	0.00	0.00	0.00	0.00	0.18
Millet type 1 - rounded processe	0.10	0.00	0.00	0.88	0.37
Millet type 2 - square processes	0.00	0.00	0.00	0.00	0.00
Cyperaceae (cones)	0.00	0.00	0.00	0.00	0.00
Polyhedral hair base	0.00	0.00	0.00	0.00	0.00
Verrucate	0.00	0.00	0.00	0.00	0.00
Striate	0.00	0.00	0.00	0.00	0.00
Mesophyll - spongy layer	0.00	0.00	0.00	0.00	0.00
Indet multicell	0.00	0.00	0.00	0.00	0.00
Indet dicot	0.10	1.01	0.35	0.22	0.00
Silica aggregate	0.10	0.00	0.35	0.44	0.00
Diatoms	0.30	0.00	1.76	1.32	0.00
Starch	0.00	0.00	0.00	0.00	0.00
Sponge spicules	0.00	0.00	0.00	0.00	0.00
Indet silica forms	0.00	0.00	0.00	0.00	0.00
Parenchyma	0.00	0.00	0.00	0.00	0.00
TOTAL	100.00	100.00	100.00	100.00	100.00

Appendix 2B. DAYINGZHUANG Phytoliths: % per gram.

Sample:	22	20	18	16	10	3
Layer	4	4	4	3	modern	modern
SINGLE-CELL						
Elongate (Smooth):	6.21	2.91	0.68	4.76	23.13	6.75
Elongate (Sinuate)	0.26	0.04	0.18	0.14	5.50	0.52
Elongate (Echinate)	8.28	1.64	1.25	0.88	4.36	3.64
Elongate (Dendritic):	6.73	0.13	0.27	1.24	4.74	0.00
Elongate (Rods)	0.00	0.00	0.00	5.54	0.00	0.00
Stomata	0.00	0.04	0.00	0.00	0.76	0.00
Hair - long	0.00	0.04	0.06	0.32	0.00	0.00
Hair - segmented	0.00	0.00	0.00	0.00	0.76	0.00
Hair - acicular	0.00	0.00	0.00	0.05	0.95	0.52
Hair - uncifrom	0.26	0.00	0.03	0.00	0.19	0.00
Hair base	0.00	0.00	0.00	0.00	0.00	0.00
Bulliform:	2.07	0.46	0.27	0.79	11.94	4.16
Cuneiform bulliform	2.07	0.30	0.62	0.00	2.84	0.52
Oryza-type cuneiform bulliform	0.52	0.76	0.09	0.00	1.33	0.00
Oryza-type double peaked cell	0.00	0.00	0.00	0.00	1.14	0.00
Crenates:	0.00	0.00	0.00	0.00	7.20	0.00
Polylobate	0.00	0.00	0.00	0.05	0.76	0.00
Bilobes:	11.38	0.76	0.95	0.79	0.76	1.56
Setaria-type bilobe	1.03	0.38	0.36	0.05	1.14	0.00
Oryza-type bilobe	1.03	0.17	0.21	0.05	3.60	0.00
1/2 bilobe	0.26	0.00	0.00	0.05	0.38	0.00
Cross - mirror image type	1.03	0.08	0.00	0.00	3.22	0.00
Cross - Bambusoidaea type	0.26	0.00	0.03	0.14	0.00	0.00
Cross - other	2.85	0.04	0.24	0.00	1.90	2.08
Rondels:	10.35	1.60	1.61	1.99	0.19	6.23
Stipa-Type Rondel	0.78	0.25	0.12	0.00	0.38	1.04
Saddles:	11.12	1.18	1.07	0.92	0.00	1.56
Collapsed saddle	1.55	0.21	0.06	0.18	0.57	0.00
Trapeziform short cell	0.78	0.08	0.03	0.00	0.00	3.64
Papillae	0.52	0.00	0.00	0.23	0.19	2.08
Sedge achene cell	1.03	0.42	0.12	0.14	0.38	0.00
Hat shaped	2.07	0.21	0.15	0.23	0.76	0.00
Reniform	0.00	0.00	0.00	0.00	0.38	0.00
Scutiform	0.00	0.00	0.00	0.00	0.00	0.00
Oval	0.52	0.00	0.00	0.05	0.19	0.00
Oblong	0.26	0.00	0.00	0.00	0.00	0.52
Conical	1.03	0.00	0.18	0.18	0.19	0.52
Trichomes	0.52	0.13	0.00	0.00	0.00	0.52
Globular smooth	1.55	0.13	0.00	0.00	0.00	0.00
Golbular rugulose	0.26	0.00	0.00	0.00	0.57	0.00
Pitted sheet	0.52	0.46	0.45	0.00	0.00	1.04
Reticulate sheet	0.00	0.00	0.00	0.00	0.00	0.00
Sheet - other	4.14	1.39	0.56	0.79	11.37	10.39
Scalloped - cucurbitaceae	0.00	0.00	0.06	0.00	0.00	0.00
Scalloped - other	0.00	0.08	0.12	0.00	0.95	0.00
Tabluar	0.00	0.00	0.00	0.00	0.38	0.00
Trapeziform sinuate	0.00	0.00	0.03	0.00	0.38	0.00
Elongate - dicot/wood	0.00	0.00	0.00	0.00	0.19	0.00
Tracheids	0.00	0.00	0.12	0.14	0.19	0.00

Appendix 2B. DAYINGZHUANG Phytoliths: % per gram.

Sample:	22	20	18	16	10	3
Irregular block	3.88	0.42	0.48	2.03	0.38	14.55
Jigsaw puzzle (stellate)	1.03	0.34	0.42	0.00	0.00	0.00
Irregular (other)	0.00	0.00	0.00	0.00	0.00	18.18
MULTI-CELL						
Leaf/culm indet. - Palisade layer	1.33	2.89	5.71	4.85	0.09	0.00
Leaf/culm rondels	0.00	0.00	0.00	0.00	0.00	0.00
Leaf/culm bilobes	0.22	0.00	0.00	0.69	0.00	2.73
Leaf/culm saddles	0.00	0.00	0.00	0.00	3.41	0.00
Leaf/culm globular smooth	0.00	0.00	0.00	0.00	0.00	0.00
Leaf/culm globular rugulose	0.00	0.00	0.00	0.00	0.00	0.00
Leaf/culm globular echinate	0.00	0.00	0.00	0.00	0.00	0.00
Leaf/culm cross	0.00	0.00	0.00	0.69	0.19	0.00
Leaf/culm sedge	0.00	0.00	0.00	0.00	0.00	0.00
Leaf/culm square ? polyhedral	0.11	0.00	0.71	0.00	0.00	0.00
Leaf jigsaw - upper epidermis	0.11	0.00	0.00	1.39	0.00	0.00
Awn	0.00	0.00	0.00	0.69	0.00	0.00
Unident husk	3.77	24.58	32.11	27.72	0.00	21.82
Unindet dendritic husk	0.00	0.00	0.00	0.00	0.00	0.00
Oryza husk	4.99	46.28	32.11	21.48	0.00	0.00
Oryza double peaked cells	0.11	0.00	5.00	3.46	0.28	2.73
Oryza single peak	0.44	6.51	2.14	3.46	0.00	0.00
Wheat Husk	0.89	0.72	4.28	2.77	0.00	0.00
Barley Husk	0.11	0.00	0.00	0.00	0.19	0.00
Setaria-Type Husk	0.22	0.00	4.28	2.08	0.00	0.00
Millet type 1 - rounded processe	0.00	0.00	0.00	0.00	0.28	0.00
Millet type 2 - square processes	0.00	0.00	0.00	0.00	0.00	0.00
Cyperaceae (cones)	0.00	0.00	0.00	0.00	0.09	0.00
Polyhedral hair base	0.00	0.00	0.00	0.69	0.00	0.00
Verrucate	0.00	0.00	0.00	0.00	0.09	0.00
Striate	0.00	0.00	0.00	0.69	0.66	0.00
Mesophyll - spongy layer	0.00	0.00	0.00	0.69	0.00	0.00
Indet multicell	0.00	0.00	0.00	0.69	0.00	0.00
Indet dicot	0.33	0.00	0.71	1.39	0.00	0.00
Silica aggregate	0.67	3.62	1.43	0.00	0.00	0.00
Diatoms	0.55	0.72	0.71	3.46	0.00	10.91
Starch	0.00	0.00	0.00	1.39	0.47	0.00
Sponge spicules	0.00	0.00	0.00	0.00	0.28	0.00
Indet silica forms	0.00	0.00	0.00	0.00	0.09	5.45
Parenchyma	0.00	0.00	0.71	0.00	0.00	0.00
TOTAL	100.00	100.00	100.00	100.00	100.00	100.00

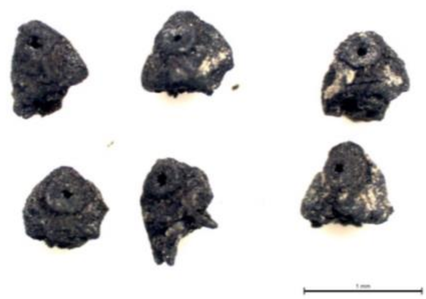
Appendix 3. Archaeobotanical remains from Baiyangcun.

Crops- rice

T2(20) *Oryza sativa*

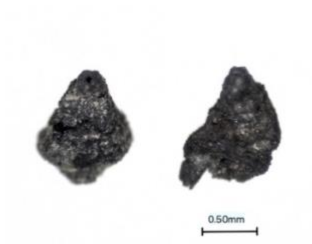
T2(20) *Oryza* sp.-grain embryo remains

F7(2) *Oryza* spikelet bases
Domesticated type 1 (ripped scar)



F7(2) *Oryza* spikelet bases
domesticated type 2 (semi-ripped scar)

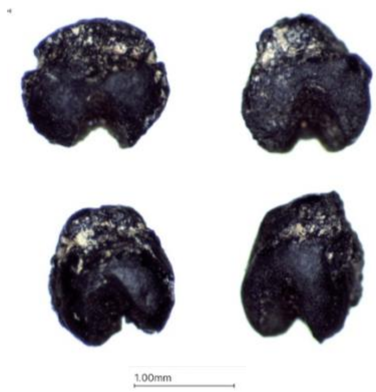
F7(2) *Oryza* sp. spikelet bases
Wild type



H73 *Oryza* spikelet bases
Immature type

Appendix 3. Archaeobotanical remains from Baiyangcun.

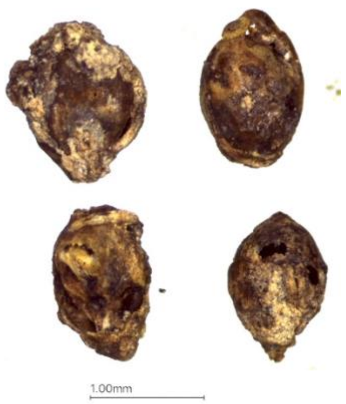
Crops- millets



T2(20) *Setaria italica*

T2(20) *Setaria italica*
immature grain

T2(20) *Panicum miliaceum*



T2(23) *Setaria italica*
Mineralised grains

T2(23) *Panicum miliaceum*
Mineralised grain

Appendix 3. Archaeobotanical remains from Baiyangcun.

Pulses

T1(10)s5 *Glycine* cf *soja*

H67 Glycine cf soja

F5 *Glycine*cf *soja*
immature

F7(1) Small indet. legume,
immature

F13 *Vigna* cf. outside view

F13 *Vigna* cf. inside view

Appendix 3. Archaeobotanical remains from Baiyangcun.

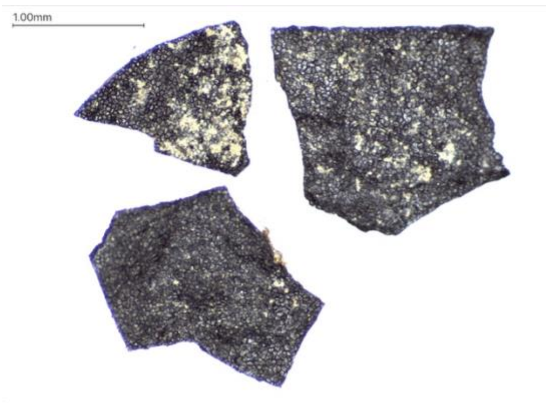
H72 *Cajanus* sp.

H72 *Cajanus* sp.
Hilum view

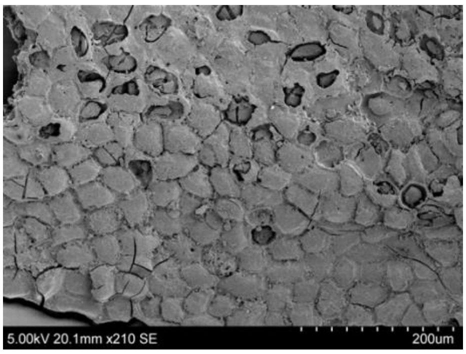
H118 *Cajanus* sp.

H47(3) *Cajanus* sp.

Nuts



T2(6) *Euryale ferox*
fragments



T2(6) *Euryale ferox*
SEM image

Appendix 3. Archaeobotanical remains from Baiyangcun.

HD1 Acorn type A

HD1 Acorn type B

Fruits

T2(23) *Cucumis* cf. *melo* mineralized

T1(14)c Cucurbitaceae indet.

T2(21)s2 *Crataegus* sp.

HT8(2) *Vitis* sp.

Appendix 3. Archaeobotanical remains from Baiyangcun.

Echinochloa remains

T2(23) *Echinochloa* sp.
mineralized

T2(20) *Echinochloa* sp.
with immature seeds

Seeds of field weeds

H118 *Setaria viridis*

T1(13)s3 *Setaria verticillata*

T2(6) *Digitaria* sp.
charred

T2(23) *Digitaria* sp.
mineralized

Appendix 3. Archaeobotanical remains from Baiyangcun.

T1(10) *Chenopodium* sp.

T2(23) *Chenopodium* sp.
mineralized

T2:23 *Eragrostis* sp.
mineralized

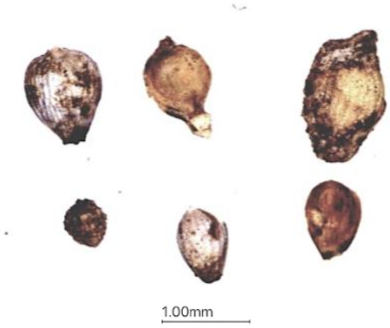
T1:8- s4 *Poa* sp.

T2(23) *Stachys/ Mosla* cf.
mineralized

T1(14)c s4 *Cyperus* sp.

Appendix 3. Archaeobotanical remains from Baiyangcun.

T1(14)c s4 *Fimbristylus* sp.
charred



T2(23) *Fimbristylus* sp.
mineralized

T2(3)d s2 *Schoenoplectus* sp.

T2(23) *Scirpus* sp.
mineralized

T1:13-s3 *Polygonum* cf. *persicaria*

T2(3)d s2 *Polygonum* sp.

Appendix 3. Archaeobotanical remains from Baiyangcun.

F13 Labiatae

F13 Malvaceae

F13 *Portulaca* sp.

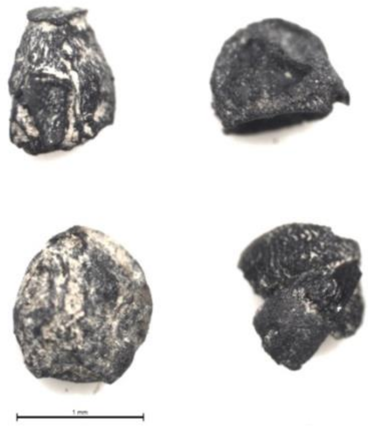
Unidentified remains

F13

F13

Appendix 3. Archaeobotanical remains from Baiyangcun.

F13

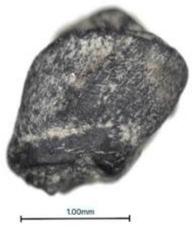


F7(2)

H67

H67

H67



H70

Appendix 3. Archaeobotanical remains from Baiyangcun.

H72

H72

H72

H84

H103

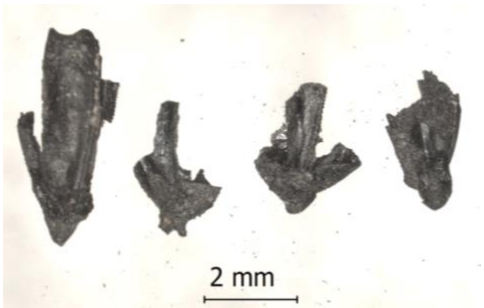
H103

Appendix 3. Archaeobotanical remains from Haimenkou.

Crops

JHDT1003(8) *Oryza sativa*

JHDT1204(6) *Oryza sativa*



JHDT1304(5) *Oryza sativa* spikelet bases

JHDT1204(6) *Panicum miliaceum*

JHDT1304(5) *Setaria italica* dehusked

JHDT1204(6) *Setaria italica*

Appendix 3. Archaeobotanical remains from Haimenkou.

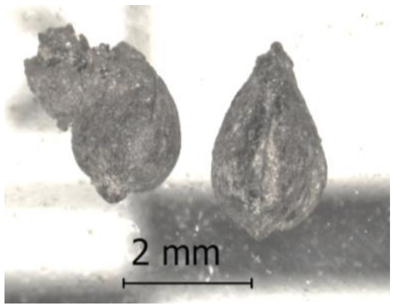
JHDT1204(6) *Triticum aestivum*

JHDT1204(6) *Hordeum vulgare*

JHDT1204(6)
T. aestivum (left) and *H. vulgare* (right)
rachises
side view

JHDT1204(6)
T. aestivum (left) and *H. vulgare* (right)
rachises
Frontal view

JHAT2003(6)s5 *Chenopodium* sp.



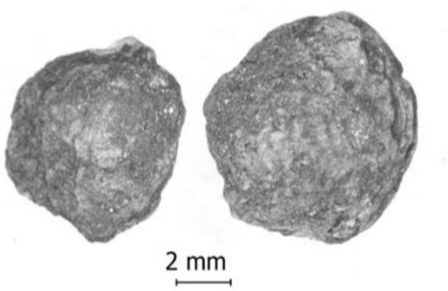
Fagopyrum cf *esculentum*

Appendix 3. Archaeobotanical remains from Haimenkou.

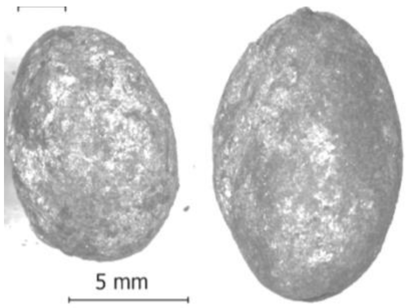
Other economic species

JHDT1204(6) *Cannabis* sp.

JHAT2004(6) *Glycine max*



JHDT1204(6) *Prunus* cf. *armeniaca*



JHAT2003(6) s5 *Prunus* cf *mume*

JHDT1204(6) *Prunus* cf. *persica*

JHDT1304-z1 Cucurbitaceae indet.

Appendix 3. Archaeobotanical remains from Haimenkou.

JHDT1304 z1 Acorn indet.

Seeds of field weeds

JHDT1004(4) *Najas* sp.

JHAT2006(5) *Polygonum* cf *persicaria*

JHDT1204(6) *Butomus* sp.

JHDT1003(7) *Polygonum* sp.

Appendix 3. Archaeobotanical remains from Haimenkou.

JHAT2004(6) *Carex* sp.

JHDT1003(8) *Setaria viridis*

JHDT1304-z1 *Galeopsis* sp.

JHDT1304(5) *Perilla* sp.

Unidentified remains

JHDT1304(5)

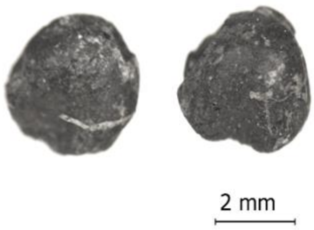
JHDT1304(5)

Appendix 3. Archaeobotanical remains from Dayingzhuang.

Crops

H11 *Oryza sativa*

H33 *Setaria italica*



Hedao 1 *Panicum miliaceum*

Hedao 1 *Hordeum vulgare*

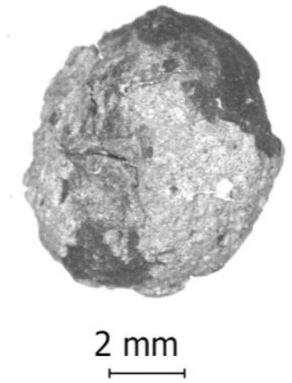
Hedao 1 *Triticum aestivum*

Hedao 1 *Triticum aestivum*
Husk still attached to grain

Appendix 3. Archaeobotanical remains from Dayingzhuang.

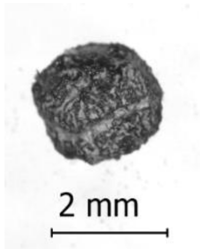
Other economic species

Layer 5 *Castanea* cf.
Inside view

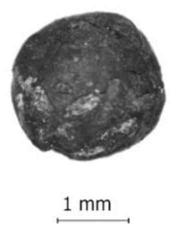


Layer 5 *Castanea* cf.
Outside view

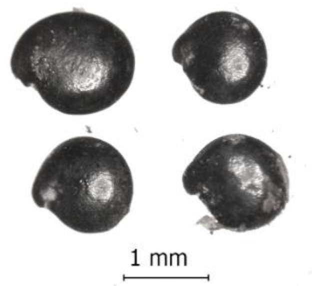
H11 Indet. nut remain



H8 *Zanthoxylum* sp.



H33 *Vicia* sp.



H11 *Chenopodium* sp.

Appendix 4. Morphometric measurements on main species.

All measurements are in mm, unless otherwise stated.

BAIYANGCUN				*Oryza sativa*			
No.	Site	Context	Period	Length	Width	Thickness	L/W mm
1	2013YBB	F11 S1	1	5.88	3.48	2.53	1.6896552
2	2013YBB	F11 S1	1	6.12	4.14	3.15	1.4782609
3	2013YBB	F11 S1	1	6.69	3.06	1.98	2.1862745
4	2013YBB	F11 S1	1	5.51	3.34	2.76	1.6497006
5	2013YBB	F11 S1	1	5.34	3.38	2.54	1.5798817
6	2013YBB	F11 S1	1	6.02	3.38	2.45	1.7810651
7	2013YBB	F11 S1	1	5.84	3.89	2.62	1.5012853
8	2013YBB	F11 S1	1	5.73	3.38	2.4	1.6952663
9	2013YBB	F11 S1	1	6.07	4.31	2.73	1.4083527
10	2013YBB	F11BENEATH S1	1	5.99	3.77	2.49	1.5888594
11	2013YBB	F11BENEATH S1	1	6.69	3.14	2.51	2.1305732
12	2013YBB	F11BENEATH S1	1	6.16	4.34	2.84	1.4193548
13	2013YBB	F11BENEATH S1	1	6.1	3.3	2.55	1.8484848
14	2013YBB	F11BENEATH S1	1	5.71	4.22	3.12	1.3530806
15	2013YBB	F11BENEATH S1	1	6.09	3.85	2.76	1.5818182
16	2013YBB	F11BENEATH S1	1	5.65	3.78	2.59	1.494709
17	2013YBB	F11BENEATH S1	1	6.42	3.64	2.63	1.7637363
18	2013YBB	F11BENEATH S1	1	6.39	4.03	2.51	1.5856079
19	2013YBB	F11BENEATH S1	1	5.85	3.25	2.26	1.8
20	2013YBB	F11BENEATH S1	1	5.98	3.94	2.59	1.5177665
21	2013YBB	F11BENEATH S1	1	5.95	3.37	2.24	1.7655786
22	2013YBB	F11BENEATH S1	1	6.47	3.87	2.63	1.6718346
23	2013YBB	F11BENEATH S1	1	5.98	3.57	2.27	1.67507
24	2013YBB	F11BENEATH S1	1	5.84	3.85	3.16	1.5168831
25	2013YBB	F11BENEATH S1	1	6.81	2.99	2.14	2.277592
26	2013YBB	F11BENEATH S1	1	6.14	3.35	2.32	1.8328358
27	2013YBB	F11BENEATH S1	1	5.92	4.02	2.87	1.4726368
28	2013YBB	F11BENEATH S1	1	6.59	3.23	2.29	2.0402477
29	2013YBB	F11BENEATH S1	1	5.78	3.57	2.14	1.6190476
30	2013YBB	F12	1	4.92	2.63	1.96	1.8707224
31	2013YBB	F12	1	5.82	3.46	2.17	1.6820809
32	2013YBB	F12	1	5.74	2.71	2.26	2.1180812
33	2013YBB	F12	1	6.01	2.91	2.33	2.0652921
34	2013YBB	F12	1	5.44	3.55	2.35	1.5323944
35	2013YBB	F12	1	6.7	2.91	2.26	2.3024055
36	2013YBB	F12	1	5.99	3.5	2.94	1.7114286
37	2013YBB	F12	1	5.58	2.98	2.39	1.8724832
38	2013YBB	F12	1	6.44	3.74	2.37	1.7219251
39	2013YBB	F12	1	5.22	3.4	2.4	1.5352941
40	2013YBB	F12	1	7.49	3.58	2.52	2.0921788
41	2013YBB	F12	1	6.56	3.71	2.87	1.7681941
42	2013YBB	F14	1	5.56	2.7	2.25	2.0592593
43	2013YBB	F14	1	5.23	3.5	2.71	1.4942857

Appendix 4. Morphometric measurements on main species.

All measurements are in mm, unless otherwise stated.

BAIYANGCUN				*Oryza sativa*			
No.	Site	Context	Period	Length	Width	Thickness	L/W mm
44	2013YBB	H167	1	5.87	3.23	2.75	1.8173375
45	2013YBB	H167	1	6.55	3.32	2.18	1.9728916
46	2013YBB	H168-1	1	5.67	2.67	2	2.1235955
47	2013YBB	H168-1	1	5.52	3.58	2.39	1.5418994
48	2013YBB	H168-1	1	6.52	1.37	2.84	4.7591241
49	2013YBB	H168-1	1	5.44	2.35	1.61	2.3148936
50	2013YBB	H168-1	1	5.92	3.08	2.3	1.9220779
51	2013YBB	H168-1	1	5.42	3.12	2.9	1.7371795
52	2013YBB	H168-1	1	6.55	3.95	2.14	1.6582278
53	2013YBB	H185	1	4.96	2.37	1.8	2.092827
54	2013YBB	H185	1	5.99	3.67	2.97	1.6321526
55	2013YBB	H185	1	5.71	4.08	2.24	1.3995098
56	2013YBB	H193	1	6.36	3.85	3.01	1.6519481
57	2013YBB	H193	1	5.69	2.88	1.84	1.9756944
58	2013YBB	H193	1	5.37	3.14	2.47	1.7101911
59	2013YBB	H193	1	5.45	3.27	2.6	1.6666667
60	2013YBB	H212	1	5.65	2.8	2.23	2.0178571
61	2013YBB	H212	1	5.24	3.61	2.71	1.4515235
62	2013YBB	H239	1	5.41	3.74	2.47	1.4465241
63	2013YBB	H239	1	5.82	3.3	2.72	1.7636364
64	2013YBB	H239	1	5.09	2.89	2.09	1.7612457
65	2013YBB	H239	1	5.86	3.06	2.27	1.9150327
66	2013YBB	H239	1	5.93	3.64	2.48	1.6291209
67	2013YBB	H239	1	6.27	4.22	2.61	1.485782
68	2013YBB	T1 16 S2	1	6.12	4.1	2.56	1.4926829
69	2013YBB	T1 16 S2	1	5.73	3.58	2.58	1.6005587
70	2013YBB	T1 16 S2	1	6.3	3.53	2.05	1.7847025
71	2013YBB	T1 16 S2	1	5.86	3.21	2.75	1.8255452
72	2013YBB	T1 16 S2	1	6.02	3.74	2.35	1.6096257
73	2013YBB	T1 16 S2	1	5.57	2.49	1.86	2.2369478
74	2013YBB	T1 17 S3	1	5.41	3.55	2.59	1.5239437
75	2013YBB	T1 17 S4	1	6.26	3.98	2.71	1.5728643
76	2013YBB	T1 17 S4	1	6.84	4.29	3.09	1.5944056
77	2013YBB	T1 17 S4	1	5.45	3.08	2.47	1.7694805
78	2013YBB	T1 17 S4	1	5.15	2.43	1.96	2.1193416
79	2013YBB	T1 18	1	6.13	3.58	2.51	1.7122905
80	2013YBB	T1 20	1	5.72	3.78	2.98	1.5132275
81	2013YBB	T1 20	1	5.75	3.72	2.8	1.5456989
82	2013YBB	T1 20	1	5.9	2.84	2.43	2.0774648
83	2013YBB	T1 20	1	5.72	3.53	2.46	1.6203966
84	2013YBB	T1 20	1	5.83	2.71	2.43	2.1512915
85	2013YBB	T1 20	1	5.29	3.57	2.67	1.4817927
86	2013YBB	T1 20 FLOOR	1	7.13	3.29	2.55	2.1671733

Appendix 4. Morphometric measurements on main species.

All measurements are in mm, unless otherwise stated.

BAIYANGCUN				*Oryza sativa*			
No.	Site	Context	Period	Length	Width	Thickness	L/W mm
87	2013YBB	T1 20 FLOOR	1	6.14	4.06	3.02	1.5123153
88	2013YBB	T1 20 FLOOR	1	6.2	3.71	2.98	1.671159
89	2013YBB	T1 20 FLOOR	1	5.35	3.62	2.76	1.4779006
90	2013YBB	T1 20 FLOOR	1	6.42	4.29	2.78	1.4965035
91	2013YBB	T1 20 FLOOR	1	6.86	3.29	2.24	2.0851064
92	2013YBB	T1 20 FLOOR	1	5.95	4.07	2.71	1.4619165
93	2013YBB	T1 20 FLOOR	1	5.85	3.7	2.55	1.5810811
94	2013YBB	T1 20 FLOOR	1	6.06	4.24	1.86	1.4292453
95	2013YBB	T1 20 FLOOR	1	6.95	3.49	2.14	1.991404
96	2013YBB	T1 20 FLOOR	1	5.87	3.33	2.58	1.7627628
97	2013YBB	T1 20 FLOOR	1	5.92	3.78	2.35	1.5661376
98	2013YBB	T1 20 FLOOR	1	5.7	3.57	2.7	1.5966387
99	2013YBB	T1 20 FLOOR	1	6.31	4.09	2.91	1.5427873
100	2013YBB	T1 20 FLOOR	1	5.75	3.39	2.47	1.6961652
101	2013YBB	T1 20 FLOOR	1	6.27	3.9	3.09	1.6076923
102	2013YBB	T1 20 FLOOR	1	5.63	4.11	2.58	1.3698297
103	2013YBB	T1 20 FLOOR	1	6.4	3.66	2.67	1.7486339
104	2013YBB	T1 20 FLOOR	1	5.94	3.66	2.66	1.6229508
105	2013YBB	T1 20 FLOOR	1	5.84	3.82	2.76	1.5287958
106	2013YBB	T1 21	1	5.89	3.68	2.73	1.6005435
107	2013YBB	T1 21	1	5.62	3.81	2.44	1.4750656
108	2013YBB	T1 21	1	6.55	4.14	2.89	1.5821256
109	2013YBB	T1 21	1	6.33	4.04	2.9	1.5668317
110	2013YBB	T1 21	1	5.16	3.54	2.54	1.4576271
111	2013YBB	T1 21	1	5.67	3.78	2.63	1.5
112	2013YBB	T1 21	1	5.79	3.3	2.48	1.7545455
113	2013YBB	T1 21	1	5.9	2.59	1.8	2.2779923
114	2013YBB	T1 21	1	5.9	3.71	2.69	1.5902965
115	2013YBB	T1 21	1	5.01	3.65	2.62	1.3726027
116	2013YBB	T1 21	1	5.78	4.18	3.13	1.3827751
117	2013YBB	T1 21	1	4.97	3.37	2.59	1.4747774
118	2013YBB	T1 22	1	5.73	3.12	2.16	1.8365385
119	2013YBB	T1 22	1	4.92	3.15	2.33	1.5619048
120	2013YBB	T1 22	1	5.39	3.61	2.52	1.4930748
121	2013YBB	T1 22	1	5.85	3.29	2.46	1.7781155
122	2013YBB	T1 22	1	5.2	3.55	2.67	1.4647887
123	2013YBB	T1 22	1	6.49	3.57	2.83	1.8179272
124	2013YBB	T1 22	1	5.57	3.86	2.64	1.4430052
125	2013YBB	T1 22	1	5.36	3.39	2.29	1.5811209
126	2013YBB	HTD8-2	1	7.2	4.76	2.75	1.512605
127	2013YBB	HTD8-2	1	6.47	4.3	2.92	1.5046512
128	2013YBB	HTD8-2	1	5.79	4.1	2.78	1.4121951
129	2013YBB	HTD8-2	1	6.17	3.85	2.67	1.6025974

Appendix 4. Morphometric measurements on main species.

All measurements are in mm, unless otherwise stated.

BAIYANGCUN				*Oryza sativa*			
No.	Site	Context	Period	Length	Width	Thickness	L/W mm
130	2013YBB	HTD8-2	1	5.54	3.53	2.58	1.5694051
131	2013YBB	HTD8-2	1	5.83	3.88	2.8	1.5025773
132	2013YBB	HTD8-2	1	6.27	2.91	2.22	2.1546392
133	2013YBB	HTD8-2	1	5.73	3.28	2.46	1.7469512
134	2013YBB	HTD8-2	1	5.33	3.8	2.78	1.4026316
135	2013YBB	HTD8-2	1	6.24	4.29	2.99	1.4545455
136	2013YBB	HTD8-2	1	5.83	3.94	2.5	1.4796954
137	2013YBB	HTD8-2	1	5.58	4.04	2.48	1.3811881
138	2013YBB	HTD8-2	1	6.33	3.23	2.33	1.9597523
139	2013YBB	HTD8-2	1	6.26	3.49	2.37	1.7936963
140	2013YBB	HTD8-2	1	5.33	4.1	2.59	1.3
141	2013YBB	HTD8-2	1	5.28	3.78	2.53	1.3968254
142	2013YBB	HTD8-2	1	5.39	4	2.77	1.3475
143	2013YBB	HTD8-2	1	6.01	4.22	2.79	1.4241706
144	2013YBB	HTD8-2	1	5.65	3.06	2.17	1.8464052
145	2013YBB	HTD8-2	1	5.57	3.78	2.52	1.473545
146	2013YBB	HTD8-3	1	6.06	4.16	2.76	1.4567308
147	2013YBB	HTD8-3	1	5.86	3.37	2.27	1.7388724
148	2013YBB	HTD8-3	1	5.27	3.39	2.51	1.5545723
149	2013YBB	HTD8-3	1	6.17	3.81	2.78	1.6194226
150	2013YBB	HTD8-3	1	5.36	3.36	2.52	1.5952381
151	2013YBB	HTD8-3	1	5.62	3.4	2.05	1.6529412
152	2013YBB	HTD8-3	1	5.45	3.27	2.46	1.6666667
153	2013YBB	HTD8-3	1	5.13	3.01	2.1	1.7043189
154	2013YBB	H125	2	5.55	3.41	2.35	1.627566
155	2013YBB	H125	2	6.4	3.15	2.39	2.031746
156	2013YBB	H125	2	6.25	4.22	2.83	1.4810427
157	2013YBB	H125	2	6.44	3.59	2.75	1.7938719
158	2013YBB	H125	2	5.49	3.53	2.51	1.5552408
159	2013YBB	H125	2	6.39	4.29	2.84	1.4895105
160	2013YBB	H125	2	6.51	3.52	2.64	1.8494318
161	2013YBB	H125	2	5.57	3.65	2.8	1.5260274
162	2013YBB	H125	2	6.06	4.21	2.92	1.4394299
163	2013YBB	H125	2	6.02	3.39	2.44	1.7758112
164	2013YBB	H125	2	6.26	4.03	2.92	1.5533499
165	2013YBB	H125	2	5.8	3.77	2.64	1.5384615
166	2013YBB	H125	2	5.54	3.67	2.93	1.5095368
167	2013YBB	H125	2	6.18	3.68	2.8	1.6793478
168	2013YBB	H125	2	6.01	3.37	2.56	1.7833828
169	2013YBB	H125	2	6.01	3.82	2.81	1.5732984
170	2013YBB	F6	2	4.8	3.57	2.41	1.3445378
171	2013YBB	F6	2	4.71	3.27	2.48	1.440367
172	2013YBB	F7 EAST	2	5.73	3.41	2.31	1.6803519

Appendix 4. Morphometric measurements on main species.

All measurements are in mm, unless otherwise stated.

BAIYANGCUN				*Oryza sativa*			
No.	Site	Context	Period	Length	Width	Thickness	L/W mm
173	2013YBB	F7 EAST	2	5.02	2.88	2.56	1.7430556
174	2013YBB	F7-1	2	4.99	4.09	2.63	1.2200489
175	2013YBB	F7-1	2	5.28	3.61	2.76	1.4626039
176	2013YBB	F7-1	2	4.88	2.6	1.77	1.8769231
177	2013YBB	F7-1	2	5.29	3.21	2.27	1.6479751
178	2013YBB	F7-2	2	6.07	3.7	2.53	1.6405405
179	2013YBB	F7-2	2	5.99	3.5	2.43	1.7114286
180	2013YBB	F7-2	2	5.94	2.88	2.35	2.0625
181	2013YBB	F7-2	2	4.47	2.31	1.9	1.9350649
182	2013YBB	F7-2	2	4.84	2.59	1.57	1.8687259
183	2013YBB	H103	2	5.5	3.29	2.92	1.6717325
184	2013YBB	H103	2	6.56	3.57	2.49	1.837535
185	2013YBB	H103	2	5.94	3.09	2.33	1.9223301
186	2013YBB	H103	2	5.8	2.98	2.52	1.9463087
187	2013YBB	H103	2	6.26	3.13	2.35	2
188	2013YBB	H103	2	6.56	4.32	3.92	1.5185185
189	2013YBB	H117	2	5.95	3.1	2.51	1.9193548
190	2013YBB	H117	2	6.06	4.1	2.84	1.4780488
191	2013YBB	H117	2	5.63	2.97	2.05	1.8956229
192	2013YBB	H117	2	5.49	3.12	2.38	1.7596154
193	2013YBB	H117	2	4.55	3.41	2.76	1.3343109
194	2013YBB	H117	2	5.24	3.65	2.34	1.4356164
195	2013YBB	H117	2	6.11	1.37	2.63	4.459854
196	2013YBB	H117	2	5.66	3.51	2.53	1.6125356
197	2013YBB	H117	2	4.91	3.27	2.61	1.5015291
198	2013YBB	H117	2	6.03	4.24	2.83	1.4221698
199	2013YBB	H117	2	6.63	4.06	3.03	1.6330049
200	2013YBB	H117	2	5.69	4.07	2.82	1.3980344
201	2013YBB	H117	2	6.22	3.55	2.95	1.7521127
202	2013YBB	H117	2	4.96	3.2	2.27	1.55
203	2013YBB	H121	2	6.39	3.52	2.31	1.8153409
204	2013YBB	H121	2	5.25	3.33	2.34	1.5765766
205	2013YBB	H121	2	5.36	3.08	2.22	1.7402597
206	2013YBB	H121	2	6.05	3.75	3.04	1.6133333
207	2013YBB	H121	2	6.27	3.89	2.76	1.6118252
208	2013YBB	H121	2	4.67	2.71	1.87	1.7232472
209	2013YBB	H121	2	5.75	3.2	2.19	1.796875
210	2013YBB	H121	2	5.78	2.55	2.08	2.2666667
211	2013YBB	H121	2	5.66	3.41	2.81	1.659824
212	2013YBB	H121	2	5.24	3.49	2.74	1.5014327
213	2013YBB	H123	2	6.22	4.1	2.7	1.5170732
214	2013YBB	H123	2	6.69	4.19	2.23	1.5966587
215	2013YBB	H123	2	4.76	2.84	2.39	1.6760563

Appendix 4. Morphometric measurements on main species.

All measurements are in mm, unless otherwise stated.

BAIYANGCUN				*Oryza sativa*			
No.	Site	Context	Period	Length	Width	Thickness	L/W mm
216	2013YBB	H123	2	5.57	3.66	2.75	1.5218579
217	2013YBB	H123	2	5.33	3.29	2.74	1.6200608
218	2013YBB	H123	2	5.35	3.98	2.39	1.3442211
219	2013YBB	H123	2	5.38	4.08	2.63	1.3186275
220	2013YBB	H123	2	6.55	3.41	2.78	1.9208211
221	2013YBB	H123	2	6.14	3.4	2.76	1.8058824
222	2013YBB	H123	2	5.39	3.15	2.22	1.7111111
223	2013YBB	H123	2	5.03	2.46	1.98	2.0447154
224	2013YBB	H123	2	4.97	3.22	2.32	1.5434783
225	2013YBB	H123	2	6.31	3.37	2.49	1.8724036
226	2013YBB	H123	2	5.45	3.54	2.68	1.539548
227	2013YBB	H123	2	6.58	3.69	2.92	1.7831978
228	2013YBB	H123	2	5.13	2.92	2.76	1.7568493
229	2013YBB	H123	2	6.25	3	2.4	2.0833333
230	2013YBB	H129	2	5.94	3.11	2.43	1.9099678
231	2013YBB	H129	2	6.61	3.39	2.61	1.9498525
232	2013YBB	H129	2	4.95	2.93	2.51	1.6894198
233	2013YBB	H129	2	5.22	4.01	2.76	1.3017456
234	2013YBB	H129	2	5.85	3.82	2.79	1.5314136
235	2013YBB	H129	2	5.92	3.59	3	1.6490251
236	2013YBB	H129	2	5.52	2.98	2.28	1.852349
237	2013YBB	H129	2	6.87	3.09	2.24	2.223301
238	2013YBB	H129	2	5.8	3.42	2.64	1.6959064
239	2013YBB	H129	2	5.81	2.7	2.52	2.1518519
240	2013YBB	H129	2	5.99	2.88	2.71	2.0798611
241	2013YBB	H129	2	6.18	2.51	2.34	2.4621514
242	2013YBB	H129	2	6.01	2.71	1.78	2.2177122
243	2013YBB	H129	2	5.49	3.35	2.47	1.638806
244	2013YBB	H129	2	5.61	3.2	2.43	1.753125
245	2013YBB	H132	2	5.58	3.51	2.47	1.5897436
246	2013YBB	H132	2	5.41	3.34	2.39	1.6197605
247	2013YBB	H132	2	4.59	2.96	2.36	1.5506757
248	2013YBB	H132	2	5.21	3.14	2.74	1.6592357
249	2013YBB	H132	2	5.45	3.04	2.55	1.7927632
250	2013YBB	H132	2	5.72	2.25	1.7	2.5422222
251	2013YBB	H132	2	7.16	3.81	2.92	1.8792651
252	2013YBB	H132	2	5.38	2.34	2.09	2.2991453
253	2013YBB	H132	2	5.71	2.69	2.24	2.1226766
254	2013YBB	H132	2	5.89	3.15	2.64	1.8698413
255	2013YBB	H132	2	6.67	3.61	2.41	1.8476454
256	2013YBB	H132	2	5.2	2.94	2.63	1.7687075
257	2013YBB	H132	2	5.3	2.9	2.08	1.8275862
258	2013YBB	H136	2	5.9	3.9	3.21	1.5128205

Appendix 4. Morphometric measurements on main species.

All measurements are in mm, unless otherwise stated.

BAIYANGCUN				*Oryza sativa*			
No.	Site	Context	Period	Length	Width	Thickness	L/W mm
259	2013YBB	H136	2	5.31	2.98	2.61	1.7818792
260	2013YBB	H136	2	6.1	3.82	2.8	1.5968586
261	2013YBB	H136	2	6.22	3.42	2.57	1.8187135
262	2013YBB	H136	2	6.23	3.18	2.59	1.9591195
263	2013YBB	H136	2	6.07	3.82	2.7	1.5890052
264	2013YBB	H136	2	5.69	3.03	2.39	1.8778878
265	2013YBB	H136	2	6.11	3.16	2.76	1.9335443
266	2013YBB	H136	2	5.86	3.26	2.46	1.797546
267	2013YBB	H136	2	5.67	3.75	2.68	1.512
268	2013YBB	H136	2	5.25	3.39	2.48	1.5486726
269	2013YBB	H136	2	4.88	3.16	2.51	1.5443038
270	2013YBB	H136	2	5.08	3.36	2.47	1.5119048
271	2013YBB	H147	2	6.22	3.19	2.68	1.9498433
272	2013YBB	H147	2	6.98	1.22	2.47	5.7213115
273	2013YBB	H236	2	6.04	3.5	2.55	1.7257143
274	2013YBB	H236	2	5.12	2.63	1.98	1.9467681
275	2013YBB	H236	2	5.84	3.09	2.15	1.8899676
276	2013YBB	H84	2	4.92	2.23	1.87	2.206278
277	2013YBB	H84	2	5.69	3.31	2.32	1.7190332
278	2013YBB	H84	2	5.54	3.35	1.91	1.6537313
279	2013YBB	H84	2	6.16	3.03	2.35	2.0330033
280	2013YBB	H84	2	5.71	2.97	2.26	1.9225589
281	2013YBB	H84	2	5.57	3.11	2.21	1.7909968
282	2013YBB	H89	2	5.24	3	2.88	1.7466667
283	2013YBB	H89	2	5.08	2.68	1.58	1.8955224
284	2013YBB	H89	2	5.22	3.23	2.41	1.6160991
285	2013YBB	H89	2	5.12	3.29	2.9	1.556231
286	2013YBB	H89	2	6.31	4.01	2.71	1.5735661
287	2013YBB	H89	2	4.92	3.1	1.65	1.5870968
288	2013YBB	H89	2	4.54	2.54	3.2	1.7874016
289	2013YBB	H89	2	4.26	2.14	2.43	1.9906542
290	2013YBB	H89	2	4.67	3.29	2.6	1.4194529
291	2013YBB	H89	2	4.54	2.13	1.38	2.1314554
292	2013YBB	H89	2	3.91	1.96	1.23	1.994898
293	2013YBB	H99	2	5.85	3.26	2.41	1.7944785
294	2013YBB	H99	2	4.66	2.9	2.25	1.6068966
295	2013YBB	H99	2	4.95	2.44	1.98	2.0286885
296	2013YBB	HD1-1	2	5.78	3.03	2.58	1.9075908
297	2013YBB	HD1-1	2	4.95	3.75	2.69	1.32
298	2013YBB	HD1-1	2	5.14	3.34	2.72	1.5389222
299	2013YBB	HD1-1	2	5.14	3.18	2.58	1.6163522
300	2013YBB	HD1-1	2	5.57	4.36	2.86	1.2775229
301	2013YBB	HD1-1	2	5.34	4.03	2.93	1.325062

Appendix 4. Morphometric measurements on main species.

All measurements are in mm, unless otherwise stated.

BAIYANGCUN				*Oryza sativa*			
No.	Site	Context	Period	Length	Width	Thickness	L/W mm
302	2013YBB	HD2-2	2	6	2.8	2.69	2.1428571
303	2013YBB	HD2-2	2	6	3.64	2.88	1.6483516
304	2013YBB	HD2-2	2	5.29	3.12	2.7	1.6955128
305	2013YBB	HD2-2	2	5.34	2.98	2.47	1.7919463
306	2013YBB	HD2-2	2	6.57	3.86	2.55	1.7020725
307	2013YBB	HD2-2	2	5.04	3.26	2.62	1.5460123
308	2013YBB	HD2-2	2	4.91	2.73	2.14	1.7985348
309	2013YBB	HD6-2	2	5.21	3.23	2.75	1.6130031
310	2013YBB	HD6-2	2	5.43	2.86	1.93	1.8986014
311	2013YBB	HD6-2	2	5.04	3.69	2.62	1.3658537
312	2013YBB	HD6-2	2	5.6	3.01	2.15	1.8604651
313	2013YBB	HD6-2	2	5.73	3.91	3.11	1.4654731
314	2013YBB	HD6-2	2	5.91	3.57	2.63	1.6554622
315	2013YBB	HD6-2	2	5.05	3.63	2.46	1.3911846
316	2013YBB	HD6-2	2	6.48	4.21	2.74	1.5391924
317	2013YBB	HD6-2	2	5.78	3.61	2.9	1.601108
318	2013YBB	HD6-4	2	5.65	3.94	3	1.4340102
319	2013YBB	HD6-4	2	4.56	2.56	1.71	1.78125
320	2013YBB	HD6-4	2	5.65	3.26	2.84	1.7331288
321	2013YBB	HD6-4	2	4.96	2.51	2.56	1.9760956
322	2013YBB	T1 8 S4	2	4.69	2.11	1.86	2.2227488
323	2013YBB	T1-10	2	6.2	3.38	2.48	1.8343195
324	2013YBB	T1-10	2	6.43	3.55	2.67	1.8112676
325	2013YBB	T1-10	2	2.58	1.47	1.27	1.755102
326	2013YBB	T1-10	2	2.84	1.99	1.37	1.4271357
327	2013YBB	T1-10	2	3.06	1.63	1.07	1.8773006
328	2013YBB	T1-10	2	2.47	1.52	1	1.625
329	2013YBB	T1-10	2	2.91	1.68	1.15	1.7321429
330	2013YBB	T1-10	2	3.12	2.1	1.4	1.4857143
331	2013YBB	T1-10	2	2.55	1.65	1.34	1.5454545
332	2013YBB	T1-10	2	2.74	1.61	1.29	1.7018634
333	2013YBB	T1-10	2	5.85	2.99	2.08	1.9565217
334	2013YBB	T1-10	2	5.85	3.68	2.26	1.5896739
335	2013YBB	T1-10	2	4.9	1.7	1	2.8823529
336	2013YBB	T1-10 S5	2	5.08	3.04	2.74	1.6710526
337	2013YBB	T1-10 S5	2	6.63	4.12	2.4	1.6092233
338	2013YBB	T1-10 S5	2	4.86	2.17	1.66	2.2396313
339	2013YBB	T1-11C S5	2	4.68	2.74	1.94	1.7080292
340	2013YBB	T1-12 S2	2	5.9	3.64	2.49	1.6208791
341	2013YBB	T1-12 S2	2	5.9	3.58	2.35	1.6480447
342	2013YBB	T1-12 S2	2	6.06	3.31	2.2	1.8308157
343	2013YBB	T1-12 S2	2	6.45	4.52	2.98	1.4269912
344	2013YBB	T1-12 S2	2	5.83	3.51	2.23	1.6609687

Appendix 4. Morphometric measurements on main species.

All measurements are in mm, unless otherwise stated.

BAIYANGCUN				*Oryza sativa*			
No.	Site	Context	Period	Length	Width	Thickness	L/W mm
345	2013YBB	T1-12 S2	2	5.93	3.32	2.18	1.7861446
346	2013YBB	T1-12 S2	2	6.37	3.59	2.56	1.7743733
347	2013YBB	T1-12 S2	2	6.35	4.09	2.71	1.5525672
348	2013YBB	T1-12 S2	2	6.12	4.06	3.12	1.5073892
349	2013YBB	T1-12B S2	2	5.45	4.01	2.47	1.3591022
350	2013YBB	T1-12B S2	2	5.34	3.53	2.41	1.5127479
351	2013YBB	T1-12B S2	2	5.47	2.96	2.07	1.847973
352	2013YBB	T1-13S S3	2	5.75	2.88	2.28	1.9965278
353	2013YBB	T1-13S S3	2	5.65	3.65	2.47	1.5479452
354	2013YBB	T1-13S S3	2	5.59	2.79	1.89	2.0035842
355	2013YBB	T1-13S S3	2	6.42	4.14	2.83	1.5507246
356	2013YBB	T1-14C S4	2	5.08	3.69	1.98	1.3766938
357	2013YBB	T1-14C S4	2	6.27	2.95	2.32	2.1254237
358	2013YBB	T1-14C S4	2	5.29	2.95	1.75	1.7932203
359	2013YBB	T1-14C S4	2	4.63	3.41	2.42	1.3577713
360	2013YBB	T1-14C S4	2	5.98	3.41	2.67	1.7536657
361	2013YBB	T1-15 S2	2	6.05	4.02	2.75	1.5049751
362	2013YBB	T1-15 S2	2	6.05	3.45	2.56	1.7536232
363	2013YBB	T1-15 S2	2	4.92	3.29	2.38	1.4954407
364	2013YBB	T1-15 S2	2	5.33	3.81	2.71	1.3989501
365	2013YBB	T1-15 S2	2	4.89	3.11	2.11	1.5723473
366	2013YBB	T1-15 S2	2	6.08	3.4	2.59	1.7882353
367	2013YBB	T1-15 S2	2	5.84	3.57	2.36	1.6358543
368	2013YBB	T1-15 S2	2	5.39	3.26	1.93	1.6533742
369	2013YBB	T1-15 S2	2	6.59	3.49	2.33	1.8882521
370	2013YBB	T1-15 S2	2	5.53	3.65	2.76	1.5150685
371	2013YBB	T1-15 S2	2	6.39	3.12	1.98	2.0480769
372	2013YBB	T1-15 S2	2	5.83	3.55	2.39	1.6422535
373	2013YBB	T1-15 S2	2	5.73	3.2	2.41	1.790625
374	2013YBB	T1-15 S2	2	6.43	3.18	2.55	2.0220126
375	2013YBB	T1-15 S2	2	6.08	3.53	2.48	1.7223796
376	2013YBB	T1-15 S2	2	5.98	4.14	2.82	1.4444444
377	2013YBB	T1-15 S2	2	4.69	2.11	1.74	2.2227488
378	2013YBB	T2-9B S2	2	4.47	2.54	1.41	1.7598425
379	2013YBB	T2-9B S2	2	4.48	2.22	1.44	2.018018
380	2013YBB	T2-9B S2	2	5.11	2.51	1.75	2.0358566
381	2013YBB	T2-9B S2	2	4.77	2.06	1.26	2.315534
382	2013YBB	T2-9B S2	2	5.03	2.51	1.45	2.0039841
383	2013YBB	T2-9B S2	2	4.88	2.14	1.27	2.2803738
384	2013YBB	T2-9B S2	2	4.28	2.22	1.46	1.9279279
385	2013YBB	T2-9B S2	2	4.86	1.73	1.24	2.8092486
386	2013YBB	T2-9B S2	2	4.7	1.94	1.21	2.4226804
387	2013YBB	T2-9B S2	2	5.45	2.41	1.79	2.2614108

Appendix 4. Morphometric measurements on main species.

All measurements are in mm, unless otherwise stated.

BAIYANGCUN				*Oryza sativa*			
No.	Site	Context	Period	Length	Width	Thickness	L/W mm
388	2013YBB	T2-9B S2	2	4.85	2.29	1.16	2.1179039
389	2013YBB	T2-9B S2	2	3.85	1.89	1.59	2.037037
390	2013YBB	T2-9B S2	2	5.21	2.74	2.1	1.9014599
391	2013YBB	T2-9B S2	2	5.45	3.29	2.25	1.656535
392	2013YBB	T2-9B S2	2	5.7	2.67	1.95	2.1348315
393	2013YBB	T2-9B S2	2	5.54	3.24	2.29	1.7098765
394	2013YBB	T2-9B S2	2	5.64	2.74	2.03	2.0583942
395	2013YBB	T2-9B S2	2	4.41	2.87	2.48	1.5365854
396	2013YBB	T2-9B S2	2	5.49	3.45	2.38	1.5913043
397	2013YBB	T2-9B S2	2	5.12	3.65	2.55	1.4027397
398	2013YBB	T2-9B S2	2	5.93	3.69	2.34	1.6070461
399	2013YBB	T2-9B S2	2	6.17	3.46	2.23	1.783237
400	2013YBB	T2-9B S2	2	6.37	3.64	2.5	1.75
401	2013YBB	T2-9B S2	2	5.37	3.39	2.71	1.5840708
402	2013YBB	T2-9B S2	2	5.37	3.97	2.53	1.3526448
403	2013YBB	T2-9B S2	2	6.65	3.86	2.56	1.7227979
404	2013YBB	T2-9B S2	2	5.4	3.45	2.25	1.5652174
405	2013YBB	T2-9B S2	2	5.83	4.06	2.35	1.4359606
406	2013YBB	T2-9B S2	2	6.84	3.39	2.48	2.0176991
407	2013YBB	T2-9B S2	2	5.07	3.45	1.93	1.4695652
408	2013YBB	T2-9B S2	2	5.22	3.03	2.21	1.7227723
409	2013YBB	T2-9B S2	2	6.24	3.58	2.56	1.7430168
410	2013YBB	T2-9B S2	2	4.89	3.04	2.23	1.6085526
411	2013YBB	T2-9B S2	2	5.78	3.14	2.07	1.8407643
412	2013YBB	T2-9B S3	2	5.59	3.85	2.23	1.4519481
413	2013YBB	T2-9B S3	2	5.37	3.17	2.72	1.6940063
414	2013YBB	T2-9B S3	2	6.1	3.84	2.45	1.5885417
415	2013YBB	F5-2	3	5.29	2.3	2.03	2.3
416	2013YBB	F5-2	3	5.08	3.08	2.34	1.6493506
417	2013YBB	F5-2	3	4.35	2.07	1.64	2.1014493
418	2013YBB	F5-2	3	4.61	1.93	1.69	2.388601
419	2013YBB	F5-2	3	3.97	1.91	1.48	2.078534
420	2013YBB	F5-2	3	4.21	1.93	1.31	2.1813472
421	2013YBB	H47	3	5.71	3.17	2.19	1.8012618
422	2013YBB	H47	3	4.91	2.14	1.69	2.2943925
423	2013YBB	H50	3	5.87	3.45	2.49	1.7014493
424	2013YBB	H50	3	5.57	3.64	2.39	1.5302198
425	2013YBB	H50	3	5.63	3.29	2.98	1.7112462
426	2013YBB	H50	3	6.33	3.37	2.43	1.8783383
427	2013YBB	H63	3	4.67	2.64	1.61	1.7689394
428	2013YBB	H63	3	4.83	3.34	2.24	1.4461078
429	2013YBB	H67	3	4.7	2.24	1.39	2.0982143

Appendix 4. Morphometric measurements on main species.

All measurements are in mm, unless otherwise stated.

BAIYANGCUN *Oryza sativa*		Length	Width	Thickness	L/W mm
	AVERAGE	5.6286	3.3057	2.4107	1.749401
	STDEV	0.7085	0.6109	0.4264	0.3759932

Appendix 4. Morphometric measurements on main species.
All measurements are in mm, unless otherwise stated.

BAIYANGCUN				*Setaria italica*			
No.	Site	Context	Period	Length	Width	Thickness	L/W mm
1	2013YBB	F12	1	1.43	1.15	1.51	1.24347826
2	2013YBB	F12	1	1.2	1.29	0.94	0.93023256
3	2013YBB	F12	1	1.34	1.15	1.13	1.16521739
4	2013YBB	F12	1	1.31	1.19	0.85	1.10084034
5	2013YBB	F12	1	1.1	1.01	0.66	1.08910891
6	2013YBB	F12	1	1.17	1.13	0.99	1.03539823
7	2013YBB	F12	1	1.27	1.27	0.94	1
8	2013YBB	F12	1	1.5	1.26	1.08	1.19047619
9	2013YBB	F12	1	1.14	1.07	0.85	1.06542056
10	2013YBB	F12	1	1.34	1.21	1.14	1.10743802
11	2013YBB	F12	1	1.39	1.21	1.2	1.14876033
12	2013YBB	F12	1	1.25	1.25	1.23	1
13	2013YBB	F12	1	1.19	1.16	1.07	1.02586207
14	2013YBB	F12	1	1.19	1.22	1.03	0.97540984
15	2013YBB	F12	1	1.42	1.49	1.21	0.95302013
16	2013YBB	F12	1	1.37	1.26	0.81	1.08730159
17	2013YBB	F12	1	1.46	1.3	0.97	1.12307692
18	2013YBB	F12	1	1.24	1.04	0.7	1.19230769
19	2013YBB	F14	1	1.2	1.03	1.22	1.16504854
20	2013YBB	F14	1	0.94	1.02	1.19	0.92156863
21	2013YBB	F14	1	1.07	1.15	1.08	0.93043478
22	2013YBB	F14	1	1	1.22	0.98	0.81967213
23	2013YBB	F14	1	1.28	1.12	0.82	1.14285714
24	2013YBB	F14	1	1.27	1.2	0.95	1.05833333
25	2013YBB	F14	1	1.14	1.24	1.16	0.91935484
26	2013YBB	F14	1	1.13	1.15	1.19	0.9826087
27	2013YBB	H129	2	1.18	1.32	1.12	0.89393939
28	2013YBB	H129	2	1.48	1.09	1.07	1.35779817
29	2013YBB	H129	2	1.37	1.27	1.01	1.07874016
30	2013YBB	H129	2	1.28	1.28	0.88	1
31	2013YBB	H129	2	1.2	1.17	0.84	1.02564103
32	2013YBB	H129	2	1.34	0.98	1	1.36734694
33	2013YBB	H129	2	1.25	1.01	1.26	1.23762376
34	2013YBB	H129	2	1.13	1.07	0.84	1.05607477
35	2013YBB	H129	2	1.29	0.98	0.81	1.31632653
36	2013YBB	H129	2	1.38	1.36	1.11	1.01470588
37	2013YBB	H129	2	1.54	1.17	1.08	1.31623932
38	2013YBB	H129	2	1.39	1.14	1.16	1.21929825
39	2013YBB	H129	2	1.39	1.28	1.16	1.0859375
40	2013YBB	H129	2	1.22	1.22	0.83	1

Appendix 4. Morphometric measurements on main species.

All measurements are in mm, unless otherwise stated.

BAIYANGCUN				*Setaria italica*			
No.	Site	Context	Period	Length	Width	Thickness	L/W mm
41	2013YBB	H129	2	1.27	1.17	1.05	1.08547009
42	2013YBB	H68-1	3	1.35	1.29	1.45	1.04651163
43	2013YBB	H68-1	3	1.17	1.17	1.04	1
44	2013YBB	H68-1	3	1.27	1.28	0.92	0.9921875
45	2013YBB	H68-1	3	1.4	1.38	1.06	1.01449275
46	2013YBB	H68-1	3	1.33	1.09	0.97	1.22018349
47	2013YBB	H68-1	3	1.19	1.25	1.11	0.952
48	2013YBB	H61	3	1.28	1.11	1.06	1.15315315
49	2013YBB	H61	3	1.24	1.07	1.06	1.1588785
50	2013YBB	H70	3	1.33	1.34	0.95	0.99253731
51	2013YBB	H70	3	1.2	1.36	0.95	0.88235294
52	2013YBB	H70	3	1.19	1.21	0.96	0.98347107
53	2013YBB	H70	3	1.32	1.31	1.03	1.00763359
54	2013YBB	H72	3	1.29	1.31	0.81	0.98473282
55	2013YBB	H72	3	1.24	1.28	0.76	0.96875
56	2013YBB	H72	3	1.14	1.16	1.01	0.98275862
57	2013YBB	H72	3	1.37	1.25	0.95	1.096
58	2013YBB	H72	3	1.36	1.33	1.25	1.02255639
59	2013YBB	H72	3	1.25	1.21	0.98	1.03305785
60	2013YBB	H72	3	1.39	1.17	1.21	1.18803419
61	2013YBB	H72	3	1.17	1.34	0.83	0.87313433
62	2013YBB	H72	3	1.33	1.24	1.13	1.07258065
63	2013YBB	H72	3	1.04	1.06	1.04	0.98113208
64	2013YBB	H72	3	1.28	1.16	1	1.10344828
65	2013YBB	H72	3	1.34	1.22	10.8	1.09836066
66	2013YBB	H72	3	0.96	1.1	0.98	0.87272727
67	2013YBB	H72	3	1.12	1.18	1.3	0.94915254
68	2013YBB	H72	3	1.24	1.24	1.13	1
69	2013YBB	H72	3	1.11	1.38	0.99	0.80434783
70	2013YBB	H72	3	1.14	1.07	0.98	1.06542056
71	2013YBB	H72	3	1.35	1.03	1.01	1.31067961
72	2013YBB	H73	3	1.13	1.16	1.05	0.97413793
73	2013YBB	H73	3	1.16	1.19	0.91	0.97478992
74	2013YBB	H73	3	1.42	1.31	0.98	1.08396947
75	2013YBB	H73	3	1.27	1.46	0.85	0.86986301
76	2013YBB	H74	3	1.2	1.12	0.98	1.07142857
77	2013YBB	H74	3	1.13	1.2	1.26	0.94166667
78	2013YBB	H74	3	1.19	1.33	1.18	0.89473684
79	2013YBB	H74	3	1.21	1.1	0.74	1.1
80	2013YBB	HD1-1	2	1.32	1.18	0.99	1.11864407

Appendix 4. Morphometric measurements on main species.

All measurements are in mm, unless otherwise stated.

BAIYANGCUN				*Setaria italica*			
No.	Site	Context	Period	Length	Width	Thickness	L/W mm
81	2013YBB	HD1-1	2	1.18	1.06	1.14	1.11320755
82	2013YBB	HD1-1	2	1.23	1.22	1.09	1.00819672
83	2013YBB	HD1-1	2	1.22	1.02	1.06	1.19607843
84	2013YBB	HD1-1	2	1.28	1.32	1.11	0.96969697
85	2013YBB	HD1-1	2	1.3	1.3	1.25	1
86	2013YBB	HD1-1	2	1.21	1.12	0.92	1.08035714
87	2013YBB	HD1-1	2	1.39	1.33	1.09	1.04511278
88	2013YBB	HD2-3	2	1.31	1.26	0.97	1.03968254
89	2013YBB	HD2-3	2	1.41	1.28	1.27	1.1015625
90	2013YBB	HD2-3	2	1.32	1.17	0.82	1.12820513
91	2013YBB	HD2-3	2	1.44	1.27	1.2	1.13385827
92	2013YBB	Hd6-2	2	1.12	1.17	0.99	0.95726496
93	2013YBB	Hd6-2	2	1.24	1.25	1.14	0.992
94	2013YBB	Hd6-2	2	1.39	1.25	1.11	1.112
95	2013YBB	Hd6-2	2	1.33	1.21	0.89	1.09917355
96	2013YBB	Hd6-2	2	1.17	1.03	0.93	1.13592233
97	2013YBB	Hd6-2	2	1.33	1.17	1.17	1.13675214
98	2013YBB	Hd6-2	2	1.19	1.07	0.85	1.11214953
99	2013YBB	Hd6-2	2	1.34	1.18	1.02	1.13559322
100	2013YBB	T1 10	2	1.25	1.35	1.03	0.92592593
101	2013YBB	T1 10	2	1.3	1.21	1.05	1.07438017
102	2013YBB	T1 10	2	1.42	1.15	1.05	1.23478261
103	2013YBB	T1 10	2	1.24	1.2	0.86	1.03333333
104	2013YBB	T1 10	2	1.23	1.35	0.99	0.91111111
105	2013YBB	T1 10	2	1.25	1.1	1.32	1.13636364
106	2013YBB	T1 10	2	1.29	1.19	0.77	1.08403361
107	2013YBB	T1 10	2	1.23	1.12	0.72	1.09821429
108	2013YBB	T1 10	2	1.31	1.56	1.06	0.83974359
109	2013YBB	T1 7 east	3	1.38	1.23	1.17	1.12195122
110	2013YBB	T1 7 east	3	1.31	1.1	1.11	1.19090909
111	2013YBB	T1 7 east	3	1.48	1.18	1.01	1.25423729
112	2013YBB	T1 7 east	3	1.26	1.09	1.08	1.1559633
113	2013YBB	T1 7 east	3	1.19	1.21	1.18	0.98347107
114	2013YBB	T1 7 east	3	1.24	1.13	1.21	1.09734513
115	2013YBB	T1 7 east	3	1.19	1.21	0.98	0.98347107
116	2013YBB	T1 7 east	3	1.31	1.06	1.04	1.23584906
117	2013YBB	T1 7 east	3	1.36	1.33	0.99	1.02255639
118	2013YBB	T1 7 east	3	1.41	1.16	0.69	1.21551724
119	2013YBB	T1 7 east	3	1.34	1.23	0.93	1.08943089
120	2013YBB	T1 7 east	3	1.4	1.16	1.05	1.20689655

Appendix 4. Morphometric measurements on main species.

All measurements are in mm, unless otherwise stated.

BAIYANGCUN				*Setaria italica*			
No.	Site	Context	Period	Length	Width	Thickness	L/W mm
121	2013YBB	F5-1	3	1.27	1.3	1.02	0.97692308
122	2013YBB	F5-1	3	1.45	1.1	1.23	1.31818182
123	2013YBB	F5-1	3	1.47	1.25	1.16	1.176
124	2013YBB	F5-1	3	1.29	1.18	1.15	1.09322034
125	2013YBB	F5-1	3	1.34	1.28	0.91	1.046875
126	2013YBB	F5-1	3	1.33	1.09	1.15	1.22018349
127	2013YBB	F5-1	3	1.37	1.17	1.14	1.17094017
128	2013YBB	F5-1	3	1.23	1.29	0.98	0.95348837
129	2013YBB	H103	2	1.32	1.23	0.94	1.07317073
130	2013YBB	H103	2	1.25	1.49	1.34	0.83892617
131	2013YBB	H103	2	1.3	1.28	1.18	1.015625
132	2013YBB	H103	2	1.23	1.25	0.75	0.984
133	2013YBB	H103	2	1.16	1.19	1.06	0.97478992
134	2013YBB	H103	2	1.21	1.24	1.11	0.97580645
135	2013YBB	H103	2	1.16	1.23	1.03	0.94308943
136	2013YBB	H103	2	1.22	1.25	1.02	0.976
137	2013YBB	H103	2	1.3	1.09	1.16	1.19266055
138	2013YBB	H103	2	1.44	1.29	0.88	1.11627907
139	2013YBB	H103	2	1.45	1.19	1.25	1.21848739
140	2013YBB	H103	2	1.23	1.17	0.98	1.05128205
141	2013YBB	H103	2	1.29	1.39	0.9	0.92805755
142	2013YBB	H103	2	1.15	1.23	0.85	0.93495935
143	2013YBB	H103	2	1.17	1.18	1.04	0.99152542
144	2013YBB	H103	2	1.35	1.21	1.07	1.11570248
145	2013YBB	H103	2	1.41	1.12	1.33	1.25892857
146	2013YBB	H103	2	1.29	1.13	0.94	1.14159292
147	2013YBB	H103	2	1.34	1.13	1.28	1.18584071
148	2013YBB	H103	2	1.27	1.07	1.07	1.18691589
149	2013YBB	H123	2	1.22	1.24	1	0.98387097
150	2013YBB	H123	2	0.93	1.19	1.24	0.78151261
151	2013YBB	H123	2	1.3	1.22	1.09	1.06557377
152	2013YBB	H123	2	1.24	1.18	1.05	1.05084746
153	2013YBB	H123	2	1.36	1.23	1.17	1.10569106
154	2013YBB	H123	2	1.29	1.21	1.05	1.0661157
155	2013YBB	H123	2	1.24	1.23	1.01	1.00813008
156	2013YBB	H123	2	1.48	1.13	0.99	1.30973451
157	2013YBB	H123	2	1.48	1.42	1.17	1.04225352
158	2013YBB	H123	2	1.15	1.12	1.14	1.02678571
159	2013YBB	H123	2	1.41	1.23	1.29	1.14634146
160	2013YBB	H123	2	1.28	1.17	0.95	1.09401709

Appendix 4. Morphometric measurements on main species.

All measurements are in mm, unless otherwise stated.

BAIYANGCUN				*Setaria italica*			
No.	Site	Context	Period	Length	Width	Thickness	L/W mm
161	2013YBB	H123	2	1.08	1.06	1.31	1.01886792
162	2013YBB	H123	2	1.36	1.16	1.07	1.17241379
163	2013YBB	H123	2	1.32	1	1.12	1.32
164	2013YBB	H123	2	1.43	1.3	1.06	1.1
165	2013YBB	H147	2	1.14	1.11	1.13	1.02702703
166	2013YBB	H147	2	0.98	1.2	0.86	0.81666667
167	2013YBB	H147	2	1.21	1.01	1.17	1.1980198
168	2013YBB	H147	2	1.33	1.04	1.01	1.27884615
169	2013YBB	H84	2	1.3	1.16	1.08	1.12068966
170	2013YBB	H84	2	1.25	1.14	1.2	1.09649123
171	2013YBB	H84	2	1.21	1.28	1.07	0.9453125
172	2013YBB	H84	2	1.38	1.26	0.91	1.0952381
173	2013YBB	H84	2	1.29	1.07	1.33	1.20560748
174	2013YBB	H84	2	1.17	1.37	0.92	0.8540146
175	2013YBB	H84	2	1.12	1.07	1.09	1.04672897
176	2013YBB	H84	2	1.11	1.08	1.07	1.02777778
177	2013YBB	H84	2	1.21	1.37	1.03	0.88321168
178	2013YBB	H84	2	1.32	1.13	1.19	1.16814159
179	2013YBB	H84	2	1.16	1.07	0.86	1.08411215
180	2013YBB	H84	2	1.49	1.21	1.13	1.23140496
181	2013YBB	H89	2	1.36	1.17	0.94	1.16239316
182	2013YBB	H89	2	1.18	1.34	0.96	0.88059701
183	2013YBB	H89	2	1.34	1.27	1.13	1.05511811
184	2013YBB	H89	2	1.05	1.42	1.01	0.73943662
185	2013YBB	H89	2	1.29	1.09	1.09	1.18348624
186	2013YBB	H89	2	1.25	1.1	0.81	1.13636364
187	2013YBB	H89	2	1.21	1.25	1.07	0.968
188	2013YBB	H89	2	1.1	1.28	1.01	0.859375
189	2013YBB	H99	2	1.31	1.29	1.02	1.01550388
190	2013YBB	H99	2	1.26	1.09	1.19	1.1559633
191	2013YBB	H99	2	1.23	1.07	1.04	1.14953271
192	2013YBB	H99	2	1.38	1.15	1.27	1.2
193	2013YBB	H99	2	1.2	1.23	0.89	0.97560976
194	2013YBB	H99	2	1.24	1.1	0.92	1.12727273
195	2013YBB	H99	2	1.21	1.21	1.05	1
196	2013YBB	H99	2	1.3	1.15	0.91	1.13043478
197	2013YBB	T1 7f S4	3	1.36	1.22	1.18	1.1147541
198	2013YBB	T1 7f S4	3	1.25	1.27	0.9	0.98425197
199	2013YBB	T1 7f S4	3	1.31	1	1.22	1.31
200	2013YBB	T1 7f S4	3	1.12	1.13	0.93	0.99115044

Appendix 4. Morphometric measurements on main species.

All measurements are in mm, unless otherwise stated.

BAIYANGCUN				*Setaria italica*			
No.	Site	Context	Period	Length	Width	Thickness	L/W mm
201	2013YBB	T2 20	1	1.3	1.03	1.14	1.26213592
202	2013YBB	T2 20	1	1.29	1.32	1.01	0.97727273
203	2013YBB	T2 20	1	1.3	1.34	1.17	0.97014925
204	2013YBB	T2 20	1	1.32	1.54	1.34	0.85714286
205	2013YBB	T2 20	1	1.28	1.41	1.18	0.90780142
206	2013YBB	T2 20	1	1.22	1.29	1	0.94573643
207	2013YBB	T2 20	1	1.46	1.35	1.1	1.08148148
208	2013YBB	T2 20	1	1.1	1.08	1.06	1.01851852
209	2013YBB	T2 20	1	1.28	1.24	1.02	1.03225806
210	2013YBB	T2 20	1	1.47	1.14	0.98	1.28947368
211	2013YBB	T2 20	1	1.17	1.21	1.14	0.96694215
212	2013YBB	T2 20	1	1.31	1.18	1.11	1.11016949
213	2013YBB	T2 20	1	1.3	1.28	1.04	1.015625
214	2013YBB	T2 20	1	1.42	1.43	0.99	0.99300699
215	2013YBB	T2 20	1	1.42	1.13	1.08	1.25663717
216	2013YBB	T2 20	1	1.38	1.31	1.28	1.05343511
217	2013YBB	T2 20	1	1.49	1.35	1.27	1.1037037
218	2013YBB	T2 20	1	1.29	1.32	1.22	0.97727273
219	2013YBB	T2 20	1	1.61	1.3		1.23846154
220	2013YBB	T2 20	1	1.37	1.38		0.99275362
221	2013YBB	T2 20	1	1.39	1.22		1.13934426
222	2013YBB	T2 20	1	1.56	1.41		1.10638298
223	2013YBB	T2 20	1	1.46	1.01	1.02	1.44554455
224	2013YBB	T2 20	1	1.45	1.27	1.1	1.14173228
225	2013YBB	T2 20	1	1.56	1.4	0.98	1.11428571
226	2013YBB	T2 20	1	1.32	1.2	1.01	1.1
227	2013YBB	T2 20	1	1.44	1.11	1.03	1.2972973
228	2013YBB	T2 20	1	1.42	1.16	1.29	1.22413793
BAIYANGCUN *Setaria italica*			AVERAGE	**1.2812**	**1.2055**	**1.0931**	**1.06951327**
			STDEV	**0.11654**	**0.1096**	**0.6670**	**0.12116501**

Appendix 4. Morphometric measurements on main species.

All measurements are in mm, unless otherwise stated.

BAIYANGCUN				*Panicum miliaceum*			
No.	Site	Context	Period	Length	Width	Thickness	L/W mm
1	2013YBB	HD1-1	2	1.84	1.78	1.47	1.03370787
2	2013YBB	HD8	1	1.58	1.71	1.34	0.92397661
3	2013YBB	HD8	1	1.71	1.86	1.51	0.91935484
4	2013YBB	HD8	1	1.79	1.51	1.38	1.18543046
5	2013YBB	HD8	1	1.77	1.39	1.22	1.27338129
6	2013YBB	HD8	1	1.79	1.88	1.52	0.95212766
7	2013YBB	HD8	1	1.86	1.81	1.56	1.02762431
8	2013YBB	HD8	1	1.81	1.64	1.61	1.10365854
9	2013YBB	HD8	1	1.9	1.69	1.76	1.12426036
10	2013YBB	HD8	1	1.86	1.67	1.36	1.11377246
11	2013YBB	HD8	1	1.78	1.82	1.38	0.97802198
12	2013YBB	HD8	1	1.78	1.81	1.32	0.98342541
13	2013YBB	HD8	1	1.84	1.66	1.69	1.10843373
14	2013YBB	HD8	1	1.9	1.66	1.42	1.14457831
15	2013YBB	HD8	1	1.68	1.74	1.45	0.96551724
16	2013YBB	HD8	1	1.74	1.69	1.84	1.0295858
17	2013YBB	HD8	1	1.81	1.69	1.74	1.07100592
18	2013YBB	HD8	1	1.61	1.61	1.31	1
19	2013YBB	HD8	1	1.85	1.8	1.53	1.02777778
20	2013YBB	HD8	1	1.71	1.87	1.43	0.9144385
21	2013YBB	HD8	1	1.87	1.77	1.56	1.05649718
22	2013YBB	HD8	1	1.77	1.85	1.42	0.95675676
23	2013YBB	HD8	1	1.84	1.73	1.54	1.06358382
24	2013YBB	HD8	1	1.85	1.69	1.55	1.09467456
25	2013YBB	HD8	1	1.63	1.81	1.73	0.90055249
26	2013YBB	HD8	1	1.46	1.28	1.11	1.140625
27	2013YBB	HD8	1	1.48	1.81	1.21	0.81767956
28	2013YBB	HD8	1	1.53	1.4	1.15	1.09285714
29	2013YBB	HD8	1	1.64	1.9	1.29	0.86315789
30	2013YBB	HD8	1	1.57	1.61	1.29	0.97515528
31	2013YBB	HD8	1	1.81	1.77	1.34	1.02259887
32	2013YBB	HD8	1	1.55	1.59	1.22	0.97484277
33	2013YBB	HD8	1	1.58	1.39	1.29	1.13669065
34	2013YBB	HD8	1	1.85	1.67	1.51	1.10778443
35	2013YBB	HD8	1	1.74	1.84	1.48	0.94565217
36	2013YBB	HD8	1	1.81	1.87	1.59	0.96791444
37	2013YBB	HD8	1	1.42	1.79	1.38	0.79329609
38	2013YBB	HD8	1	1.9	2.13	1.34	0.89201878
39	2013YBB	HD8	1	1.72	1.55	1.45	1.10967742
40	2013YBB	HD8	1	1.88	1.85	1.77	1.01621622

Appendix 4. Morphometric measurements on main species.

All measurements are in mm, unless otherwise stated.

BAIYANGCUN				*Panicum miliaceum*			
No.	Site	Context	Period	Length	Width	Thickness	L/W mm
41	2013YBB	HD8	1	1.64	1.42	1.31	1.15492958
42	2013YBB	HD8	1	1.75	1.73	1.26	1.01156069
43	2013YBB	HD8	1	1.97	1.51	1.44	1.30463576
44	2013YBB	HD8	1	1.46	1.37	1.28	1.06569343
45	2013YBB	H103	2	1.51	1.63	1.22	0.92638037
46	2013YBB	H103	2	1.88	1.86	1.4	1.01075269
47	2013YBB	H103	2	1.46	1.67	0.97	0.8742515
48	2013YBB	T2 20	1	1.64	1.73	1.6	0.94797688
49	2013YBB	T2 20	1	1.72	1.6	1.47	1.075
50	2013YBB	T2 20	1	1.45	1.79	1.45	0.81005587
51	2013YBB	T2 20	1	1.78	1.59	1.66	1.11949686
52	2013YBB	T2 20	1	1.79	1.63	1.6	1.09815951
53	2013YBB	T2 20	1	2.04	1.53	1.57	1.33333333
54	2013YBB	T2 20	1	1.75	1.59	1.7	1.10062893
55	2013YBB	T2 20	1	1.69	2.05	1.4	0.82439024
56	2013YBB	T2 20	1	1.63	1.88	1.77	0.86702128
57	2013YBB	T2 20	1	1.95	1.69	1.62	1.15384615
58	2013YBB	T2 20	1	1.75	1.54	1.42	1.13636364
59	2013YBB	T2 20	1	1.83	1.91	1.71	0.95811518
60	2013YBB	T2 20	1	1.55	1.48	1.43	1.0472973
61	2013YBB	T2 20	1	1.71	1.78	1.75	0.96067416
62	2013YBB	T2 20	1	1.78	1.75	1.19	1.01714286
63	2013YBB	T2 20	1	1.68	1.83	1.46	0.91803279
64	2013YBB	T2 20	1	1.83	1.8	1.62	1.01666667
65	2013YBB	T2 20	1	1.87	1.99	1.65	0.93969849
66	2013YBB	T2 20	1	1.89	1.62	1.51	1.16666667
67	2013YBB	T2 20	1	1.62	1.73	1.37	0.93641618
68	2013YBB	T2 20	1	1.84	1.71	1.39	1.07602339
69	2013YBB	T2 20	1	1.97	1.94	1.72	1.01546392
70	2013YBB	T2 20	1	1.95	1.69	1.7	1.15384615
71	2013YBB	T2 20	1	1.83	1.74	1.61	1.05172414
72	2013YBB	T2 20	1	1.74	1.77	1.65	0.98305085
73	2013YBB	T2 20	1	1.51	1.66	1.51	0.90963855
74	2013YBB	T2 20	1	1.66	1.85	1.55	0.8972973
75	2013YBB	T2 20	1	1.67	1.6	1.32	1.04375
76	2013YBB	T2 20	1	1.81	1.72	1.76	1.05232558
77	2013YBB	T2 20	1	1.75	1.87	1.69	0.93582888
78	2013YBB	T2 20	1	1.98	1.79	1.81	1.10614525
79	2013YBB	T2 20	1	1.91	1.73	1.51	1.10404624
80	2013YBB	T2 20	1	1.95	2.13	1.26	0.91549296

Appendix 4. Morphometric measurements on main species.

All measurements are in mm, unless otherwise stated.

BAIYANGCUN				*Panicum miliaceum*			
No.	Site	Context	Period	Length	Width	Thickness	L/W mm
81	2013YBB	T2 20	1	1.63	1.92	1.35	0.84895833
82	2013YBB	T2 20	1	1.87	1.68	1.76	1.11309524
83	2013YBB	T2 20	1	1.79	1.69	1.14	1.0591716
84	2013YBB	T2 20	1	1.47	1.54	1.48	0.95454545
85	2013YBB	T2 20	1	1.74	1.63	1.33	1.06748466
BAIYANGCUN *Panicum miliaceum*			AVERAGE	**1.7435**	**1.7170**	**1.4756**	**1.02201631**
			STDEV	**0.1448**	**0.1606**	**0.1863**	**0.1085356**

Appendix 4. Morphometric measurements on main species.

All measurements are in mm, unless otherwise stated.

BAIYANGCUN				*Glycine soja*
No.	site	context	Period	Width mm
1	2013YBB	F12	1	0.95
2	2013YBB	HD8	1	2.22
3	2013YBB	t1 18	1	1.92
4	2013YBB	F6	2	1.01
5	2013YBB	H123	2	1.13
6	2013YBB	H123?	2	1.69
7	2013YBB	HD9	2	2.08
8	2013YBB	T1 10 s3	2	1.71
9	2013YBB	T1 10 s5	2	1.3
10	2013YBB	t2 7f s4	2	1.75
11	2013YBB	H58	3	1.87
12	2013YBB	H61-2	3	0.93
13	2013YBB	H61-2	3	1.25
14	2013YBB	H61-2	3	1.58
15	2013YBB	H63	3	1.09
16	2013YBB	H67	3	1.78
17	2013YBB	H72	3	1.48
18	2013YBB	H72	3	1.58
19	2013YBB	H72	3	1.35
20	2013YBB	H72	3	1.67
21	2013YBB	H72	3	1.64
22	2013YBB	H72	3	1.3
23	2013YBB	H72	3	1.59
24	2013YBB	HD10	3	1.87
25	2013YBB	HD11	3	1.84
26	2013YBB	HD12	3	1.82
27	2013YBB	HD13	3	1.72
28	2013YBB	HD14	3	1.6
29	2013YBB	HD15	3	1.71
BAIYANGCUN *Glycine soja*			AVERAGE	1.56655172
			STDEV	0.33410088

Appendix 4. Morphometric measurements on main species.

All measurements are in mm, unless otherwise stated.

BAIYANGCUN				*Cajanus* sp.			
No.	Site	Context	Period	Length	Width	Thickness	L/W mm
1	2013YBB	t1-10-s3	2	1.05	1.27	0.818	0.82677165
2	2013YBB	t1-10-s3	2	1.01	0.99	0.892	1.02020202
3	2013YBB	H63	3	1.2	1.05	0.589	1.14285714
4	2013YBB	H63	3	1.14	1.11	0.789	1.02702703
5	2013YBB	H63	3	1.27	1.21	0.739	1.04958678
6	2013YBB	H70	3	1.08	1.36	0.786	0.79411765
7	2013YBB	H70	3	1.16	1.17	0.511	0.99145299
8	2013YBB	H70	3	1.26	1.15	0.886	1.09565217
9	2013YBB	H70	3	1.26	1.56	0.601	0.80769231
10	2013YBB	H70	3	1.03	1.07	0.792	0.96261682
11	2013YBB	H103	3	1.19	1.15	0.557	1.03478261
12	2013YBB	H103	3	0.938	1.25	0.729	0.7504
13	2013YBB	H72	3	1.16	1.17	0.716	0.99145299
14	2013YBB	H72	3	1.16	1.21	0.667	0.95867769
15	2013YBB	8c s4	3	1.14	1.34	0.984	0.85074627
16	2013YBB	8c s4	3	1.08	1.12	0.687	0.96428571
17	2013YBB	8c s4	3	1.09	1.32	0.895	0.82575758
18	2013YBB	H68	3	1.08	1.81	0.591	0.59668508
19	2013YBB	H68	3	1.25	1.2	0.584	1.04166667
20	2013YBB	H118	3	1.4	1.32	0.642	1.06060606
21	2013YBB	H118	3	1.79	1.46	0.939	1.2260274
22	2013YBB	H118	3	1.39	1.43	0.883	0.97202797
23	2013YBB	H118	3	1.5	1.56	1	0.96153846
24	2013YBB	H118	3	1.27	1.51	0.654	0.8410596
25	2013YBB	H118	3	1.22	1.34	0.855	0.91044776
BAIYANGCUN *Cajanus* sp.			AVERAGE	**1.2047**	**1.2852**	**0.7514**	**0.94816554**
			STDEV	**0.1776**	**0.1906**	**0.1413**	**0.1370432**

Appendix 4. Morphometric measurements on main species.

All measurements are in mm, unless otherwise stated.

BAIYANGCUN				*Chenopodium* sp.				
No.	Site	Context	Period	Length mm	Nose mm	Width mm	Thickness mm	Seed coat thickness um
1	2013YBB	H61-1	3	0.892	0.0807	0.857	0.405	
2	2013YBB	H61-1	3	0.775	0.0722	0.726	0.258	
3	2013YBB	H61-1	3	1.01	0.166	0.91	0.423	
4	2013YBB	H61-1	3	0.92	0.139	0.81	0.359	
5	2013YBB	H61-1	3	0.804	0.0832	0.787	0.38	
6	2013YBB	H61-1	3	0.926	0.141	0.806	0.544	
7	2013YBB	H61-1	3	0.826	0.108	0.758	0.364	
8	2013YBB	H61-1	3	0.846	0.102	0.811	0.431	
9	2013YBB	H61-1	3	0.781	0.109	0.688	0.347	
10	2013YBB	H61-1	3	0.964	0.116	0.9	0.567	16.5918462
11	2013YBB	H61-1	3	0.958	0.0793	0.9	0.384	
12	2013YBB	H61-1	3	0.896	0.13	0.786	0.522	
13	2013YBB	H123	2	0.883	0.117	0.919	0.611	
14	2013YBB	H123	2	0.869	0.0706	0.893	0.408	20.3002857
15	2013YBB	H123	2	0.868	0.0963	0.898	0.455	19.8503684
16	2013YBB	Layer 21	1	0.95	0.078	0.802	0.387	27.165
17	2013YBB	Layer 21	1	0.881	0.0875	0.83	0.348	
18	2013YBB	Layer 21	1	0.869	0.0656	0.842	0.378	
19	2013YBB	Layer 21	1	0.975		0.875	0.457	19.6477
20	2013YBB	Layer 21	1	0.884	0.0473	0.864	0.385	
21	2013YBB	Layer 21	1	0.866	0.0684	0.817	0.371	
22	2013YBB	Layer 21	1	0.961	0.0847	0.922	0.554	29.5951
BAIYANGCUN *Chenopodium* sp.			AVERAGE	**0.8886**	**0.0972**	**0.8301**	**0.4244**	**22.1917 um**
			STDEV	**0.0637**	**0.0296**	**0.0640**	**0.0865**	**5.02 um**

Appendix 4. Morphometric measurements on main species.

All measurements are in mm, unless otherwise stated.

HAIMENKOU				*Oryza sativa*			
No.	Site	Context	Period	Length	Width	Thickness	L/W mm
1	2008 JHDT	1003-7	2	4.46	2.11	1.54	2.11374408
2	2008 JHDT	1003-7	2	4.69	2.62	2.49	1.79007634
3	2008 JHDT	1003-7	2	4.27	2.15	1.81	1.98604651
4	2008 JHDT	1003-7	2	5.08	2.44	1.54	2.08196721
5	2008 JHDT	1003-7	2	5.15	3.12	2.26	1.65064103
6	2008 JHDT	1003-7	2	4.85	3.89	2.09	1.24678663
7	2008 JHDT	1003-7	2	5.72	3.01	2.64	1.90033223
8	2008 JHDT	1003-7	2	5.21	3.47	2.34	1.50144092
9	2008 JHDT	1003-7	2	5.07	3.19	2.13	1.58934169
10	2008 JHDT	1003-7	2	4.7	3.07	2.43	1.53094463
11	2008 JHDT	1003-7	2	4.45	2.73	2.18	1.63003663
12	2008 JHDT	1003-7	2	4.43	2.61	1.95	1.69731801
13	2008 JHDT	1003-7	2	4.69	3.01	2.32	1.55813953
14	2008 JHDT	1003-7	2	5.18	2.63	2.64	1.96958175
15	2008 JHDT	1003-7	2	4.59	2.93	2.3	1.5665529
16	2008 JHDT	1003-7	2	4.67	3.09	2.22	1.51132686
17	2008 JHDT	1003-7	2	5.13	3.14	2.85	1.63375796
18	2008 JHDT	1003-7	2	4.67	3.56	2.22	1.31179775
19	2008 JHDT	1003-7	2	5.5	3.21	2.2	1.71339564
20	2008 JHDT	1003-7	2	4.58	3.33	2.39	1.37537538
21	2008 JHDT	1003-7	2	5.33	3.57	2.71	1.4929972
22	2008 JHDT	1003-7	2	4.51	3.16	1.96	1.42721519
23	2008 JHDT	1003-7	2	5.07	2.96	1.93	1.71283784
24	2008 JHDT	1003-7	2	5.55	3.25	2.53	1.70769231
25	2008 JHDT	1003-7	2	4.97	3.19	2.51	1.55799373
26	2008 JHDT	1003-7	2	5.3	2.7	2.1	1.96296296
27	2008 JHDT	1003-7	2	4.85	3.32	2.26	1.46084337
28	2008 JHDT	1003-7	2	5.08	3.17	2.09	1.60252366
29	2008 JHDT	1003-7	2	4.55	3.18	2.29	1.43081761
30	2008 JHDT	1003-7	2	5.03	2.98	2.06	1.68791946
31	2008JHDT	1003-8	1	4.28	2.46	1.46	1.7398374
32	2008JHDT	1003-8	1	5.13	2.96	1.85	1.73310811
33	2008JHDT	1003-8	1	3.78	2.2	1.91	1.71818182
34	2008JHDT	1003-8	1	4.38	2.67	2	1.64044944
35	2008JHDT	1003-8	1	5.02	2.27	2.01	2.21145374
36	2008 JHDT	1204-6	2	5.11	2.69	2.33	1.89962825
37	2008 JHDT	1204-6	2	5.47	2.94	2.59	1.86054422
38	2008 JHDT	1204-6	2	4.9	3.17	2.42	1.54574132
39	2008 JHDT	1204-6	2	5.57	3.06	2.15	1.82026144
40	2008 JHDT	1204-6	2	5.2	2.72	2.09	1.91176471

Appendix 4. Morphometric measurements on main species.

All measurements are in mm, unless otherwise stated.

HAIMENKOU				*Oryza sativa*			
No.	Site	Context	Period	Length	Width	Thickness	L/W mm
41	2008 JHDT	1204-6	2	5.44	3.01	2.39	1.80730897
42	2008 JHDT	1204-6	2	5.88	3.35	2.04	1.75522388
43	2008 JHDT	1304-5	3	5.76	3.29	3.16	1.75075988
44	2008 JHDT	1304-5	3	4.93	2.64	2.28	1.86742424
45	2008 JHDT	1304-5	3	4.89	2.83	2.41	1.72791519
46	2008 JHDT	1304-5	3	4.98	2.75	1.75	1.81090909
47	2008 JHDT	1304-5	3	4.45	2.94	1.73	1.51360544
48	2008 JHDT	1304-5	3	4.68	2.81	2.21	1.66548043
49	2008 JHDT	1304-5	3	4.69	2.8	2.17	1.675
50	2008 JHDT	1304-5	3	4.55	2.29	2.04	1.98689956
51	2008 JHDT	1304-5	3	4.82	2.41	1.81	2
52	2008 JHDT	1304-5	3	4.48	2.59	1.82	1.72972973
53	2008 JHDT	1304-5	3	4.86	2.91	1.59	1.67010309
54	2008 JHDT	1304-5	3	4.76	2.72	1.98	1.75
55	2008 JHDT	1304-5	3	4.59	2.69	2.01	1.7063197
56	2008 JHDT	1304-5	3	4.42	2.87	1.91	1.54006969
57	2008 JHDT	1304-5	3	4.63	2.83	1.87	1.6360424
58	2008 JHDT	1304-5	3	4.55	2.72	1.89	1.67279412
59	2008 JHDT	1304-5	3	4.68	3.08	2.05	1.51948052
60	2008 JHDT	1304-5	3	4.67	3.3	2.11	1.41515152
61	2008 JHDT	1304-5	3	4.45	2.85	2.42	1.56140351
62	2008 JHDT	1304-5	3	4.33	2.71	1.66	1.59778598
63	2008 JHDT	1304-5	3	4.72	3.01	1.99	1.56810631
64	2008 JHDT	1304-5	3	4.61	2.54	1.84	1.81496063
65	2008 JHDT	1304-5	3	4.4	2.35	1.78	1.87234043
66	2008 JHDT	1304-5	3	4.11	2.29	1.78	1.79475983
67	2008 JHDT	1304-5	3	4.58	2.43	1.95	1.88477366
68	2008 JHDT	1304-5	3	4.93	2.77	1.94	1.77978339
69	2008 JHDT	1304-5	3	4.4	2.4	1.98	1.83333333
70	2008 JHDT	1304-5	3	4.76	2.36	1.64	2.01694915
71	2008 JHDT	1304-5	3	4.55	2.65	1.82	1.71698113
72	2008 JHDT	1304-5	3	5.03	2.64	2.03	1.90530303
73	2008 JHDT	1304-5	3	4.04	2.14	2.03	1.88785047
74	2008 JHDT	1304-5	3	4.75	2.34	2.04	2.02991453
75	2008 JHDT	1304-5	3	4.02	2.48	2.02	1.62096774
76	2008 JHDT	1304-5	3	4.36	2.41	2.04	1.80912863
77	2008 JHDT	1304-5	3	4.66	2.17	1.85	2.14746544
78	2008 JHDT	1304-5	3	4.81	2.48	1.72	1.93951613
79	2008 JHDT	1304-5	3	4.64	3.05	1.89	1.52131148
80	2008 JHDT	1304-5	3	4.41	2.7	1.9	1.63333333

Appendix 4. Morphometric measurements on main species.

All measurements are in mm, unless otherwise stated.

HAIMENKOU				*Oryza sativa*			
No.	Site	Context	Period	Length	Width	Thickness	L/W mm
81	2008 JHDT	1304-5	3	4.74	2.93	2.31	1.61774744
82	2008 JHDT	1304-5	3	4.49	2.48	1.81	1.81048387
83	2008 JHDT	1304-5	3	4.44	3.02	2.22	1.47019868
84	2008 JHDT	1304-5	3	4.3	2.75	2.2	1.56363636
85	2008 JHDT	1304-5	3	5	2.67	2.16	1.87265918
86	2008 JHDT	1304-5	3	3.98	2.9	2.51	1.37241379
87	2008 JHDT	1304-5	3	4.61	2.85	1.99	1.61754386
88	2008 JHDT	1304-5	3	4.41	2.92	2	1.51027397
89	2008 JHDT	1304-5	3	4.15	2.79	2.13	1.4874552
90	2008 JHDT	1304-5	3	4.58	2.51	1.91	1.8247012
91	2008 JHDT	1304-5	3	4.61	2.85	1.99	1.61754386
92	2008 JHDT	2003-6-s5	3	5.29	2.82	2.75	1.87588652
93	2008 JHDT	2003-6-s5	3	4.07	2.63	1.93	1.54752852
94	2008 JHDT	2003-6-s5	3	4.56	2.67	1.83	1.70786517
95	2008 JHDT	2003-6-s5	3	4.44	2.85	1.92	1.55789474
HAIMENKOU *Oryza sativa*			AVERAGE	4.7485	2.8123	2.0946	1.70603574
			stdev	0.4126	0.3506	0.3024	0.19270555

Appendix 4. Morphometric measurements on main species.

All measurements are in mm, unless otherwise stated.

HAIMENKOU				*Setaria italica*			
No.	Site	Context	Period	Length	Width	Thickness	L/W
1	2008 JHDT	1003-7	2	1.21	1.22	1.06	0.99180328
2	2008 JHDT	1003-7	2	1.46	1.38	1.22	1.05797101
3	2008 JHDT	1003-7	2	1.34	1.37	1.19	0.97810219
4	2008 JHDT	1003-7	2	1.22	1.44	1.27	0.84722222
5	2008 JHDT	1003-7	2	1.38	1.22	1.23	1.13114754
6	2008 JHDT	1003-7	2	1.33	1.36	1.16	0.97794118
7	2008 JHDT	1003-7	2	1.34	1.36	1.06	0.98529412
8	2008 JHDT	1003-7	2	1.3	1.15	1.16	1.13043478
9	2008 JHDT	1003-7	2	1.28	1.34	0.75	0.95522388
10	2008 JHDT	1003-7	2	1.17	1.25	1.13	0.936
11	2008 JHDT	1003-7	2	1.1	1.35	1.33	0.81481481
12	2008 JHDT	1003-7	2	1.27	1.31	1.08	0.96946565
13	2008 JHDT	1003-7	2	1.34	1.42	0.96	0.94366197
14	2008 JHDT	1003-7	2	1.17	1.28		0.9140625
15	2008 JHDT	1003-7	2	1.34	1.24	0.97	1.08064516
16	2008 JHDT	1003-7	2	1.14	1.4	1.28	0.81428571
17	2008 JHDT	1003-7	2	1.32	1.27	1.19	1.03937008
18	2008 JHDT	1003-7	2	1.26	1.38	1.16	0.91304348
19	2008 JHDT	1003-7	2	1.26	1.23	1.06	1.02439024
20	2008 JHDT	1003-7	2	1.27	1.35	1.2	0.94074074
21	2008 JHDT	1003-7	2	1.33	1.54	1.46	0.86363636
22	2008 JHDT	1003-7	2	1.28	1.22	1.01	1.04918033
23	2008 JHDT	1003-7	2	1.36	1.43	1.49	0.95104895
24	2008 JHDT	1003-7	2	1.3	1.42	1.19	0.91549296
25	2008 JHDT	1003-7	2	1.16	1.39	1.22	0.83453237
26	2008 JHDT	1003-7	2	1.28	1.35	1.23	0.94814815
27	2008 JHDT	1003-8	1	1.28	1.6	1.53	0.8
28	2008 JHDT	1003-8	1	1.29	1.3	0.9	0.99230769
29	2008 JHDT	1003-8	1	1.34	1.41	1.04	0.95035461
30	2008 JHDT	1003-8	1	1.43	1.43	1.24	1
31	2008 JHDT	1003-8	1	1.32	1.32	1.15	1
32	2008 JHDT	1003-8	1	1.3	1.57	1.21	0.82802548
33	2008 JHDT	1003-8	1	1.27	1.29	1.036	0.98449612
34	2008 JHDT	1003-8	1	1.28	1.44	1.02	0.88888889
35	2008 JHDT	1003-8	1	1.22	1.38	1.25	0.88405797
36	2008 JHDT	1003-8	1	1.26	1.17	1.05	1.07692308
37	2008 JHDT	1003-8	1	1.2	1.33	1.27	0.90225564
38	2008 JHDT	1003-8	1	1.24	1.66	1.16	0.74698795
39	2008 JHDT	1003-8	1	1.51	1.34	1.14	1.12686567
40	2008 JHDT	1003-8	1	1.15	1.27	1.33	0.90551181

Appendix 4. Morphometric measurements on main species.

All measurements are in mm, unless otherwise stated.

HAIMENKOU				*Setaria italica*			
No.	Site	Context	Period	Length	Width	Thickness	L/W
41	2008 JHDT	1003-8	1	1.53	1.38	1.16	1.10869565
42	2008 JHDT	1003-8	1	1.22	1.53	1.22	0.79738562
43	2008 JHDT	1003-8	1	1.31	1.26	1.28	1.03968254
44	2008 JHDT	1003-8	1	1.29	1.16	1.29	1.11206897
45	2008 JHDT	1003-8	1	1.25	1.44	1.155	0.86805556
46	2008 JHDT	1003-8	1	1.23	1.25	0.82	0.984
47	2008 JHDT	1304-5	3	1.48	1.27	1.12	1.16535433
48	2008 JHDT	1304-5	3	1.64	1.23	0.96	1.33333333
HAIMENKOU *Setaria italica*			AVERAGE	**1.2968**	**1.3479**	**1.1572**	**0.96881064**
			stdev	**0.1038**	**0.1125**	**0.1543**	**0.11373211**

HAIMENKOU				*Panicum miliaceum*			
No.	Site	Context	Period	Length	Width	Thickness	L/W
1	2008 JHDT	1204-6	2	1.88	2.08	1.47	0.90384615
2	2008 JHDT	1204-6	2	1.44	1.88	1.34	0.76595745
HAIMENKOU *Panicum miliaceum*			AVERAGE	**1.6600**	**1.9800**	**1.4050**	**0.8349018**
			STDEV	**0.3111**	**0.1414**	**0.0919**	**0.09750204**

HAIMENKOU				*Fagopyrum* cf *esculentum*			
No.	Site	Context	Period	Length	Width	Thickness	L/W
1	2008JHAT	2003-6-s5	3	2.84	1.77	1.72	1.60451977
2	2008JHAT	2003-6-s5	3	2	1.63	1.68	1.22699387
HAIMENKOU *Fagopyrum* cf *esculentum*			AVERAGE	**2.42**	**1.7**	**1.7**	**1.41575682**
			STDEV	**0.5939**	**0.0989**	**0.0282**	**0.26695113**

Appendix 4. Morphometric measurements on main species.

All measurements are in mm, unless otherwise stated.

HAIMENKOU				*Triticum aestivum*			
No.	Site	context	Period	Length	Width	Thickness	L/W
1	2008 JHDT	1204-6	2	4.85	3.17	2.3	1.52996845
2	2008 JHDT	1204-6	2	4.95	2.33	1.9	2.12446352
3	2008 JHDT	1204-6	2	4.39	2.61	2.28	1.68199234
4	2008 JHDT	1204-6	2	5.05	2.96	2.24	1.70608108
5	2008 JHDT	1204-6	2	4.92	3.94	3.76	1.24873096
6	2008 JHDT	1204-6	2	5.1	3.25	3.2	1.56923077
7	2008 JHDT	1204-6	2	4.72	3.53	2.55	1.33711048
8	2008 JHDT	1204-6	2	4.72	3.29	2.8	1.43465046
9	2008 JHDT	1204-6	2	4.45	3.43	3.1	1.29737609
10	2008 JHDT	1204-6	2	4.17	3.91	2.86	1.06649616
11	2008 JHDT	1204-6	2	5.23	3.86	3.4	1.35492228
12	2008 JHDT	1204-6	2	5.13	4.02	3.12	1.2761194
13	2008 JHDT	1204-6	2	4.76	3.32	2.99	1.43373494
14	2008 JHDT	1204-6	2	4.78	3.04	2.75	1.57236842
15	2008 JHDT	1204-6	2	4.61	3.44	2.7	1.34011628
16	2008 JHDT	1204-6	2	5.76	3.5	3.12	1.64571429
17	2008 JHDT	1204-6	2	4.57	2.77	2.82	1.64981949
18	2008 JHDT	1204-6	2	5.19	3.48	3.02	1.49137931
19	2008 JHDT	1204-6	2	5.41	3.52	2.85	1.53693182
20	2008 JHDT	1204-6	2	4.84	3.67	2.57	1.31880109
21	2008 JHDT	1204-6	2	4.26	3.53	2.77	1.20679887
22	2008 JHDT	1204-6	2	5.24	3.55	2.95	1.47605634
23	2008 JHDT	1204-6	2	5	3.08	2.85	1.62337662
24	2008 JHDT	1204-6	2	4.82	3.26	3.21	1.47852761
25	2008 JHDT	1204-6	2	4.85	3.56	2.97	1.36235955
26	2008 JHDT	1204-6	2	4.92	3.24	2.98	1.51851852
27	2008 JHDT	1204-6	2	5.17	3.51	3.1	1.47293447
28	2008 JHDT	1204-6	2	4.96	3.67	3.12	1.35149864
29	2008 JHDT	1204-6	2	5.24	3.64	2.97	1.43956044
30	2008 JHDT	1204-6	2	5.02	3.34	3.32	1.50299401
31	2008 JHDT	1204-6	2	5.09	3.25	2.99	1.56615385
32	2008 JHDT	1204-6	2	5.92	3.79	3.27	1.56200528
33	2008 JHDT	1204-6	2	4.9	3.64	3.55	1.34615385
34	2008 JHDT	1204-6	2	5.45	3.76	3.47	1.44946809
35	2008 JHDT	1304-5	3	4.93	3.79	3.12	1.30079156
36	2008 JHDT	1304-5	3	4.8	3.46	2.9	1.38728324
37	2008 JHDT	1304-5	3	5.04	3.26	3.03	1.54601227
HAIMENKOU *Triticum aestivum*			AVERAGE	**4.957692**	**3.381282**	**2.913076**	**1.484574**
			STDEV	**0.351429**	**0.383921**	**0.388608**	**0.195576**

Appendix 4. Morphometric measurements on main species.

All measurements are in mm, unless otherwise stated.

HAIMENKOU			*Chenopodium* sp.					
No.	Context	Period	Length mm	Nose mm	Width mm	Thickness mm	L/W mm	Seed coat thickness um
1	Layer 8	1	1.42	0.181	1.27	0.69	1.11811024	
2	Layer 8	1	1.19		0.944	0.542	1.26059322	
3	Layer 8	1	1.16	0.111	1.05	0.641	1.1047619	
4	Layer 8	1	1.43	0.176	1.27	0.711	1.12598425	
5	Layer 8	1	1.08	0.177	0.983	0.604	1.09867752	
6	Layer 8	1	1.26	0.156	1.13	0.697	1.11504425	47.2928333
7	Layer 8	1	1.49	0.261	1.3	0.771	1.14615385	
8	Layer 8	1	1.21	0.139	1.07	0.64	1.13084112	
9	Layer 8	1	1.35	0.186	1.24	0.706	1.08870968	
10	Layer 8	1	1.33	0.157	1.2	0.639	1.10833333	
11	Layer 8	1	1.12	0.142	1.01	0.617	1.10891089	
12	Layer 8	1	1.3	0.168	1.17	0.715	1.11111111	
13	Layer 8	1	1.12	0.127	1.03	0.552	1.08737864	
14	Layer 8	1	1.36	0.146	1.23	0.722	1.10569106	
15	Layer 8	1	1.29	0.19	1.17	0.547	1.1025641	
16	Layer 8	1	1.06	0.0939	0.962	0.54	1.1018711	
17	Layer 8	1	1.14	0.154	1.01	0.571	1.12871287	
18	Layer 8	1	1.16	0.136	1.04	0.587	1.11538462	
19	Layer 8	1	1.05	0.135	0.984	0.586	1.06707317	
20	Layer 8	1	1.32	0.15	1.25	0.74	1.056	
21	Layer 8	1	1.17	0.0621	1.04	0.661	1.125	
22	Layer 8	1	1.2	0.122	1.14	0.646	1.05263158	
23	Layer 8	1	1.66	0.196	1.5	0.863	1.10666667	49.0261818
24	Layer 8	1	1.23		1.15	0.743	1.06956522	24.5244
25	Layer 8	1	1.66	0.197	1.43	0.878	1.16083916	43.5446316
26	Layer 8	1	1.19	0.138	1.11	0.593	1.07207207	
27	Layer 8	1	1.14	0.192	0.968	0.576	1.17768595	
28	Layer 8	1	1.22	0.106	1.16	0.637	1.05172414	
29	Layer 8	1	1.51	0.156	1.29	0.658	1.17054264	16.757
30	Layer 8	1	1.29	0.145	1.12	0.699	1.15178571	47.6834444
31	Layer 8	1	1.55	0.152	1.25	0.511	1.24	16.48825
32	Layer 8	1	1.28		1.03	0.876	1.24271845	39.25125
33	Layer 8	1	1.16	0.109	1.07	0.475	1.08411215	37.2157083
34	Layer 8	1	1.54	0.193	1.4	0.58	1.1	13.3991429
35	1204-6	2	1.28	0.155	1.24	0.713	1.03225806	20.5458
36	1204-6	2	1.14	0.143	1.23	0.738	0.92682927	
37	1204-6	2	1.52	0.17	1.32	0.89	1.15151515	
38	1204-6	2	1.39		1.54	0.919	0.9025974	13.4317692
39	1204-6	2	1.37	0.196	1.29	1.02	1.0620155	18.3490714

Appendix 4. Morphometric measurements on main species.

All measurements are in mm, unless otherwise stated.

HAIMENKOU			*Chenopodium* sp.					
No.	Context	Period	Length mm	Nose mm	Width mm	Thickness mm	L/W mm	Seed coat thickness um
40	1204-6	2	1.51	0.178	1.3	1.02	1.161538	20.3437273
41	1204-6	2	1.49	0.152	1.24	0.792	1.201612	
42	1204-6	2	1.26		1.11	0.832	1.135135	
43	1204-6	2	1.46	0.206	1.32	0.906	1.106060	
44	1204-6	2	1.27	0.154	1.2	0.807	1.058333	9.26377778
45	1204-6	2	1.08	0.179	0.939	0.662	1.150159	18.8598571
46	1204-6	2	1.37	0.148	1.23	0.799	1.113821	
47	1204-6	2	1.33	0.147	1.22	0.849	1.090163	
48	1204-6	2	1.41	0.202	1.12	0.78	1.258928	
49	1204-6	2	1.42	0.188	1.17	0.829	1.213675	13.4441818
50	1204-6	2	1.48	0.137	1.27	0.669	1.165354	
51	1204-6	2	1.35	0.15	1.17	0.733	1.153846	
52	1204-6	2	1.15	0.168	0.947	0.791	1.214361	14.3245789
53	1204-6	2	1.29	0.182	1.08	0.783	1.194444	
54	1204-6	2	1.48	0.21	1.35	0.925	1.096296	
55	1204-6	2	1.19	0.154	1.14	0.884	1.043859	15.5475
56	1204-6	2	1.33	0.146	1.12	0.972	1.1875	12.2702222
57	1204-6	2	1.12	0.123	1	0.533	1.12	
58	1204-6	2	1.4	0.156	1.41	0.812	0.992907	15.2296667
59	1204-6	2	1.02	0.122	1.02	0.694	1	
60	1204-6	2	1.03	0.119	1.01	0.699	1.019801	
61	1204-6	2	1.27	0.162	1.23	0.911	1.032520	10.527625
62	1204-6	2	1.23	0.133	1.03	0.608	1.194174	
63	1204-6	2	1.28	0.175	1.08	0.818	1.185185	
64	1204-6	2	1.28	0.165	1.07	0.815	1.196261	
65	2005-6	2	1.58	0.133	1.34	0.663	1.179104	13.7165
66	2005-6	2	1.39	0.143	1.31	0.595	1.061068	
67	2005-6	2	1.36	0.0865	1.17	0.659	1.162393	
68	2005-6	2	1.43	0.212	1.21	0.697	1.181818	30.673375
69	2005-6	2	1.09	0.136	0.986	0.601	1.105476	
70	2005-6	2	1.29	0.117	1.11	0.888	1.162162	
71	2005-6	2	1.42	0.213	1.12	0.673	1.267857	
72	2005-6	2	1.44	0.169	1.2	0.629	1.2	18.61725
73	2005-6	2	1.34	0.124	1.23	0.642	1.089430	
74	2005-6	2	1.37		1.24	0.567	1.104838	26.123
75	2005-6	2	1.22	0.167	1.16	0.678	1.051724	
76	2005-6	2	1.22	0.137	1.14	0.674	1.070175	28.0241538
77	2005-6	2	1.09	0.111	1.03	0.633	1.058252	
78	2005-6	2	1.19	0.162	1.05	0.582	1.133333	

Appendix 4. Morphometric measurements on main species.

All measurements are in mm, unless otherwise stated.

HAIMENKOU			*Chenopodium* sp.					
No.	Context	Period	Length mm	Nose mm	Width mm	Thickness mm	L/W mm	Seed coat thickness um
79	2005-6	2	1.39		1.13	0.79	1.230088	
80	2005-6	2	1.61	0.22	1.33	0.599	1.210526	
81	2005-6	2	1.34	0.184	1.17	0.567	1.145299	
82	2005-6	2	1.52	0.188	1.03	0.602	1.475728	19.678625
83	2005-6	2	1.24	0.168	1.01	0.561	1.227722	
84	1304-5	3	1.39	0.18	1.27	0.938	1.094488	20.3025238
85	1304-5	3	1.43		1.45	0.905	0.986206	20.3378947
86	1304-5	3	1.16	0.138	0.989	0.713	1.172901	18.6683636
87	1304-5	3	1.27	0.115	1.21	0.915	1.049586	18.3285556
88	1304-5	3	1.37	0.168	1.11	0.884	1.234234	34.3812
89	1304-5	3	1.26	0.145	1.14	0.864	1.105263	17.6333333
90	1304-5	3	1.45		1.25	1.07	1.16	
91	1304-5	3	1.48	0.216	1.23	1.05	1.203252	
92	1304-5	3	1.39	0.194	1.18	0.992	1.177966	38.7530435
93	1304-5	3	1.26	0.116	1.23	0.987	1.024390	
94	1304-5	3	1.45	0.18	1.19	0.919	1.218487	9.70375
95	1304-5	3	1.58	0.215	1.29	1	1.224806	15.963375
96	1304-5	3	1.31	0.17	1.24	0.91	1.056451	
97	1304-5	3	1.32	0.136	1.17	0.911	1.128205	
98	1304-5	3	1.44	0.131	1.31	1.14	1.099236	
99	1304-5	3	1.5	0.217	1.17	1.05	1.282051	35.4392963
100	1304-5	3	1.63	0.147	1.31	1.11	1.244274	25.4746
101	1304-5	3	1.21		1.17	1.07	1.034188	22.2803
102	1304-5	3	1.4	0.168	0.99	0.963	1.414141	14.310875
103	1304-5	3	1.35	0.179	1.18	0.868	1.144067	15.0890588
104	1304-5	3	1.41	0.213	1.16	1.08	1.215524	22.1887391
105	1304-5	3	1.38		1.13	1.01	1.221238	24.5322857
106	1304-5	3	1.21	0.155	0.952	1.17	1.271008	19.2106
107	1304-5	3	1.38	0.124	1.23	1.03	1.121951	18.2242857
108	1304-5	3	1.29		1.22	0.778	1.057377	
109	1304-5	3	1.36	0.144	1.19	0.828	1.142857	13.3125263
110	1304-5	3	1.4		1.32	0.951	1.060606	
111	1304-5	3	1.29	0.126	1.21	0.887	1.066115	19.49055
112	1304-5	3	1.23	0.167	1.26	0.824	0.976190	18.5097778
113	1304-5	3	1.28		1.16	0.845	1.103448	18.962
		AVERAGE	**1.3207**	**0.1584**	**1.1703**	**0.7732**	**1.1314**	**22.3050**
		STDEV	**0.1440**	**0.0333**	**0.1258**	**0.1634**	**0.0851**	**10.2840**

Appendix 4. Morphometric measurements on main species.

All measurements are in mm, unless otherwise stated.

HAIMENKOU				*Cannabis* sp.			
No.	Site	Context	Period	Length	Width	Thickness	L/W
1	2008 JHDT	1204-6	2	3.55	2.83	2.22	1.25441696
2	2008 JHDT	1204-6	2	3.88	3.33	2.8	1.16516517
3	2008 JHDT	1204-6	2	3.31	2.76	2.27	1.19927536
4	2008 JHDT	1204-6	2	3.17	2.58	2.33	1.22868217
5	2008 JHDT	1204-6	2	3.81	3.02	2.49	1.2615894
6	2008 JHDT	1204-6	2	3.49	2.57	2.25	1.35797665
7	2008 JHDT	1204-6	2	3	2.37	2.06	1.26582278
8	2008 JHDT	1204-6	2	3.32	2.46	2.16	1.3495935
9	2008 JHDT	1204-6	2	3.26	2.44	2.11	1.33606557
10	2008 JHDT	1204-6	2	3.2	2.44	2.04	1.31147541
11	2008 JHDT	1204-6	2	3.66	2.88	2.51	1.27083333
12	2008 JHDT	1204-6	2	3.68	3.02	2.53	1.21854305
13	2008 JHDT	1204-6	2	3.42	2.76	2.19	1.23913043
14	2008 JHDT	1204-6	2	3.34	2.47	2.14	1.35222672
15	2008 JHDT	1204-6	2	3.98	2.97	2.53	1.34006734
16	2008 JHDT	1204-6	2	2.87	2.19	1.7	1.31050228
17	2008 JHDT	1204-6	2	3.33	2.35	1.99	1.41702128
18	2008 JHDT	1204-6	2	3.23	2.34	1.92	1.38034188
19	2008 JHDT	1204-6	2	3.74	2.86	2.4	1.30769231
20	2008 JHDT	1204-6	2	2.99	2.4	1.98	1.24583333
21	2008 JHDT	1204-6	2	3.25	2.55	2.27	1.2745098
22	2008 JHDT	1204-6	2	3.36	2.63	2.07	1.27756654
23	2008 JHDT	1204-6	2	3.36	2.51	1.96	1.33864542
24	2008 JHDT	1204-6	2	3.42	2.51	1.76	1.3625498
25	2008 JHDT	1204-6	2	3.55	2.87	2.23	1.2369338
26	2008 JHDT	1204-6	2	3.33	2.73	2.45	1.21978022
27	2008 JHDT	1204-6	2	2.59	2.04	1.68	1.26960784
28	2008 JHDT	1204-6	2	3.14	2.54	2.15	1.23622047
29	2008 JHDT	1204-6	2	3.33	2.57	2.12	1.29571984
30	2008 JHDT	1204-6	2	4.17	3.3	2.8	1.26363636
HAIMENKOU		**AVERAGE**		**3.391**	**2.643**	**2.2036666**	**1.2862475**
***Cannabis* sp.**		**STDEV**		**0.33080**	**0.30027**	**0.2802398**	**0.05924603**

HAIMENKOU			*Glycine max*			
No.	Site	Context	Length	Width	Thickness	L/W
1	2008 JHAT	2004:6	5.3	3.8	2.93	1.39473684
2	2008 JHDT	1204-6	3.6	2.47	2.22	1.45748988
HAIMENKOU	**AVERAGE**		**4.45**	**3.135**	**2.275**	**1.4261**
Glycine max	**STDEV**		**1.2020**	**0.9404**	**0.5020**	**0.0443**

Appendix 4. Morphometric measurements on main species.

All measurements are in mm, unless otherwise stated.

DAYINGZHUANG				*Oryza sativa*			
No.	Site	Context	Period	Length	Width	Thickness	L/W
1	2017 YHD	H8	2	5.09	2.13	2.09	2.38967136
2	2017 YHD	H8	2	4.72	2.26	1.36	2.08849558
3	2017 YHD	H8	2	4.79	2.66	2.62	1.80075188
4	2017 YHD	H8	2	5.02	2.85	2.4	1.76140351
5	2017 YHD	H8	2	3.1	2.29	2.6	1.35371179
6	2017 YHD	Layer 2	3	4.86	2.77	2.16	1.75451264
7	2017 YHD	Layer 2	3	5.12	2.81	2.4	1.82206406
8	2017 YHD	Layer 3	3	5.35	2.96	2.26	1.80743243
9	2017 YHD	Layer 5	1	5.33	3.07	2.72	1.73615635
10	2017 YHD	Layer 5	1	4.57	2.36	1.66	1.93644068
11	2017 YHD	Layer 5	1	4.57	2.96	2.33	1.54391892
12	2017 YHD	Layer 5	1	4.69	2.71	1.91	1.73062731
13	2017 YHD	Layer 5	1	4.37	2.77	2.15	1.57761733
14	2017 YHD	H30	1	4.06	2.7	1.92	1.5037037
15	2017 YHD	H34	1	4.43	2.53	1.78	1.75098814
16	2017 YHD	H11	2	5.24	2.86	2.33	1.83216783
17	2017 YHD	H28	1	4.52	2.9	2.24	1.55862069
18	2017 YHD	H28	1	4.36	2.61	1.72	1.67049808
19	2017 YHD	H8	2	4.65	2.88	2.17	1.61458333
20	2017 YHD	H8	2	5.49	2.46	2.16	2.23170732
21	2017 YHD	Jicao 4	1	4.68	2.27	1.93	2.06167401
DAYINGZHUANG *Oryza sativa*			AVERAGE	**4.7147**	**2.6576**	**2.1385**	**1.78698795**
			STDEV	**0.5259**	**0.2702**	**0.3394**	**0.24785926**

Appendix 4. Morphometric measurements on main species.

All measurements are in mm, unless otherwise stated.

DAYINGZHUANG				*Setaria italica*			
No.	Site	Context	Period	Length	Width	Thickness	L/W
1	2017 YHD	H9	2	1.4	1.14	1.13	1.22807018
2	2017 YHD	H9	2	1.12	1.33	1	0.84210526
3	2017 YHD	H9	2	1.2	1.32	1.03	0.90909091
4	2017 YHD	5 s3	1	1.29	1.21	1.05	1.0661157
5	2017 YHD	5 s3	1	0.98	1.04	0.76	0.94230769
6	2017 YHD	F1	3	0.87	1	0.87	0.87
7	2017 YHD	H30	1	1.2	1.22	0.86	0.98360656
8	2017 YHD	H30	1	1.2	1.39	1.04	0.86330935
9	2017 YHD	H28	1	1.18	1.28	1.11	0.921875
10	2017 YHD	H33	1	1.33	1.33	0.97	1
11	2017 YHD	H33	1	1.09	1.06	0.84	1.02830189
12	2017 YHD	H8	2	1.15	1.18	0.98	0.97457627
13	2017 YHD	H8	2	1.33	1.29	0.91	1.03100775
14	2017 YHD	H8	2	0.93	1.16	0.88	0.80172414
15	2017 YHD	H8	2	1.13	1.16	0.95	0.97413793
16	2017 YHD	H8	2	1.2	1.29	1.06	0.93023256
17	2017 YHD	H8	2	1.18	1.11	0.98	1.06306306
18	2017 YHD	H8	2	1.11	1.06	0.84	1.04716981
DAYINGZHUANG *Setaria italica*			AVERAGE	**1.1605**	**1.1983**	**0.9588**	**0.9709274**
			STDEV	**0.1369**	**0.1156**	**0.1026**	**0.1009117**

Appendix 4. Morphometric measurements on main species.

All measurements are in mm, unless otherwise stated.

DAYINGZHUANG				*Panicum miliaceum*			
No.	Site	Context	Period	Length	Width	Thickness	L/W
1	2017 YHD	Hedao1-2	1	1.88	1.71	1.17	1.0994152
2	2017 YHD	Hedao1-2	1	1.59	1.49	1.15	1.06711409
3	2017 YHD	Hedao1-2	1	1.73	1.83	1.33	0.94535519
4	2017 YHD	Hedao 1	1	1.57	1.57	1.31	1
5	2017 YHD	Hedao 1	1	1.86	1.54	1.16	1.20779221
6	2017 YHD	Hedao 1	1	1.7	1.75	1.34	0.97142857
7	2017 YHD	Hedao 1	1	1.72	2.03	1.13	0.84729064
8	2017 YHD	Hedao 1	1	1.76	1.69	1.46	1.04142012
9	2017 YHD	Hedao 1	1	1.67	1.76	1.28	0.94886364
10	2017 YHD	Hedao 1	1	1.78	1.52	0.89	1.17105263
11	2017 YHD	H30	1	1.93	2.12	1.52	0.91037736
12	2017 YHD	H15	2	2.01	2.16	1.6	0.93055556
13	2017 YHD	H28	1	1.93	1.6	1.64	1.20625
14	2017 YHD	H29	1	1.47	1.58	1.44	0.93037975
15	2017 YHD	H29	1	1.85	1.68	1.64	1.10119048
DAYINGZHUANG *Panicum miliaceum*			AVERAGE	**1.7633**	**1.7353**	**1.3373**	**1.02523236**
			STDEV	**0.1503**	**0.2147**	**0.2160**	**0.11313948**

Appendix 4. Morphometric measurements on main species.

All measurements are in mm, unless otherwise stated.

DAYINGZHUANG				*Triticum aestivum*			
No.	Site	Context	Period	Length	Width	thickness	L/W
1	2017 YHD	H9	2	3.39	2.55	2.05	1.32941176
2	2017 YHD	HDM3	2	4.12	2.46	2.39	1.67479675
3	2017 YHD	HDM3	2	4.32	2.83	2.54	1.52650177
4	2017 YHD	HDM3	2	3.55	2.27	2.16	1.56387665
5	2017 YHD	Hedao 1	1	3.37	2.75	2.39	1.22545455
6	2017 YHD	Hedao 1	1	4.81	3.55	2.99	1.35492958
7	2017 YHD	Hedao 1	1	4.15	3.18	2.77	1.30503145
8	2017 YHD	Hedao 1	1	3.91	3.3	2.95	1.18484848
9	2017 YHD	Hedao 1	1	3.48	2.77	2.24	1.25631769
10	2017 YHD	Hedao 1	1	4.17	3.09	2.99	1.34951456
11	2017 YHD	Hedao 1	1	3.97	3.16	2.94	1.25632911
12	2017 YHD	Hedao 1	1	4.44	3.49	2.88	1.2722063
13	2017 YHD	Hedao 1	1	4.55	2.9	2.27	1.56896552
14	2017 YHD	Hedao 1	1	4.6	3.2	2.86	1.4375
15	2017 YHD	Hedao 1	1	4.27	3.09	2.77	1.38187702
16	2017 YHD	Hedao 1	1	3.66	2.78	2.42	1.31654676
17	2017 YHD	Hedao 1	1	3.79	3.09	2.64	1.22653722
18	2017 YHD	Hedao 1	1	3.89	2.87	2.62	1.3554007
19	2017 YHD	Hedao 1	1	3.84	2.76	2.41	1.39130435
20	2017 YHD	Hedao 1	1	3.86	2.99	2.7	1.2909699
21	2017 YHD	Hedao 1	1	4.23	2.89	2.27	1.46366782
22	2017 YHD	Hedao 1	1	3.78	3.05	2.88	1.23934426
23	2017 YHD	Hedao 1	1	4.32	2.74	2.48	1.57664234
24	2017 YHD	Hedao 1	1	3.78	2.86	2.5	1.32167832
25	2017 YHD	Hedao 1	1	4.5	3.31	2.8	1.35951662
26	2017 YHD	Hedao 1	1	4.93	3.44	2.69	1.43313953
27	2017 YHD	Hedao 1	1	4.14	2.55	2.42	1.62352941
28	2017 YHD	Hedao 1	1	4.29	3.08	2.45	1.39285714
29	2017 YHD	Hedao 1	1	3.75	2.46	2.56	1.52439024
30	2017 YHD	Hedao 1	1	3.46	2.76	2.36	1.25362319
31	2017 YHD	Hedao 1	1	3.62	2.83		1.27915194
32	2017 YHD	Hedao 1	1	4.01	3.01		1.33222591
33	2017 YHD	Hedao 1	1	3.71	2.97		1.24915825
34	2017 YHD	Hedao 1	1	4.89	3.3		1.48181818
35	2017 YHD	Hedao 1-2	1	4.69	3.11	2.68	1.50803859
36	2017 YHD	Hedao 1-2	1	4.53	3.81	2.74	1.18897638
37	2017 YHD	Hedao 1-2	1	3.55	3	2.3	1.18333333
38	2017 YHD	Hedao 1-2	1	4.25	3.03	2.61	1.40264026
39	2017 YHD	Hedao 1-2	1	4.12	2.94	2.77	1.40136054
40	2017 YHD	Hedao 1-2	1	4.49	3.3	2.63	1.36060606

Appendix 4. Morphometric measurements on main species.

All measurements are in mm, unless otherwise stated.

DAYINGZHUANG				*Triticum aestivum*			
No.	Site	Context	Period	Length	Width	thickness	L/W
41	2017 YHD	Hedao 1-2	1	3.77	2.97	2.5	1.26936027
42	2017 YHD	Hedao 1-2	1	4.01	3.16	2.53	1.26898734
43	2017 YHD	Hedao 1-2	1	4.3	2.99	2.73	1.43812709
44	2017 YHD	Hedao 1-2	1	4.12	2.82	2.61	1.46099291
45	2017 YHD	Hedao 1-2	1	4.04	2.93	2.81	1.37883959
46	2017 YHD	Hedao 1-2	1	4.18	2.97	2.67	1.40740741
47	2017 YHD	Hedao 1-2	1	4.34	3.56	3.02	1.21910112
48	2017 YHD	Hedao 1-2	1	5.03	3.4	3.06	1.47941176
49	2017 YHD	Hedao 1-2	1	4.08	3.1	2.42	1.31612903
50	2017 YHD	Hedao 1-2	1	4.04	3.1	2.59	1.30322581
51	2017 YHD	Hedao 1-2	1	4.4	3.54	2.83	1.24293785
52	2017 YHD	Hedao 1-2	1	4	3.49	2.67	1.14613181
53	2017 YHD	Hedao 1-2	1	3.91	3.05	2.2	1.28196721
54	2017 YHD	Hedao 1-2	1	4.25	3.27	2.72	1.29969419
55	2017 YHD	Hedao 1-2	1	3.72	2.91	1.99	1.27835052
56	2017 YHD	Hedao 1-2	1	4.51	3.46	2.61	1.30346821
57	2017 YHD	Hedao 1-2	1	4.36	2.87	2.54	1.51916376
58	2017 YHD	Hedao 1-2	1	4.08	2.82	2.64	1.44680851
59	2017 YHD	Hedao 1-2	1	3.7	2.62	2.24	1.41221374
60	2017 YHD	Hedao 1-2	1	4.14	2.66	2.53	1.55639098
61	2017 YHD	Hedao 1-2	1	4.85	3.45	2.97	1.4057971
62	2017 YHD	Hedao 1-2	1	3.81	2.98	2.6	1.27852349
63	2017 YHD	Hedao 1-2	1	4.32	3.49	2.67	1.23782235
64	2017 YHD	Hedao 1-2	1	4.54	3.31	3.17	1.37160121
65	2017 YHD	Jicao 2	1	4.62	3.02	2.39	1.52980132
66	2017 YHD	Jicao 2	1	4.34	2.07	1.67	2.09661836
67	2017 YHD	Layer 2	3	4.71	3.57	2.31	1.31932773
68	2017 YHD	Layer 3	3	3.16	2.24	2.13	1.41071429
69	2017 YHD	Layer 3	3	3.57	2.95	2.59	1.21016949
70	2017 YHD	Layer 3	3	3.9	2.84	2.48	1.37323944
71	2017 YHD	Layer 3	3	3.95	2.81	2.63	1.40569395
72	2017 YHD	Layer 4	2	4.43	2.76	2.42	1.60507246
73	2017 YHD	Layer 4	2	4.44	3.09	2.92	1.4368932
74	2017 YHD	Layer 4	2	3.58	2.22	2.08	1.61261261
75	2017 YHD	Layer 5	1	3.75	2.57	2.24	1.45914397
76	2017 YHD	Layer 5	1	4.15	2.9	2.49	1.43103448
77	2017 YHD	Layer 5	1	3.04	2.12	2.15	1.43396226
78	2017 YHD	Layer 5	1	3.56	2.69		1.32342007
79	2017 YHD	Layer 5	1	3.24	2.12		1.52830189
80	2017 YHD	Layer 5	1	3.61	2.73		1.32234432

Appendix 4. Morphometric measurements on main species.

All measurements are in mm, unless otherwise stated.

DAYINGZHUANG				*Triticum aestivum*			
No.	Site	Context	Period	Length	Width	thickness	L/W
81	2017 YHD	F1	2	3.67	2.55	2.13	1.43921569
82	2017 YHD	F1	2	3.55	2.42	2.39	1.46694215
83	2017 YHD	H11	2	4.4	4.2	2.85	1.04761905
84	2017 YHD	H11	2	4.89	3.4	2.04	1.43823529
85	2017 YHD	H11	2	3.72	3.03	2.75	1.22772277
86	2017 YHD	H15	2	4.08	2.81	1.6	1.4519573
87	2017 YHD	H15	2	4.13	2.94	2.59	1.4047619
88	2017 YHD	H15	2	3.55	2.44		1.45491803
89	2017 YHD	H15	2	3.55	2.57		1.38132296
90	2017 YHD	H8	2	4.34	2.68	2.33	1.61940299
DAYINGZHUANG *Triticum aestivum*			\VERAGE	**4.0623**	**2.9575**	**2.5385**	**1.38441022**
			STDEV	**0.4320**	**0.3845**	**0.3019**	**0.14378873**

DAYINGZHUANG				*Hordeum vulgare*			
No.	Site	Context	Period	Length	Width	Thickness	L/W
1	2017 YHD	Hedao 1	1	5.93	2.62	2.1	2.26335878
2	2017 YHD	Hedao 1	1	5.5	3.02	2.55	1.82119205
3	2017 YHD	Layer 4	2	4.97	2.5	2.08	1.988
4	2017 YHD	F1		4.12	2.3	1.78	1.79130435
DAYINGZHUANG *Hordeum vulgare*			AVERAGE	**5.13**	**2.61**	**2.1275**	**1.96596379**
			stdev	**0.7794**	**0.3035**	**0.3174**	**0.21632857**

Appendix 4. Morphometric measurements on main species.

All measurements are in mm, unless otherwise stated.

DAYINGZHUANG			*Chenopodium* sp.				
No.	Context	Period	Length	Nose	Width	Thickness	Seed coat Thickness um
1	F1-1	2/3	1.04	0.132	0.926	0.341	
2	F1-1	2/3	1.1	0.135	0.916	0.618	
3	F1-1	2/3	1.02	0.145	0.97	0.368	
4	F1-1	2/3	1.02	0.129	0.959	0.335	
5	F1-1	2/3	1.05	0.114	0.967	0.61	39.8840526
6	F1-1	2/3	0.918	0.0823	0.896	0.499	30.2428485
7	F1-1	2/3	0.966	0.121	0.88	0.404	35.7919063
8	H11	2/3	1.27	0.15	1.16	0.59	
9	H11	2/3	1.35	0.165	1.2	0.662	
10	H11	2/3	1.15	0.104	1.09	0.612	
11	H11	2/3	1.23	0.179	1.12	0.617	
12	H11	2/3	1.23	0.156	1.18	0.687	
13	H11	2/3	1.19	0.117	1.08	0.62	
14	H11	2/3	1.28	0.213	1.38	0.742	
15	H11	2/3	1.13	0.145	1.08	0.509	
16	H9	2/3	0.978	0.077	0.962	0.443	
17	H9	2/3	1.04	0.157	0.912	0.548	
18	H9	2/3	1.07	0.131	0.922	0.536	32.6842222
19	H9	2/3	1.14	0.143	1.04	0.374	36.1108947
20	H9	2/3	1.04	0.0862	0.992	0.488	
21	H9	2/3	1.4	0.219	1.36	0.532	
22	H9	2/3	1.27	0.161	1.09	0.856	23.95075
23	H9	2/3	1.42	0.145	1.06	0.815	
24	Layer 5	1	1.16	0.12	1.01	0.86	
25	Layer 5	1	1.03	0.146	0.868	0.494	
26	Layer 5	1	0.94	0.101	0.895	0.326	
27	Layer 5	1	0.903	0.0845	0.901	0.458	
28	Layer 5	1	0.955	0.115	0.94	0.49	30.8504
DAYINGZHUANG *Chenopodium* sp		AVERAGE	**1.12**	**0.13**	**1.03**	**0.55**	**32.79**
		STDEV	**0.15**	**0.04**	**0.14**	**0.15**	**5.14**

Appendix 5. Yunnan.

Site	Drainage system/ Location	Elevation (m asl)	Exc. date	Exc. area (m^2)	Site size (ha)	Chronology	Features	House structure	Graves characteristics	Ceramics	Lithic	Main archaeobotanical remains	Faunal remains	References
Baiyangcun 白羊村	Middle Jinsha, Binchuan county	1442	1973/74 2013/2014	290 +100	10-20	AMS 2650-1690 cal BC	11 houses 14 hearts 48 pits 34 graves	wattle and daub	shaft pit: extended supine position	Baiyangcun type: impressed/ incised	ground	*Oryza sativa* *Setaria italica* *P. miliaceum* *Echinochloa* sp. *Glycine soja* *Vigna* sp. *Cajanus* sp. *Cucumis* sp. *Euryale ferox* *Vitis* sp.	Pig Cattle Goat/sheep Wild boar Black bear Deer	Yunnan 1981; Dal Martello et al. 2018; Dal Martello 2019
Haidong 海东	Qilu Lake, Tonghai county		1988/89	372	3-8.5	c. 2500-1750 BC	30 graves 40 hearths	shell mound site	shaft pit: extended facing E/ crouched facing S supine position	Shizhaishan (Neolithic type): corded ware	ground	Rice [hand- picked]	Lacustrine resources; tortoise shells, and other unspecified animal bones	He 1990; Xiao 2001; Zhang & Hung 2010; Yao 2010; D'Alpoim Guedes & Butler 2014
Xinguang 新光	Upper Langcan, Yongping county	1600	1993/94	1000	3-8	2500-1750 BC	21 pits 6 houses 1 moat 7 hearths	Semi-subterr./ wattle and daub		Xinguang type: impressed/ incised	ground	Charred rice grains from G3 [hand-picked]	n/a	Yunnan 2002; Yao 2010; D'Alpoim Guedes & Butler 2014
Dadunzi 大墩子	Middle Jinsha, Yuanmou county	1080	1972/73 1999- 2010	921	1.6	AMS 2200-1650 cal BC	15 houses 5 hearts 4 pits 37 graves	wattle and daub/ semi-subterr./ stilt houses	shaft pits/ stone cists/ urns	Dadunzi type: impressed/ incised	ground	*Oryza sativa* *Setaria italica P. miliaceum* *Vigna* sp. Cucurbitaceae	Pig Dog Cattle Goat/sheep Chicken Muntjac Deer	Jin et al. 2014

Appendix 5. Yunnan.

Site	Drainage system/ Location	Elevation (m asl)	Exc. date	Exc. area (m^2)	Site size (ha)	Chronology	Features	House structure	Graves characteristics	Ceramics	Lithic	Main archaeobotanical remains	Faunal remains	References
													Lacustrine resources	
Xingyi 兴义	Qilu Lake, Tonghai county (Kunming)		2015/16	190	52	c. 2000-0 BC	47 floors 18 houses 24 graves 16 pits 4 streets 2 ditches 1 walled structure	n/a	Shaft pits/ urns: flexed	Shizhaishan (Neolithic type): corded ware		Acorns, *Oryza* sp. (unpubl.)	Abundant lacustrine resources: *Margarya* sp.	Yunnan 2017
Haimenkou 海门口	Middle Jinsha, Jianchuan county	2190	1957 1978 2008	1350	10	AMS 1600-400 cal BC	Unknown no. of Houses Pits Hearths	wood pile-stilt houses		Early: Baiyangcun type: : incised/ impressed Late: NW China ceramics	ground	*Oryza sativa* *Setaria italica* *P. miliaceum* *Chenopodium* sp. *Triticum aestivum* *Hordeum vulgare* *Fagopyrum* cf *esculentum* *Cannabis* sp. *Prunus* cf *persica* *Prunus* cf *armeniaca* *Quercus* sp.	*Sus domesticus* *Ovis/Capra* sp. *Canis familiaris* *Bos gaurus* *Cervus unicolor* *Sus scrofa* *Axis porcinus* *M. muntjak* *M. berezovskii,* *Macaca* sp. *Ursus* sp. *Lepus* sp. *Volpe* sp.	Yunnan 1958; Xue 2010; Jin 2013; D'Alpoim Guedes & Butler 2014; Li & Min 2014; Wang 2018

Appendix 5. Yunnan.

Site	Drainage system/ Location	Elevation (m asl)	Exc. date	Exc. area (m^2)	Site size (ha)	Chronology	Features	House structure	Graves characteristics	Ceramics	Lithic	Main archaeobotanical remains	Faunal remains	References
Mopandi 磨盘地	Middle Jinsha, Yongren county	1535	1983	100	0.8	c. 1400 BC	2 houses 1 hearth 17 postholes 1 ditch 7 graves	wattle and daub, mostly rectangular, some circular	stone cists	Caiyuanzi type: incised/ impressed	ground	Rice	Pig Cattle Goat/sheep Dog Chicken Deer Muntjac	Yunnan 2003; Zhao 2003; D'Alpoim Guedes & Butler 2014
Shifodong 石佛洞	Middle Langcan, Gengma county	968	1982 2003	750	0.3	c. 1400-1100 BC	Several hearths	Cave site		Shifodong type: incised/ impressed	ground	*Oryza sativa* *Setaria italica* *Chenopodium* sp. *Tamarindus* cf *indica* Indet. tree legume	Pig Dog Cattle Deer Horse? Indet. birds/ fish species	Kan/ Yunnan 1983; Liu & Dai 2008; Yao 2010; Zhao 2010; D'Alpoim Guedes & Butler 2014
Nanbiqiao 南碧桥	Lower Langcan		1982		0.3	c. 1250-970 BC		Cave site		Shifodong type	ground	Rice [hand-picked]	n/a	Kan/ Yunnan 1983; An 1999
Shizhaishan 石寨山	Dianchi Lake, Jinning county		1953 1955 1958 1960	204.3	0.05?	AMS 779-488 cal BC	28 graves		shaft pit: supine extended	Dian type: Incised/ impressed		*Triticum aestivum* *Oryza sativa* *Setaria italica*	n/a	Yunnan 1963; Yao & Jiang 2012
Hebosuo 河泊所	Dianchi Lake Jinning county	1760	2014	25?	31	AMS 735 cal BC-40 AD				Dian type		*Oryza sativa* *Triticum aestivum* *Setaria italica* *P. miliaceum* *Glycine max*	n/a	Yang 2016; Yao et al. 2015; Yao & Jiang 2012

Appendix 5. Yunnan.

Site	Drainage system/ Location	Elevation (m asl)	Exc. date	Exc. area (m^2)	Site size (ha)	Chronology	Features	House structure	Graves characteristics	Ceramics	Lithic	Main archaeobotanical remains	Faunal remains	References
Anjiang	Dianchi Lake Jinning county	1910	2008 2010/11	Survey		AMS 770- 430 cal BC	n/a			Shizhaishan/ Dian		*Oryza sativa* *Triticum aestivum* *Hordeum vulgare* *Setaria italica* *P. miliaceum* *Chenopodium* sp.	n/a	Yao et al. 2015
Shilinggang 石岭岗	Middle Nujiang, Lushui county	842	2003 2013/14	500	10	AMS 723- 339 cal BC	42 graves 4 pits 4 floors 2 houses	wattle and daub?	shaft pits	Dianbian type		*Oryza sativa* *Setaria italica*	Pig Goat Cattle Dog Deer	Li et al. 2016; Ren et al. 2017
Dayingzhuang 大營庄	Dianchi Lake, Kunming	1886	2017	500	10	AMS 750-390 cal BC	35 pits 4 houses 5 rivers 2 floors 5 *jicao*	Pavillion structure		Dian type	ground	*Oryza sativa* *Setaria italica* *Triticum aestivum* *Hordeum vulgare* *Chenopodium* sp. *Zantoxhylum* sp.	n/a	Dal Martello 2019
Xueshan 学山	Dianchi Lake, Chengjiang county	1700	2010	35	1.4	c. 700-300 BC	20 houses 260+ graves Unknown no. of pits	Semi-subterr./ wattle and daub	n/a	Dian type		*Triticum aestivum* *Oryza sativa* *Setaria italica* *P. miliaceum* *Glycine max* *Fagopyrum* cf *Hordeum vulgare* Fruits, Acorns	*Margarya melanioides*	Wang 2014; Yunnan 2010

Appendix 5. Yunnan.

Site	Drainage system/ Location	Elevation (m asl)	Exc. date	Exc. area (m²)	Site size (ha)	Chronology	Features	House structure	Graves characteristics	Ceramics	Lithic	Main archaeobotanical remains	Faunal remains	References
Guangfentou 光坟头	Fuxian Lake, Jiangchuan County	1740	1984 2011/12	600	17	c. 700-300 BC	26 houses 30 pits 11 floors	Semi-cript		Dian type		*Triticum aestivum* *Oryza sativa* *Setaria italica* *Hordeum* sp *P. miliaceum* *Chenopodium* sp.	n/a	Li & Liu 2016
Yubeidi 玉碑地	Bingu River (Jinsha River), Dongchuan County	2000	2013	300	1.8	c. 700-300 BC	15 houses 49 pits 6 graves Unknown no. of floors and postholes	Semi-subterr.	Urns	Dian type		*Oryza sativa* *Triticum aestivum* *Setaria italica* *Glycine max* *Chenopodium* sp. *Zantoxhylum* sp.	n/a	Yang 2016
Xiaogucheng	Dianchi Lake	1917	2008 2010/11	Survey		c. 700-300 BC	n/a			Dian type		*Oryza sativa* *P. miliaceum* *Chenopodium* sp.	n/a	Yao et al 2015

Appendix 5. Sichuan, Chongqing and the Tibetan Plateau

Site	Drainage system/ Location	Elevation (m asl)	Exc. date	Exc. area (m^2)	Site size (ha)	Chronology	Features	House structure	Graves characteristics	Ceramics	Lithic	Main archaeobotanical remains	Faunal remains	References
Yingpanshan 营盘山	Upper Minjiang, Mao county	1650	2000~2006	n/a	15	C14 3300-2600 cal BC	11 houses 9 (human bones) pits 120 pits 4 kilns 13 hearths	wattle and daub?		NW China style (Majiayao)	ground and polished	*Setaria italica* *P. miliaceum* *Glycine* sp. *Chenopodium* sp. *Prunus* spp.	n/a	Zhao 2010
Haxiu 哈休	Upper Daduhe, Ma'erkang		2006	n/a	n/a	c. 4000-3000 BC	Unknown no. of pits			Painted (Majiayao)	ground and polished	*P. miliaceum* *Setaria italica* *Prunus* sp. *Avena* sp. *Zanthoxylum simulans*	Dog Pig Cattle Macaca Muntjac Deer	Zhao 2008; D'Alpoim Guedes 2014; Stevens & Fuller 2017; Chen & He 2007
Baodun 宝墩	Sichuan Basin, Chengdu Plain	470	1996-2009/2010	64	n/a	AMS 2700-2000 cal BC	12 pits 1 river			Baodun		*Oryza sativa* *Setaria italica* *Vicia* sp. *Coix* lachryma-jobi *Vigna* sp. *Chenopodium* sp. *Echinochloa* sp. *Crataegus* sp.	n/a	He et al. 2012; D'Alpoim Guedes et al. 2013; Chengdu et al. 2000

Appendix 5. Sichuan, Chongqing and the Tibetan Plateau

Site	Drainage system/ Location	Elevation (m asl)	Exc. date	Exc. area (m^2)	Site size (ha)	Chronology	Features	House structure	Graves characteristics	Ceramics	Lithic	Main archaeobotanical remains	Faunal remains	References
Zhongba 中靶	Three Gorges (Yangzi River), Zhongxian County (Chongqing)	660	1959 1987 1997 1999/2001 2003	4600 175 2600 200	n/a	AMS 2470- 200 cal BC	29 floors 54 pits 3 gullies 3 burials 3 kilns + 19 pits 8 floors 1 burial + 145 pits 36 floors 5 gullies 58 pits 37 floors 13 gullies 5 burials Unknown no. of postholes	(wattle and daub?)	shaft pit	Connection with Middle Yangzi Rice producing sites		*P. miliaceum* *Setaria italica* *Oryza sativa*	*Sus scrofa* *Nycterteutes procyonides* *Rhizomys sinensis* *Canis familiaris* *Bos p.* *Bubalus* sp. *Cervus* spp. *Vulpes* sp. *Macaca* sp. Fish: Cypriniformes Siluriformes Perciformes + giant salamander Snakes turtles	Flad 2011
Gaopo 高坡	An'ning River, Chengdu Plain		2011	272	0.56	c. 1600-1300	n/a					*Oryza sativa;* *Panicum miliaceum;* *Chenopodium* sp.	n/a	Chengdu, 2012

Appendix 5. Sichuan, Chongqing and the Tibetan Plateau

Site	Drainage system/ Location	Elevation (m asl)	Exc. date	Exc. area (m^2)	Site size (ha)	Chronology	Features	House structure	Graves characteristics	Ceramics	Lithic	Main archaeobotanical remains	Faunal remains	References
Ashaonao 阿梢垴	Jiuzhaigou (E Tibet Plateau, in Sichuan)	2600	2008 2010			c. 1400-1000 cal BC/ 400-1 cal BC	1 ash pit					*Triticum aestivum* *Hordeum vulgare* *Setaria italica* *Chenopodium* sp. Fruits	Sheep; Deer	D'Alpoim Guedes et al. 2018; D'Alpoim Guedes et al. 2015
Zhonghai guoji shequ 中海国际社区	Sichuan Basin, Jinniu District (Chengdu)		2004/2005	3500	1.26	c. 1400 BC?	18 pits 1 house numerous postholes			Baodun style?		*Oryza sativa* *Triticum aestivum* *Setaria italica* *P. miliaceum* *Chenopodium* sp. Fruits	n/a	Chengdu 2012b; Chengdu 2005
Zhengjiaba 郑家坝	Jialing River (Yangzi), Nanchong city (Langzhong)	354	2011	2000	16	c. 1300 BC	n/a					*Oryza sativa* *Setaria italica* *P. miliaceum* *Hordeum vulgare* *Glycine* sp. *Vigna* sp. *Chenopodium* sp. *Vitis* sp. *Prunus* sp.	n/a	Chengdu 2011
Boluocun 菠萝村	Sichuan Basin, Pi District (Chengdu)	566	2011	1600	31.7	c. 1250-800 BC	143 pits 5 ditches 4 graves 2 kilns					*Oryza sativa* *Setaria italica* *P. miliaceum* *Chenopodium* sp. Fruits	Macaca	Chengdu 2012

Appendix 5. Sichuan, Chongqing and the Tibetan Plateau

Site	Drainage system/ Location	Elevation (m asl)	Exc. date	Exc. area (m^2)	Site size (ha)	Chronology	Features	House structure	Graves characteristics	Ceramics	Lithic	Main archaeobotanical remains	Faunal remains	References
Sangongtang 三宫堂	Sichuan Basin, Shuangliu District (Chengdu)	481	2009/10	650	10	c. 1250-800 BC	90+ pits 10 streams 1 grave 1 kiln					*Oryza sativa* *Setaria Italica* *P. miliaceum* *Glycine* sp. *Vigna* sp. Fruits	n/a	Chengdu et al. 2013
Jinniu 5C / Jinsha 金牛区 5 号 C 地点 / 金沙	Sichuan Basin, Chengdu	503	2007/08	2500		c. 1250-700 BC	Unknown no. of houses, kilns, pits, ditches, graves, and others.					*Oryza sativa* *Setaria Italica* *Panicum miliaceum* *Glycine* sp.	n/a	Jiang et al. n.d.
NETP survey[1] (18 sites)	Yellow River and tributaries; Qinghai Lake, Qaidam Basin - NE Tibetan Plateau	various below 2500 m asl	2008-2013	survey		3200- 1600 cal BC	survey			Cultural connection with Yellow River		*Setaria italica* *Panicum miliaceum*	Sheep	Chen et al. 2015

[1] A total of 54 sites were surveyed during the Northeastern Tibetan Plateau Survey (NEPT, Chen et al., 2015); these are located on the northeastern edge of the Tibetan Plateau in modern Qinghai Province. Even though not formally belonging to the geographical limits of Southwestern China, these sites have been mentioned here as they have strong connections with North Sichuan, as well as providing a point of reference for the southern spread of wheat and barley.

Appendix 5. Sichuan, Chongqing and the Tibetan Plateau

Site	Drainage system/ Location	Elevation (m asl)	Exc. date	Exc. area (m^2)	Site size (ha)	Chronology	Features	House structure	Graves characteristics	Ceramics	Lithic	Main archaeobotanical remains	Faunal remains	References
NETP survey (36 sites, one also present in previous time period)	Yellow River and tributaries; Qinghai Lake, Qaidam Basin	various up to 3800m asl	2008-2013	survey		1600- 400 cal BC	survey			Cultural connection with Yellow River		*Setaria italica* *Panicum miliaceum* *Hordeum vulgare* *Triticum aestivum*	Pig Sheep Cattle Fish Horse	Chen et al. 2015

Appendix 5. Sichuan, Chongqing and the Tibetan Plateau

Site	Drainage system/ Location	Elevation (m asl)	Exc. date	Exc. area (m^2)	Site size (ha)	Chronology	Features	House structure	Graves characteristics	Ceramics	Lithic	Main archaeobotanical remains	Faunal remains	References
Karuo 卡若	Upper Mekong, Eastern Tibet	3100	1978/1979- 2002		1	AMS 2700- 2300 cal BC	28 houses 3 walls 2 platforms 3 stone circles 4 pits	round and rectangular semi-subterranean		Painted pottery showing similarities with NW China-W Sichuan	micro lithics and polished stone tools	*Setaria italica* *Panicum miliaceum* F*ragaria/potentilla sp.* R*ubus sp.*	Pig Fish	D'Alpoim Guedes et al., 2013
Changguogou 昌果沟	Yarlung Tsangpo, Gongga County, Southern Tibet	3570	1994	n/a		c. 1400 BC	1 storage pit with high quantity of charred plant remains					*Triticum aestivum* *Hordeum vulgare* *Setaria italica* *Pisum* sp. *Secale* sp.	n/a	Fu 2010

Appendix 5. Mainland Southeast Asia

Site	Drainage system/ Location	Elevation (m asl)	Exc. date	Exc. area (m²)	Site size (ha)	Chronology	Features	House structure	Graves characteristics	Ceramics	Lithic	Main archaeobotanical remains	Faunal remains	References
Lao Pako	Nam Ngum (Mekong), Laos		1995 2000 2002/03			2600-2200	n/a					Rice- husk chaff in pottery and impressions *Oryza* phytoliths	n/a	Källén 2004; Bowdery 1999
Non Pa Wai	Lopburi River, Khao Wong Prachan Valley-Thailand		1986-90	370	5	2470-2200; 1000-700	50+ burials copper smelting furnaces		n/a	Incised/ impressed: double S decoration; bivalve moulds for metal axes	polished	*Setaria italica*; 2nd phase *Oryza sativa, Setaria italica*, Job's tear?	*Sus scrofa* *Canis familiaris* *Cervus* spp. *Bos* sp. *Bubalus bubalis* *Bos frontalis* *Bos indicus* Claridae family *Mystis* sp. Birds (fowl) turtles snakes & lizards	Weber et al. 2010; Pigott et al. 2006; Rispoli et al. 2013
Non Mak La	Lopburi River, Khao Wong Prachan Valley-Thailand		1994	100	3	2100-1450; 1450-700	56 burials; Copper smelting furnaces		shaft pit			*Setaria italica* 2nd phase: *Oryza sativa, Setaria italica*, Job's tear? panicoid, millet and palm morphotypes phytoliths	n/a	Pigott et al. 2006; Weber et al. 2010

Appendix 5. Mainland Southeast Asia

Site	Drainage system/ Location	Elevation (m asl)	Exc. date	Exc. area (m^2)	Site size (ha)	Chronology	Features	House structure	Graves characteristics	Ceramics	Lithic	Main archaeobotanical remains	Faunal remains	References
Khok Phanom Di	Bang Pakong River, Chonburi Province-Central Thailand	12	1979 1982 1985	15 21 100	5	2000-1400	154 burials		shaft pit			*Oryza sativa* *Coix* sp. *Paspalum* sp. *Eragrostis* sp. *Amaranthus* sp. *Eleocharis* sp. *Cyperus* sp. *Oryza* phytoliths	*Sus scrofa* *Macaca* sp. *Cervus* sp. *Canis* sp. *Muntiacus muntjak* *Bos* sp. *Bubalus bubalis*	Thompson 1996
Rach Nui	Vam Co Dong, Vam Co Tay, Dong Nai Rivers, Long An province-Vietnam	0-3	1978 2003 2012	60 76 61		1845-1385	mound site with artificial platforms and clay floors			cord mark and combed patterns decoration	ground	*Oryza sativa* *Setaria italica* roots & tubers sedges	Shellfish&fish: *Geloina coaxans* *Cerithidea obtusa* *Neritina violacea* *Ellobium* sp. Reptiles: *Batagur* sp, turtles: *Cuora* sp. *Cyclemys* sp. *Crocodylus porosus* *Varanus* sp. Mammals: *Macaca* sp. Pig Dog Deer Birds	Oxenham et al. 2015; Castillo et al., 2018

Appendix 5. Mainland Southeast Asia

Site	Drainage system/ Location	Elevation (m asl)	Exc. date	Exc. area (m^2)	Site size (ha)	Chronology	Features	House structure	Graves characteristics	Ceramics	Lithic	Main archaeobotanical remains	Faunal remains	References
Tha Kae	Lopburi River, Khao Wong Prachan Valley- Thailand		1970s 1980s		12	1700-1100				Incised/impressed: double S decoration		Rice- husk chaff in pottery and impressions *Oryza* morphotypes		Rispoli et al. 2013
Ban Chiang	Mekong River, Thailand		1974/75	200	10	1650-1050; 1050-400	123 burials			footed corded marked wares with incised/impressed designs		Rice-grains and husk chaff in pottery and impressions	*Bos* sp *Cervus* sp. *Sus scrofa* *Canis familiaris* *Bubalus bubalis*	Yen 1982; White 1982; Thompson 1996
Ban Non Wat	Mun River, Nakhon Ratchasima Province- Thailand		seven seasons	892		1750-1050; 1050-420; 420 BC- 500 AD	13 burials		flexed	incised/impressed decorations		*Oryza sativa*	Pig	Castillo, 2013; Silva et al, 2015: S1 Map
Nil Kham Haeng	Lopburi River, Khao Wong Prachan Valley- Thailand		1986 1990 1992		4	1350-800; 800-500	copper smelting furnaces					*Setaria italica* 2nd phase: *Oryza sativa* *Setaria italica*, Job's tear? *Oryza* and panicoid morphoptypes Phytoliths	Turtles	Pigott et al. 2006; Weber et al. 2010

Appendix 5. Mainland Southeast Asia

Site	Drainage system/ Location	Elevation (m asl)	Exc. date	Exc. area (m²)	Site size (ha)	Chronology	Features	House structure	Graves characteristics	Ceramics	Lithic	Main archaeobotanical remains	Faunal remains	References
Lo Gach	Vietnam					1100-700						*Oryza sativa* Job's tear?		Castillo, n.d.
Ban Na Di	Udon Thani-Thailand		1965/66	204		900-500	91 burials		shaft pits			*Oryza sativa* *Oryza* phytoliths	Cattle Pig Crocodile Frogs Turtles Chicken	Chang & Loresto 1984; Vincent 2002; Vincent 2003b
Khao Sam Kheo	Tha Tapao River, Chumphon Province-Thailand	30	2006 2009			AMS 400-100 cal BC						*Oryza japonica* *Setaria italica* *Eleusine* cf *coracana* *Vigna* spp (including *umbellata* *Macrotyloma uniflorum* *Citrus* sp. *Gossypium* sp. *Sesamum indicum*		Castillo 2013; Castillo & Fuller 2010; Castillo et al., 2016
Non Hua Raet						500-0						Rice		Castillo, n.d.
Khao Sek						c. 400- 100 BC						*Oryza sativa*		Castillo, 2018

Appendix 5. Mainland Southeast Asia

Site	Drainage system/ Location	Elevation (m asl)	Exc. date	Exc. area (m^2)	Site size (ha)	Chronology	Features	House structure	Graves characteristics	Ceramics	Lithic	Main archaeobotanical remains	Faunal remains	References
Ban Don Ta Phet						300-100						Rice hemp cotton [hand-picked]	silk	Castillo, 2012
Phu Khao Thong	Kra Isthmus, Thailand		2006-09			AMS 200 BC-AD 20						*Oryza japonica* *Vigna* spp. (including *umbellata*) *Macrotyloma uniflorum* *Citrus* sp. *Gossypium* sp. *Sesamum indicum*		Castillo 2013; Castillo et al. 2016
Phromtin Thai	Chao Phraya River, Central Thailand		1991			500 BC-900 AD						*Oryza sativa* *Vigna* sp. (possibly mung bean) Indet. fabaceae *Setaria italica* High quantity of Cyperaceae weeds		D'Alpoim Guedes et al. 2018

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Site	Lab No.	Original Samples No.	Sample Material	Archaeological context	h.l. 5730	h.l. 5568	68.20% cal BC	95.40% cal BC	Method	REFERENCES
YUNNAN				m						
Baiyangcun	ZK-0220	n/a	wood charcoal	F3 posthole2	3770±85	3663±85	2200-1920	2300-1770	LSC	Yunnan, 1981; Zhongguo, 1978
	ZK-0330	n/a	wood charcoal	Unno. posthole in trench 7	3675±85	3571±85	2030-1770	2190-1690	LSC	Yunnan, 1981; Zhongguo ,1978
	Beta-501547	2013YBB (5)	Rice grain	Layer 5		3480±30	1880-1750	1890-1690	AMS	Dal Martello 2019
	OxA-33286	2013YBBT2(8)c S4	Rice grain	Layer 8		3743±29	2210-2060	2280-2030	AMS	Dal Martello et al., 2018
	OxA-33290	2013YBBT2(8)c S4	Rice grain	Layer 8		3764±28	2280-2130	2290-2040	AMS	Dal Martello et al., 2018
	OxA-33291	2013YBBT2(9)c S3	Rice grain	Layer 9		3718±29	2200-2040	2210-2030	AMS	Dal Martello et al., 2018
	OxA-33327	2013YBBT2(9)c S3	Rice grain	Layer 9		3689±35	2140-2030	2200-1960	AMS	Dal Martello et al., 2018
	OxA-33328	2013H118	Rice grain	H118（sealed by layer 15）		3731±30	2200-2040	2270-2030	AMS	Dal Martello et al 2018
	OxA-33293	2013H118	Rice grain	H118（sealed by layer 15）		3735±29	2200-2050	2270-2030	AMS	Dal Martello et al 2018
	OxA-33287	2013YBBT2(17) S4	Rice grain	Layer 17		3916±29	2470-2340	2480-2290	AMS	Dal Martello et al., 2018
	OxA-33292	2013YBBT2(17) S3	Rice grain	Layer 17		3898±29	2470-2340	2470-2290	AMS	Dal Martello et al., 2018
	SUERC-73806	2013YBBT2(20)	Millet grain	Layer 20		3929±23	2480-2340	2490-2330	AMS	Dal Martello, 2019
	OxA-33288	2013YBBT2(21)c S4	Rice grain	Layer 21		3958±30	2570-2410	2570-2340	AMS	Dal Martello et al., 2018
	OxA-33289	2013YBBT2(21)c S4	Rice grain	Layer 21		4035±28	2580-2490	2630-2470	AMS	Dal Martello et al., 2018
	SUERC- 73802	2013YBBT2(24) S3	Millet grain	Layer 24		4110±34	2860-2580	2879-2570	AMS	Dal Martello, 2019
Haidong	BK89079?	n/a	n/a	n/a	4235±150	4115±150	2890-2490	3090-2200	LSC?	Xiao, 2001; Yao, 2010

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Xinguang	BK94072	T1104F5	peat	F5	4030±80	3658±70	2140-1940	2280-1780	LSC	Yunnan 2002
	BK94073	T1104I2	peat	I2	3830±70	3668±70	2140-1940	2290-1880	LSC	Yunnan 2002
	BK94074	T1105(8)	peat	Layer 8	3775±70	3721±70	2280-1980	2350-1920	LSC	Yunnan 2002
	BK94075	T1105(6)	peat	Layer 6	3765±70	3916±80	2560-2280	2620-2140	LSC	Yunnan 2002
Dadunzi	ZK-0229	n/a	wood charcoal	F5 posthole 12	3210±90	3119±90			LSC?	Yunnan 1977; Z hongguo 1974
	n/a	2010MDT18-2-S1	Rice grain	Layer 2		3385±30	1740-1630	1750-1610	AMS	Li et al., 2016
	n/a	2010MDT18-H3-2-S1	Rice grain	H3		3420±20	1750-1690	1870-1650	AMS	Li et al., 2016
	n/a	2010MDT18-4-S1	Rice grain	Layer 4		3540±35	1940-1780	1970-1750	AMS	Li et al., 2016
	n/a	2010MDT18-5-S1	Rice grain	Layer 5		3555±25	1950-1880	2010-1770	AMS	Li et al., 2016
	n/a	2010MDT18-7-S1	Rice grain	Layer 7		3555±25	1950-1880	2010-1770	AMS	Li et al., 2016
	n/a	2010MDT18-8-S1	Rice grain	Layer 8		3685±25	2140-2030	2190-1970	AMS	Li et al., 2016
	n/a	2010MDT18-9-S1	Foxtail millet grain	Layer 9		3665±40	2140-1970	2200-1920	AMS	Li et al., 2016
Haimenkou	ZK2335	CH T2 (4)	wood charcoal	Layer 4	2595±75	2520±75	800-540	810-420	LSC	Zhongguo, 1990
	not provided	T1005-4-s1	Rice grain	Layer 4		2400±20	490-400	540-400	AMS	Li & Min 2014
	not provided	T1003-4-s2	Wheat grain	Layer 4		2405±35	520-400	750-390	AMS	Li & Min 2014
	not provided	T100454-s6	Foxtail millet grain	Layer 4		2435±03	730-410	760-400	AMS	Li & Min 2014
	not provided	T1003-5-s2	Wheat grain	Layer 5		2445±35	740-410	760-400	AMS	Li & Min 2014

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Haimenkou	not provided	T1005-6-s4	Rice grain	Layer 6		2960±25	1220-1120	1270-1050	AMS	Li & Min 2014
	not provided	T1003-6-s2	Wheat grain	Layer 6		2975±45	1270-1120	1390-1040	AMS	Li & Min 2014
	not provided	T1003-6-s1	Wheat grain	Layer 6		3000±35	1290-1130	1390-1120	AMS	Li & Min 2014
	not provided	T1004-6-s3	Soybean	Layer 6		3045±40	1390-1230	1400-1220	AMS	Li & Min 2014
	not provided	T1004-6-s3	Foxtail millet grair	Layer 6		3050±30	1390-1260	1410-1120	AMS	Li & Min 2014
	not provided	T1003-7-s2	Wheat grain	Layer 7		3060±35	1400-1270	1420-1220	AMS	Li & Min 2014
	not provided	T1004-7-s6	Rice grain	Layer 7		3075±35	1400-1290	1430-1230	AMS	Li & Min 2014
	not provided	T1005-7-s2	Wheat grain	Layer 7		3095±30	1420-1300	1430-1270	AMS	Li & Min 2014
	not provided	T1005-7-s1	Wheat grain	Layer 7		3125±30	1440-1310	1500-1290	AMS	Li & Min 2014
	not provided	T1004-7-s3	Foxtail millet grair	Layer 7		3210±30	1510-1440	1600-1410	AMS	Li & Min 2014
	not provided	T1003-7-s2	Rice grain	Layer 7		3240±40	1610-1450	1620-1430	AMS	Li & Min 2014
	not provided	T1005-8-s2	Wheat grain	Layer 8		3105±25	1420-1300	1440-1290	AMS	Li & Min 2014
	not provided	T1005-8-s2	Rice grain	Layer 8		3250±35	1610-1460	1620-1440	AMS	Li & Min 2014
	not provided	T1003-8-s2	Foxtail millet grair	Layer 8		3275±35	1610-1460	1620-1450	AMS	Li & Min 2014
	not provided	T1003-9-s2	Foxtail millet grair	Layer 9		3230±40	1600-1440	1620-1420	AMS	Li & Min 2014
	not provided	T1003-9-s2	Rice grain	Layer 9		3275±35	1610-1500	1640-1450	AMS	Li & Min 2014
	not provided	T1003-10-s1	Rice grain	Layer 10		3380±25	1730-1630	1750-1620	AMS	Li & Min 2014
	BA081094	2008JHAT1304(5)	seed	Layer 5		3000±35	1290-1130	1390-1120	AMS	Min 2013
	BA081095	2008JHAT2121(5)	rhizome	Layer 5		2200±35	360-200	380-170	AMS	Min 2013

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Haimenkou	BA081096	2008JHAT2002(6)	charred wheat	Layer 6		2435±35	730-410	760-400	AMS	Min 2013
	BA081097	2008JHDT1005(6)	charred grain	Layer 6		3020±35	1380-1210	1400-1120	AMS	Min 2013
	BA081098	2008JHDT1304(6)	vegetable fiber	Layer 6		3075± 35	1400-1290	1430-1230	AMS	Min 2013
	BA081099	2008JHAT2003(6)	charred rice	Layer 6		2930±35	1200-1050	1230-1010	AMS	Min 2013
	BA081100	2008JHAT2003(6)	charred millet	Layer 6		2940±35	1220-1080	1260-1020	AMS	Min 2013
	BA081101	2008JHDT2003(7)	charred millet	Layer 7		3550±40	1950-1780	2020-1750	AMS	Min 2013
	BA081102	2008JHAT2505(7)	rhizome	Layer 7		3205±35	1510-1430	1610-1410	AMS	Min 2013
	BA081103	2008JHDT1205(8)	charcoal	Layer 8		3605±40	2030-1560	2130-1830	AMS	Min 2013
	BA081104	2008JHDT1005(9)	charcoal	Layer 9		3345±35	1690-1560	1740-1530	AMS	Min 2013
	BA081105	2008JHDT1004(9)	wood charcoal	Layer 9		4210±35	2900-2700	1740-1530	AMS	Min 2013
	BA081106	2008JHDT1003(10)	rhizome	Layer 10		4485±35	3340-3090	3350-3030	AMS	Min 2013
Shifodong	ZK-3198	2003GST13(4)D	wood charcoal	Layer 4D		2977±59	1290-1110	1400-1020	C14	CASS 2005
	ZK-3199	2003GST13(4)D	wood charcoal	Layer 4D		2998±47	1370-1120	1400-1050	C14	CASS 2005
Shizhaishan	BA 091158	n/a	seed	Layer 6		n/a	n/a	779- 488	AMS?	Yao & Jiang 2012
Hebuosuo	Beta 312944	n/a	n/a	n/a		n/a	n/a	410-38	AMS?	Yao et al., 2015
	Beta 312945	n/a	n/a	n/a		n/a	n/a	200 BC- 40 AD	AMS?	Yao et al., 2015
	Beta 405371	n/a	n/a	n/a		n/a	n/a	734-400	AMS?	Yao et al., 2015
Anjiang	Beta 312943	n/a	n/a	Layer 6		n/a	n/a	770-650	AMS?	Yao et al., 2015

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Anjiang	Beta 312942	n/a	n/a	Layer 5		n/a	n/a	730-590	AMS?	Yao et al., 2015
	BA 091156	n/a	n/a	Layer 3		n/a	n/a	640-430	C14?	Yao et al., 2015
Shilinggang	LZU1468	n/a	Rice grain	Layer 4		2375±30	490-390	710-390	AMS	Li et al., 2016
	LZU1469	n/a	Rice grain	Layer 5		2480±30	760-540	780-430	AMS	Li et al., 2016
Dayingzhuang	Beta-501549	2017YHD 2	Wheat grain	Layer 2		100±30	modern	modern	AMS	Dal Martello 2019
	Beta-051550	2017YHD 4	Wheat grain	Layer 4		2380±30	485-400	727-393	AMS	Dal Martello 2019
	Beta-051549	2017 YHD 5	Wheat grain	Layer 5		2430±30	726-414	750-405	AMS	Dal Martello 2019
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Yingpanshan	BA03280	2000SMYT10H8	wood			4390±60			C14	Zhao 2010
	BA03281	2000SMYT1 2(6)	wood			4170±60			C14	Zhao 2010
	ZK-3210	2003SMY H58	wood			4274±31			C14	Zhao 2010
	ZK-3211	2003SMY H26	wood			4419±32			C14	Zhao 2010
Baodun	BA110053	T 2426 (3)	Rice	Han		2015±30		45-17	AMS	Chengdu et al. 2000; d'Alpoim Guedes et al., 2013
	BA110056	T 2431 (3)	Rice	Han		2150±25		342-169	AMS	Chengdu et al. 2000; d'Alpoim Guedes et al., 2013
	BA110054	T 2426 (3)	Rice	Han		3565±25		1938-1887	AMS	Chengdu et al. 2000; d'Alpoim Guedes et al., 2013
	BA110051	T 1830 (4) H3	Rice	Baodun Phase 1		3705±30		2139-2039	AMS	Chengdu et al. 2000; d'Alpoim Guedes et al., 2013
	BA110050	T 2431 (5)	Rice	Baodun Phase 1		3730±30		2196-2048	AMS	Chengdu et al. 2000;

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										d'Alpoim Guedes et al., 2013
	BA111219	T 3411 (7) H18	Rice	Baodun Phase 1		3735±20		2199-2058	AMS	Chengdu et al. 2000; d'Alpoim Guedes et al., 2013
	BA111220	T 3211 (6) H10	Rice	Baodun Phase 2		3795±25		2284-2155	AMS	Chengdu et al. 2000; d'Alpoim Guedes et al., 2013
	BA111216	T 3209 (5c) H8	Rice	Baodun Phase 3		3795±25		2284-2155	AMS	Chengdu et al. 2000; d'Alpoim Guedes et al., 2013
	BA110048	T 2426 (5)	Rice	Baodun Phase 1		3830±30		2299-2207	AMS	Chengdu et al. 2000; d'Alpoim Guedes et al., 2013
	BA110052	T 2341 (4) H9	Rice	Baodun Phase 1		3830±30		2299-2207	AMS	Chengdu et al. 2000; d'Alpoim Guedes et al., 2013
	BA111215	T 3411 (7) H17	Rice	Baodun Phase 1		3840±25		2340-2209	AMS	Chengdu et al. 2000; d'Alpoim Guedes et al., 2013
	BA111217	T 3211 (6)	Rice	Baodun Phase 3		3885±25		2460-2309	AMS	Chengdu et al. 2000; d'Alpoim Guedes et al., 2013
	BA110060	T 2431 (4) H2	Rice	Baodun Phase 1		3885±30		2460-2309	AMS	Chengdu et al. 2000; d'Alpoim Guedes et al., 2013
	BA110047	T 1830 (5)	Rice	Baodun Phase 1		3890±35		2462-2341	AMS	Chengdu et al. 2000; d'Alpoim Guedes et al., 2013
	BA110055	T 2426 (4)	Rice	Baodun Phase 2		3990±30		2566-2472	AMS	Chengdu et al. 2000; d'Alpoim Guedes et al., 2013
	BA111218	T 3312 (7)	Wood	Baodun Phase 1		3995±20		2566-2473	AMS	Chengdu et al. 2000; d'Alpoim Guedes et al., 2013
	BA110059	T 2431 (4) H1	Rice	Baodun Phase 1		4000±30		2567-2476	AMS	Chengdu et al. 2000; d'Alpoim Guedes et al., 2013

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Baodun	BA110057	T 2431 (3) G1	Rice	Baodun Phase 2		4000±30		2567-2476	AMS	Chengdu et al. 2000; d'Alpoim Guedes et al., 2013
	BA110061	T 2431 (4) H11	Rice	Baodun Phase 1		4005±30		2569-2469	AMS	Chengdu et al. 2000; d'Alpoim Guedes et al., 2013
	BA110049	T 2426 (5) H6	Rice	Baodun Phase 1		4010±50		2570-2486	AMS	Chengdu et al. 2000; d'Alpoim Guedes et al., 2013
	BA110062	T 2431 (4) H8	Rice	Baodun Phase 1		4015±35		2571-2487	AMS	Chengdu et al. 2000; d'Alpoim Guedes et al., 2013
	BA110058	T 2431 (4) H1	Rice	Baodun Phase 1		4060±30		2621-2501	AMS	Chengdu et al. 2000; d'Alpoim Guedes et al., 2013
Zhongba	BA01398	FCN3582-1	Bone	68		3380±90		1730-1640	AMS	Flad et al., 2009
	BA01403	FCN3582-6	Bone	68		3840±60		2340-2209	AMS	Flad et al., 2009
	BA02030	FCN3498	Bone	65b		3640±100		2032-1965	AMS	Flad et al., 2009
	BK2002048	FCN3320	Wood charcoal	64		3800±70		2285-2200	AMS	Flad et al., 2009
	BA02028	FCN3329	Bone	64		3660±100		2121-1979	AMS	Flad et al., 2009
	BA02018	FCN3142	Bone	58a		3800±80		2285-2200	AMS	Flad et al., 2009
	BA01390	FCN2958-1	Bone	56		3590±60		1972-1898	AMS	Flad et al., 2009
	BA01397	FCN2975-4	Bone	56		3540±60		1924-1785	AMS	Flad et al., 2009
	BA01439	FCN2842	Bone	53		2730±80		902-837	AMS	Flad et al., 2009
	BA01437	FCN2699	Bone	52a		2680±70		833-809	AMS	Flad et al., 2009
	BK2002047	FCN2658	wood charcoal	50		3210±120		1501-1447	AMS	Flad et al., 2009
	BA01453	FCN2675	Bone	50		3240±100		1529-1463	AMS	Flad et al., 2009

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Site	Lab No.	Original Samples No.	Sample Material	Archaeological context	h.l. 5730	h.l. 5568	68.20% cal BC	95.40% cal BC	Method	REFERENCES
Zhongba	BA01382	FCN2613-1	Bone	49B		3100±60		1415-1311	AMS	Flad et al., 2009
	BA01384	FCN2613-3	Bone	49B		3110±100		1421-1320	AMS	Flad et al., 2009
	BA01434	FCN2728	Bone	49a		3110±120		1421-1320	AMS	Flad et al., 2009
	BA01433	FCN2578	Bone	48		2780±60		974-900	AMS	Flad et al., 2009
	BA01374	FCN2513-1	Bone	46		2520±70		780-569	AMS	Flad et al., 2009
	BK2002045	FCN2514	wood charcoal	46		2730±85		902-837	AMS	Flad et al., 2009
	BA01380	FCN2527	Bone	46		2480±80		756-542	AMS	Flad et al., 2009
	BK2002046	FCN2528	wood charcoal	46		3025±90		1373-1227	AMS	Flad et al., 2009
	BA01429	FCN2379	Bone	43		2490±70		760-547	AMS	Flad et al., 2009
	BA01368	FCN2219-1	Bone	38b		2450±60		738-488	AMS	Flad et al., 2009
	BA01373	FCN2275	Bone	38b		2540±60		790-763	AMS	Flad et al., 2009
	BA01424	FCN2229	Bone	37		2390±70		483-403	AMS	Flad et al., 2009
	BA01420	FCN2136	Bone	33		2640±60		813-798	AMS	Flad et al., 2009
	BA01419	FCN2094	Bone	32		2430±60		702-413	AMS	Flad et al., 2009
	BA01362	FCN0981-1	Bone	29		2640±60		813-798	AMS	Flad et al., 2009
	BA01367	FCN1082	Bone	29		2600±60		804-792	AMS	Flad et al., 2009
	BA01409	FCN0643	Bone	22		2460±60		747-512	AMS	Flad et al., 2009
	BA01357	FCN0006	Bone	18		2430±80		702-413	AMS	Flad et al., 2009
	BA01361	FCN0104-2	Bone	18		2380±70		471-399	AMS	Flad et al., 2009

APPENDIX 6. Chronology of sites from Southwest China mentioned in Chapter 8.

Site	Lab No.	Original Samples No.	Sample Material	Archaeological context	h.l. 5730	h.l. 5568	68.20% cal BC	95.40% cal BC	Method	REFERENCES
Zhengjiaba	n/a	n/a	wood	n/a		n/a		1500-1410	C14	Chengdu 2011
	n/a	n/a	seed	n/a		n/a		1430-1300	AMS	Chengdu 2011
Ashaonao	n/a	n/a	Wheat grains	Layers 6A-5		n/a		400-200	OSL	D'Alpoim Guedes et al., 2018a
	n/a	n/a	Wheat grains	Layers 7-6		n/a		1400-1000	OSL	D'Alpoim Guedes et al., 2018a
TIBET										
Karuo	ZK0816	F18-170cm	Wood charcoal			5120±300		3968-3942	C14	d'Alpoim Guedes et al., 2013
	ZK0815	T62(3)F17:84	Wood charcoal			4810±100		3641-3538	C14	Alpoim Guedes et al., 2013
	BK79072	T102(3) F18	Wood charcoal			4550±100		3361-3137	C14	Alpoim Guedes et al., 2013
	BK79069	T41F9(3)西壁	Wood charcoal			4540±80		3356-3132	C14	Alpoim Guedes et al., 2013
	BK79071	T102(3) F19	Wood charcoal			4490±90		3331-3100	C14	Alpoim Guedes et al., 2013
	WB79-58	T62(3)F17	Wood charcoal			4460±85		3316-3030	C14	Alpoim Guedes et al., 2013
	ZK0810	F7:24 陶罐下	Wood charcoal			4420±110		3092-3022	C14	Alpoim Guedes et al., 2013
	ZK0617	T1(2)-30cm	Wood charcoal			4390±100		3081-2928	C14	Alpoim Guedes et al., 2013
	BK79073	T103(4)F31	Wood charcoal			4380±100		3021-2926	C14	Alpoim Guedes et al., 2013
	ZK0817	T102(3)F19	Wood charcoal			4300±90		2914-2896	C14	Alpoim Guedes et al., 2013
	BK79077	(3)F29 西北角柱洞	Wood charcoal			4280±80		2906-2889	C14	Alpoim Guedes et al., 2013
	ZK0813	T61(3)F14 烧土下	Wood charcoal			4280±100		2880-2713	C14	Alpoim Guedes et al., 2013
	ZK0637	F3(3)	Wood charcoal			4190±90		2880-2713	C14	Alpoim Guedes et al., 2013

APPENDIX 6. Chronology of sites from Southwest China mentioned in Chapter 8.

Site	Lab No.	Original Samples No.	Sample Material	Archaeological context	h.l. 5730	h.l. 5568	68.20% cal BC	95.40% cal BC	Method	REFERENCES
Karuo	BK78044	F3(3)	Wood charcoal			4180±120		2876-2705	C14	Alpoim Guedes et al., 2013
	BK79074	T42(4)F8 低	Wood charcoal			4160±80		2873-2679	C14	Alpoim Guedes et al., 2013
	ZK0812	T4(3) F9	Wood charcoal			4160±100		2873-2679	C14	Alpoim Guedes et al., 2013
	WB79-51	T56(3) F20 柱洞	Wood charcoal			4120±140		2854-2626	C14	Alpoim Guedes et al., 2013
	BA111228	02XCK T7 H2	Foxtail Millet			4115±25		2852-2621	C14	Alpoim Guedes et al., 2013
	BK79070	T4,T14F12(2)(3)	Wood charcoal			4110±100		2850-2586	C14	Alpoim Guedes et al., 2013
	ZK0620	T22(2)-133 cm	Wood charcoal			4110±80		2850-2586	C14	Alpoim Guedes et al., 2013
	ZK0811	T42(4)F8 东壁	Wood charcoal			4060±100		2621-2501	C14	Alpoim Guedes et al., 2013
	WB79-52	T102(3)F19 柱洞	Wood charcoal			4030±75		2579-2491	C14	Alpoim Guedes et al., 2013
	ZK0814	F15 柱洞内	Wood charcoal			4030±100		2579-2491	C14	Alpoim Guedes et al., 2013
	BK78046	F4(6)	Wood charcoal			4000±85		2567-2476	C14	Alpoim Guedes et al., 2013
	BA111229	02XCK T7 H1	Foxtail Millet			3995±25		2566-2473	C14	Alpoim Guedes et al., 2013
	Beta325960	02XCKT7 东壁 3 下 H4	Broomcorn Mille			3980±40		2561-2471	C14	Alpoim Guedes et al., 2013
	ZK0636	T24,T13, T23F5	Wood charcoal			3980±90		2561-2471	C14	Alpoim Guedes et al., 2013
	BA111230	02XCK T7 H1	Undet. Fragmen			3965±25		2548-2466	C14	Alpoim Guedes et al., 2013
	ZK0619	T12(2)	Wood charcoal			3950±95		2479-2461	C14	Alpoim Guedes et al., 2013
	BA111227	02XCKT7 东壁 3 下 H4	Undet. Fragmen			3945±20		2476-2459	C14	Alpoim Guedes et al., 2013
	BK78045	F5(4)	Wood charcoal			3940±80		2475-2457	C14	Alpoim Guedes et al., 2013

APPENDIX 6. Chronology of sites from Southwest China mentioned in Chapter 8.

Site	Lab No.	Original Samples No.	Sample Material	Archaeological context	h.l. 5730	h.l. 5568	68.20% cal BC	95.40% cal BC	Method	REFERENCES
Karuo	BA111226	02XCKT7 东壁 3 下 H4	Foxtail Millet			3910±25		2469-2347	C14	Alpoim Guedes et al., 2013
	BK79068	T62(3)F17	Wood charcoal			3910±90		2469-2347	C14	Alpoim Guedes et al., 2013
	WB78-34	F4 柱内	Wood charcoal			3910±130		2469-2347	C14	Alpoim Guedes et al., 2013
	BA111231	02XCKT7 F1	Undet. Seed			3895±25		2461-2346	C14	Alpoim Guedes et al., 2013
	WB79-54	T102(3)	Wood charcoal			3870±70		2457-2293	C14	Alpoim Guedes et al., 2013
	ZK0820	T103(4)F31	Wood charcoal			3870±100		2457-2293	C14	Alpoim Guedes et al., 2013
	WB78-35	F5	Wood charcoal			3840±80		2340-2209	C14	Alpoim Guedes et al., 2013
	WB78-37	F1	Wood charcoal			3820±90		2292-2206	C14	Alpoim Guedes et al., 2013
	ZK0819	F30(2)	Wood charcoal			3820±80		2292-2206	C14	Alpoim Guedes et al., 2013
	ZK0818	F22(2)	Wood charcoal			3790±80		2281-2151	C14	Alpoim Guedes et al., 2013
	WB80-63	F22-29	Wood charcoal			3760±95		2203-2141	C14	Alpoim Guedes et al., 2013
	ZK0618	T13(2)-150 cm	Wood charcoal			3760±170		2200-1938	C14	Alpoim Guedes et al., 2013
	WB79-57	T42(4)F8 低	Wood charcoal			3740±70		2200-2061	C14	Alpoim Guedes et al., 2013
	WB79-59	T59(2)F10	Wood charcoal			3610±165		2021-1938	C14	Alpoim Guedes et al., 2013
	WB78-36	F3	Wood charcoal			3600±95		2013-1917	C14	Alpoim Guedes et al., 2013
	WB79-55	T4(3)F9 东北角木柱	Wood charcoal			3580±95		1951-1894	C14	Alpoim Guedes et al., 2013
	WB79-53	T4,T14F12(2)(3)	Wood charcoal			3540±105		1924-1785	C14	Alpoim Guedes et al., 2013
	BK200264	02XCKT7K1	Wood charcoal			4105±70		2840-2538	C14	Alpoim Guedes et al., 2013
	BK200265	02XCKT7F1	Wood charcoal			4070±70		2625-2572	C14	Alpoim Guedes et al., 2013

APPENDIX 6. Chronology of sites from Southwest China mentioned in Chapter 8.

Site	Lab No.	Original Samples No.	Sample Material	Archaeological context	h.l. 5730	h.l. 5568	68.20% cal BC	95.40% cal BC	Method	REFERENCES
Karuo	BK200266	02XCKT3F1	Wood charcoal			3890±70		2462-2341	C14	Alpoim Guedes et al., 2013
	BK200267	02XCKT7H2	Wood charcoal			3975±70		2559-2233	C14	Alpoim Guedes et al., 2013
	BK200268	02XCKT7H1	Wood charcoal			3848±70		2398-2233	C14	Alpoim Guedes et al., 2013
	BK200269	02XCKT1 (4)	Wood charcoal			4716±80		3625-3381	C14	Alpoim Guedes et al., 2013
Changguogou	n/a	H2	Wood charcoal			2958±102		1422-916	C14	Alpoim Guedes et al., 2013
		H2	Animal bone			2814±99		1257-803	C14	Alpoim Guedes et al., 2013
GUIZHOU										
Wujiadaping		K2	Rice grain			3120±65		1521-1216	C14	Guizhou 2006

Appendix 6. Chronology of sites from Southwest China mentioned in Chapter 8.

Sites dated by cultural association.

Site	Province	Chronology BC	Reference
Haxiu	Sichuan	c. 3300-2700	Zhao 2008
Mopandi	Yunnan	c. 3400	Yunnan 2003
Xingyi	Yunnan	c. 2000-0 AD	Yunnan 2017
Gaopo	Sichuan	c. 1600-1300	Chengdu 2011
Zhonghai Guojishequ	Sichuan	c. 1400	Chengdu 2005
Jigongshan	Guizhou	c. 1300-800	Zhao 2003
Nanbiqiao	Yunnan	c. 1250-970	An 1999
Boluocun	Sichuan	c. 1250-800	Chengdu 2011
Sangongtang	Sichuan	c. 1250-800	Chengdu et al., 2013
Jinniu 5C	Sichuna	c. 1250-800	Jiang et al., 2011
Xueshan	Yunnan	c. 700- 300	Wang 2014; Yunnan 2010
Guanfentou	Yunnan	c. 700-300	Li & Liu 2016
Yubeidi	Yunnan	c. 700-300	Yang 2016
Xiaogucheng	Yunnan	c. 700-300	Yao et al., 2015

Appendix 7. List of sites shown in fig. 8-14 Chapter 8.

Site	Country, Province	Location	Latitude	Longitude	Dating Quality	Broad Cultural Period	Regional Cultural Period	Start Date BC	Finish Date BC	Est. Date Median BC	Cultigens	References
Xihe 西河	China, Shandong	Zhangqiu City	36.705893	117.630122	-	Neolithic	Houli	6070	5900	5985	*Oryza* sp. (wild?); *Setaria italica*	Jin & Wang, 2011
Yuezhuang 月庄	China, Shandong		36.619940	116.828610	AMS rice	Neolithic	Houli	6060	5750	5905	*Oryza sativa; Panicum miliaceum; Setaria italica*	Crawford et al., 2006
Zhuzhai	China, Henan	Zhengzhou, Dengfeng	34.825232	113.305482	AMS	Neolithic		5974	5823	5898	*Oryza sativa?; Panicum miliaceum; Setaria italica*	Bestel et al., 2017
Xiangjiawan 向家湾	China, Shaanxi	Xixiang	32.819978	107.619649	-	Neolithic	Yangshao	5100	3000	4050	*Oryza sativa; Panicum miliaceum? Setaria italica?*	Shang et al. 2012
Dongpan	China, Shandong	Linshu	34.926032	118.749682	AMS	Neolithic	Beixin	5000	4500	4750	*Oryza sativa; Panicum miliaceum; Setaria italica*	Wang et al. 2012; d'Alpoim Guedes et al., 2015
Chengtoushan 城头山	China, Hunan		29.692930	111.655720	AMS rice	Neolithic	Daxi	4450	3850	4150	*Oryza sativa; Panicum miliaceum*	Pei, 1998; Nasu et al., 2007; 2012
Nanjiaokou 南交口	China, Henan		34.869680	111.424720	AMS	Neolithic	Yangshao	4400	3000	3700	*Oryza sativa; Panicum miliaceum; Setaria italica*	Qin & Fuller, 2009
Baligang 八里岗	China, Henan	Nanyang City, Dengzhou	32.690279	112.132440	AMS	Neolithic	Yangshao	4300	3000	3650	*Oryza sativa; Panicum miliaceum; Setaria italica*	Deng et al., 2015; Weisskopf, 2014
Xinglefang 兴乐坊	China, Shaanxi	Huayin	34.543439	109.984276	-	Neolithic	Miaodigou	4000	3500	3750	*Oryza sativa; Panicum miliaceum; Setaria italica*	Liu et al., 2011

Appendix 7. List of sites shown in fig. 8-14 Chapter 8.

Site	Country, Province	Location	Latitude	Longitude	Dating Quality	Broad Cultural Period	Regional Cultural Period	Start Date BC	Finish Date BC	Est. Date Median BC	Cultigens	References
Dingdian 丁店	China, Shanxi	Sushui River	35.393772	111.257990	ass	Neolithic	Yangshao	4000	3300	3650	*Oryza sativa; Panicum miliaceum; Setaria italica*	Song, 2011
Huitupo 灰土坡	China, Henan	South	32.686110	112.083340	ass	Neolithic	Yangshao	4000	3000	3500	*Oryza sativa; Panicum miliaceum; Setaria italica*	Fuller & Qin, n.d.
Xipo 西坡	China, Henan	Sha River	34.498614	110.702134		Neolithic	Miaodigou (Middle Yangshao)	4000	3000	3500	*Oryza sativa; Panicum miliaceum; Setaria italica*	Ma, 2005; Weisskopf, 2014; Team for Study on Agriculture 2011
Yuanqiao 袁桥	China Henan	Ying River	34.388684	112.996140	ass	Neolithic	Yangshao	4000	3000	3500	*Oryza sativa; Panicum miliaceum; Setaria italica*	Fuller & Zhang, 2007; Zhang et al. 2010
Cangdi 蒼帝	China Shanxi	Sushui River	35.472904	111.367890	ass	Neolithic	Yangshao	4000	2600	3300	*Oryza sativa; Setaria italica*	Song, 2011
Diantoubao 店頭堡	China Shanxi	Sushui River	35.337395	111.317080	ass	Neolithic	Yangshao	4000	2600	3300	*Oryza sativa; Panicum miliaceum; Setaria italica*	Song, 2011 Shelach et al., 2011.
Diantoubao (N) 店頭堡 (北)	China Shanxi	Sushui River	35.337500	111.317078	ass	Neolithic	Yangshao	4000	2600	3300	*Oryza sativa; Panicum miliaceum; Setaria italica*	Song, 2011
Shangshaowang 上邵王	China Shanxi	Sushui River	35.358536	111.253740	ass	Neolithic	Yangshao	4000	2600	3300	*Oryza sativa; Panicum miliaceum; Setaria italica*	Song, 2011
Xincun	China, Guangdong	Yaogu Bay	21.915433	112.978009	ass	Neolithic		4000	2500	3250	*Oryza* sp. (wild?)	Yang et al., 2016

Appendix 7. List of sites shown in fig. 8-14 Chapter 8.

Site	Country, Province	Location	Latitude	Longitude	Dating Quality	Broad Cultural Period	Regional Cultural Period	Start Date BC	Finish Date BC	Est. Date Median BC	Cultigens	References
Nanjiaokou 南交口	China, Henan		34.869680	111.424720	AMS	Neolithic	Yangshao	3950	3850	3900	*Oryza sativa; Panicum miliaceum; Setaria italica*	Qin & Fuller, 2009
Lixian 6 礼县	China, Guansu	Li County , Xihanshui River Valley	34.189091	105.178434	ass	Neolithic	Miaodigou	3750	3550	3650	*Oryza sativa; Panicum miliaceum; Setaria italica*	Ji, 2009
Anban 案板村	China Shaanxi	Fufeng County, Chengguan	34.352681	107.913833	ass	Neolithic	Yangshao	3500	3000	3250	*Oryza sativa; Panicum miliaceum; Setaria italica*	Shao, 2002: 90; Xie, 2000
Li County: unnamed site	China Gansu	Li County	34.074061	105.133781	ass	Neolithic		3500	3000	3250	*Oryza sativa; Panicum miliaceum; Setaria italica*	An et al., 2010
Quanhu 泉护村	China Shaanxi		34.234510	109.753420		Neolithic	Yangshao	3500	3000	3250	*Oryza sativa; Setaria italica*	Liu et al., 2008
Zhaocheng 赵城	China Henan	Luoyang Shi	34.564250	112.885725	C14	Neolithic	Yangshao	3500	3000	3250	*Oryza sativa; Setaria italica*	Lee et al., 2007
Yingpangshan 营盘山	China, Sichuan		32.18014	104.547226	ass	Neolithic		3500	2700	3200	*Panicum miliaceum; Setaria italica*	Zhao &Chen, 2011
Lixian 5 礼县	China Gansu	Xihanshui River Valley. Li County	34.189091	105.178434	ass	Neolithic	Yangshao	3500	2500	3000	*Oryza sativa; Panicum miliaceum; Setaria italica*	Ji, 2009
Shiyangguan 石羊关	China Henan		34.371220	113.196440	ass	Neolithic	Yangshao	3500	2500	3000	*Oryza sativa; Panicum miliaceum; Setaria italica*	Fuller & Zhang, 2007
Yuancun 袁村	China Henan	Yinghe (Silver River)	34.388390	113.031890	ass	Neolithic	Yangshao	3500	2500	3000	*Oryza sativa;*	Fuller & Zhang, 2007

Appendix 7. List of sites shown in fig. 8-14 Chapter 8.

Site	Country, Province	Location	Latitude	Longitude	Dating Quality	Broad Cultural Period	Regional Cultural Period	Start Date BC	Finish Date BC	Est. Date Median BC	Cultigens	References
											Panicum miliaceum; Setaria italica	
Gantouyan 感驮岩	China Guangxi	Napo, Bose	23.412673	105.848778	C14	Neolithic		3500	1000	2250	*Oryza sativa; Setaria italica*	Lu, 2005; 2006; 2009
Zhuzhai	China Henan	Zhengzhou, Dengfeng	34.825232	113.305482	AMS	Neolithic	Yangshao	3308	3130	3219	*Oryza sativa; Panicum miliaceum; Setaria italica*	Bestel et al., 2017
Haxiu 哈休	China, Sichuan		32.17412	102.145469	ass	Neolithic		3300	2700	3000	*Panicum miliaceum; Setaria italica*	D'Alpoim Guedes, 2013
Huanglianshu (Longshangang) 黄楝树	China Henan	Xichuan , Taohe	32.979724	111.328310	ass	Neolithic	Qujialing	3300	2600	2950	*Oryza sativa; Setaria italica*	Hunt et al., 2008
Ledu Liuwan 乐都柳湾	China Qinghai	Ledu, Haidong,	36.454089	102.555789	ass	Neolithic	Majiayao	3300	2000	2650	*Panicum miliaceum; Setaria italica*	Jin & Chen 2007
Nanshan 南山	China, Fujian	Min River	26.21201	117.1331	C14	Neolithic	Shixia	3200	2400	2800	*Oryza sativa; Setaria italica*	Yang et al., 2018
Renhuahe (Jiawuhuoshan) 杏花河（屋后山）	China, Guangdong		23.439131	111.722412	ass	Neolithic	Shixia	3050	2100	2575	*Oryza sativa*	Zhang & Hung, 2010
Kuniangang 苦稔岗	China, Guangdong		23.389123	111.700894	ass	Neolithic	Shixia	3050	2100	2757	*Oryza sativa*	Xiang & Yao 2006
Xujiacun 胥家村	China Shandong	Rizhao	35.617803	119.609408		Neolithic	Dawenkou	3000	2600	2800	*Oryza sativa;*	Chen, 2007a; 2007b

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Site	Country, Province	Location	Latitude	Longitude	Dating Quality	Broad Cultural Period	Regional Cultural Period	Start Date BC	Finish Date BC	Est. Date Median BC	Cultigens	References
											Panicum miliaceum; Setaria italica	
Yuchisi 尉迟寺	China Anhui	Mengcheng County	33.358139	116.749680	ass	Neolithic	Dawenkou (Late) Longshan	3000	2600	2800	*Oryza sativa; Setaria italica*	Wang & Jia, 1998; Zhao, 2007, Lee et al., 2007
K'en-ting	Taiwan		21.944780	120.799260	ass	Neolithic	Tapenkeng	3000	2500	2750	*Oryza sativa*	Bellwood, 2007: 213
Baligang 八里岗	China Henan	Nanyang City, Dengzhou	32.690279	112.132440	AMS	Neolithic	Qujialing	3000	2500	2750	*Oryza sativa; Panicum miliaceum; Setaria italica*	Deng et al., 2015; Weisskopf, 2014
Gushuihe (GSH) 谷水河	China Henan		34.226940	113.347280	ass	Neolithic	Longshan	3000	2500	2750	*Oryza sativa; Panicum miliaceum; Setaria italica*	Fuller & Zhang, 2007
Nankuanli 南關里	Taiwan Taiwan		25.136640	121.416530	C14	Neolithic	Tapenkeng	3000	2500	2750	*Oryza sativa; Panicum miliaceum; Setaria italica*	Tsang, 2005; Lu, 2005; Tsang et al., 2017
Qinglongquan 青龙泉	China Hubei	Yun county: Hanjiang River	32.640000	111.410000	ass	Neolithic	Qujialing	3000	2500	2750	*Oryza sativa; Panicum miliaceum; Setaria italica*	Zhongguo, 2011
Juxian/ Jiaozhou	China Shandong	Jiaozhou, Qingdao	36.269895	120.043785	ass	Neolithic	Dawenkou/ Longshan	3000	2400	2700	*Oryza sativa; Setaria italica*	Jin et al., 2009; d'Alpoim et al., 2015
Gushuihe 谷水河	China Henan		34.226940	113.347280	ass	Neolithic	Longshan	3000	2200	2600	*Oryza sativa; Panicum miliaceum; Setaria italica*	Fuller & Zhang 2007; Zhang et al. 2010
Chenjiazhuang 程家庄	China Shanxi	Juxian	35.405563	111.276222	ass	Neolithic	Longshan	3000	2000	2500	*Oryza sativa; Setaria italica*	Jin, Guiyun, pers.comm. 2015

Appendix 7. List of sites shown in fig. 8-14 Chapter 8.

Site	Country, Province	Location	Latitude	Longitude	Dating Quality	Broad Cultural Period	Regional Cultural Period	Start Date BC	Finish Date BC	Est. Date Median BC	Cultigens	References
Duanjiahe 段家河	China Shandong	Juxian	35.527699	118.984893	ass	Neolithic	Longshan	3000	2000	2500	*Oryza sativa; Setaria italica*	Jin, Guiyun pers.comm. 2015
Shuinan 水南	China Shanxi	Sushui River	35.249457	111.151747		Neolithic	Longshan	3000	2000	2500	*Panicum miliaceum; Setaria italica; Triticum aestivum*	Song, 2011
Tonglin 桐林	China Shandong		36.894350	118.225780	ass	Neolithic	Longshan	3000	2000	2500	*Oryza sativa; Panicum miliaceum; Setaria italica*	Song, 2011
Xilou 西楼村	China Shandong	Juxian	35.501000	118.998700		Neolithic	Longshan	3000	2000	2500	*Oryza sativa; Setaria italica*	Underhill et al., 2008
Yuangjiaquan	China Shandong		37.318150	120.917150	ass	Neolithic	Longshan	3000	2000	2500	*Oryza sativa; Panicum miliaceum; Setaria italica*	Luan et al. 2007
Nankuanli E 南關里	China, Taiwan		23.658	120.1635	C14			3000	2300	2600	*Oryza sativa; Setaria italica; Panicum miliauceum*	Tsang et al., 2017
Buziping 堡子坪	China Gansu	Yunshancun, Dingxi	35.459109	104.466885		Neolithic	Majiayao	2940	2760	2850	*Panicum miliaceum; Setaria italica*	An et al., 2014, Jia et al., 2013, Lee et al., 2007
Zhoujiazhuang 周家庄	China Shanxi	Sushui River	35.481361	111.477410	ass	Neolithic	Yangshao, Late	2900	2800	2850	*Oryza sativa; Panicum miliaceum; Setaria italica*	Song, 2011
Diantoubao (N) 店頭堡 (北)	China Shanxi	Sushui River	35.337500	111.317078	ass	Neolithic	Yangshao, Late	2900	2600	2750	*Oryza sativa; Panicum miliaceum; Setaria italica*	Song, 2011

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Site	Country, Province	Location	Latitude	Longitude	Dating Quality	Broad Cultural Period	Regional Cultural Period	Start Date BC	Finish Date BC	Est. Date Median BC	Cultigens	References
Fengcun Northwest 汾村	China Shanxi	Sushui River	35.353355	111.313477	ass	Neolithic	Miaodigou II	2900	2600	2750	*Oryza sativa; Panicum miliaceum; Setaria italica*	Song, 2011
Hougong 后宫	China Shanxi	Sushui River	35.356297	111.401880	ass	Neolithic	Yangshao	2900	2600	2750	*Oryza sativa; Panicum miliaceum; Setaria italica*	Song, 2011
Maoshan 茅山	China Zhejiang	Hangzhou	30.432342	120.263030	ass	Neolithic	Liangzhu	2900	2600	2750	*Oryza sativa; Setaria italica?*	Zhuang et al., 2014; Zheng et al., 2014; Gao et al., n.d.
Suncun 孙村	China Shanxi	Sushui River	35.356438	111.299230		Neolithic	Yangshao, Late	2900	2600	2750	*Oryza sativa; Panicum miliaceum; Setaria italica*	Song, 2011
Tanshishan 曇石山	China, Fujian		26.146961	119.151212	C14	Neolithic	Tanshishan	2870	2340	2605	*Oryza sativa*	Zhang & Hung, 2010
Nantunling 南屯岭	China Shandong	Rhizhao	35.366407	119.452565	ass	Neolithic	Dawenkou	2800	2500	2650	*Oryza sativa; Panicum miliaceum; Setaria italica*	Chen, 2007; Underhill et al., 2008
Xishanping 西山坪	China Gansu		34.578950	105.726930	AMS rice	Neolithic	Longshan	2700	2350	2525	*Oryza sativa; Panicum miliaceum; Setaria italica*	Li, et al., 2007; Flad et al., 2010
Changdu Karuo 昌都卡若	China Tibet	Changdu, Qamdo	31.060907	97.209364	C14	Neolithic		2700	2300	2500	*Panicum miliaceum; Setaria italica*	D'Alpoim Guedes et al., 2013
Nanguanli (Nankuanli) 南關里	Taiwan Taiwan		23.105506	120.282272		Neolithic	Dabenkeng	2700	2200	2450	*Oryza sativa; Setaria italica*	Tsang et al. 2006; Zhang. & Hung 2010
Nanguanlidong	Taiwan Taiwan		23.078169	120.277037		Neolithic	Dabenkeng	2700	2200	2450	*Oryza sativa; Setaria italica*	Tsang et al. 2006; Zhang, & Hung 2010

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南關里東												
Baodun 宝墩	China Sichuan	Xinjin	30.434442	103.759096		Neolithic	Baodun	2700	2000	2350	*Oryza sativa; Setaria italica*	d'Alpoim Guedes & Butler, 2014; d'Alpoim Guedes, 2013; d'Alpoim Guedes et al., 2009
Baitoushan 白头山			26.075067	119.091636	C14	Neolithic		2700	1500	2250	(*Oryza sativa;* indet millets. From phytoliths)	Zai et al., 2019
Baiyangcun 1 白羊村	China Yunnan	Binchuan	25.840397	100.593691	AMS	Neolithic		2650	2450	2550	*Oryza sativa; Panicum miliaceum; Setaria italica*	Dal Martello et al., 2018
Fengcun (NW) 汾村	China Shanxi	Sushui	35.353355	111.313477	ass	Neolithic	Miaodigou II	2600	2400	2500	*Oryza sativa; Panicum miliaceum; Setaria italica*	Song, 2011
Hougou	China Shanxi	Sushui	35.356297	111.401878	ass	Neolithic	Yangshao	2600	2400	2500	*Oryza sativa; Panicum miliaceum; Setaria italica*	Song, 2011
Suncun (S) 孙村	China Shanxi	Sushui River	35.356438	111.299232	ass	Neolithic	Yangshao	2600	2400	2500	*Oryza sativa; Panicum miliaceum; Setaria italica*	Song, 2011
Liangchengzhen 两城镇	China Shandong		35.579030	119.571950	AMS	Neolithic	Longshan	2600	2000	2300	*Oryza sativa; Panicum miliaceum; Setaria italica*	Crawford et al., 2005

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Xuejiazhuang	China Shandong	Zhucheng	36.056337	119.442259	ass	Neolithic	Longshan	2600	2000	2300	*Oryza sativa; Panicum miliaceum; Setaria italica*	Jin et al., 2009; D'Alpoim Guedes et al., 2015
Zhaojialai 赵家来	China Shaanxi	Wugong	34.300548	108.124613		Neolithic	Longshan	2600	1950	2275	*Setaria italica; Triticum aestivum*	Flad et al. 2010
Fangjia	China Shandong	Zhangdian	36.778352	118.026030	ass	Neolithic	Longshan	2600	1900	2250	*Oryza sativa; Panicum miliaceum; Setaria italica*	Jin et al., 2011; Alpoim Guedes et al., 2015
Shantaisi 山台寺	China Henan		34.116670	115.183330	ass	Neolithic	Longshan	2600	1900	2250	*Oryza sativa; Panicum miliaceum; Setaria italica*	Crawford et al., 2005
Bianjiashan	China Zhejiang		30.373080	119.988190	ass	Neolithic	Liangzhu	2500	2300	2400	*Oryza sativa; Setaria italica*	Zheng et al., 2014; Team Study on Early Agriculture, 2011
Xiazhai	China Henan	Nanyang basin	33.016944	111.270278	AMS	Neolithic	Shijiahe	2500	2250	2375	*Oryza sativa; Panicum miliaceum; Setaria italica*	Deng, et al. n.d
Baligang 八里岗	China Henan	Nanyang City, Dengzhou	32.690279	112.132440	AMS	Neolithic	Shijiahe	2500	2200	2350	*Oryza sativa; Panicum miliaceum; Setaria italica*	Deng et al., 2015; Weisskopf, 2014
Qinglongquan 青龙泉	China Hubei	Yun county: Hanjiang River	32.640000	111.410000	ass	Neolithic	Shijiahe	2500	2200	2350	*Oryza sativa; Panicum miliaceum; Setaria italica*	
Zhaojiazhuang 赵家庄	China Shandong	Jiaozhou, Qingdao	36.050408	119.787864	C14	Neolithic	Longshan	2500	2200	2350	*Oryza sativa; Panicum miliaceum; Setaria italica*	Wang, 2007; Jin et al., 2007

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Site	Country, Province	Location	Latitude	Longitude	Dating Quality	Broad Cultural Period	Regional Cultural Period	Start Date BC	Finish Date BC	Est. Date Median BC	Cultigens	References
Shixia	China Guangdong		24.676660	113.600250	AMS	Neolithic	Shixia III	2500	2100	2300	*Oryza sativa*	Yang, 1978; Zhang et al., 2006; Zhang & Hung, 2010; Yang et al., 2016
Dingshishan	China Guangxi		22.748260	108.494690	C14	Neolithic		2500	2000	2250	*Oryza sativa*	Lu 2005; 2006, Zhang & Hung, 2010
Jizhai 冀寨	China Henan	Ying	34.218640	113.338190	ass	Neolithic	Longshan	2500	2000	2250	*Oryza sativa; Panicum miliaceum; Setaria italica*	Fuller & Zhang 2007
Lilou 李楼	China Henan	Yiluo River, Ruzhou	34.155685	112.668660	ass	Neolithic	Longshan	2500	2000	2250	*Oryza sativa; Setaria italica*	Dong et al., 2013
Xiaojin	China Guangxi		24.958470	110.834430	ass	Neolihic		2500	2000	2250	*Oryza sativa*	Rispoli 2007: 269; Lu 2009; Zhang & Hung, 2010
Xinzhai 新砦	China Henan	East	34.506560	113.415990	AMS rice	Neolithic	Longshan	2500	2000	2250	*Oryza sativa; Panicum miliaceum; Setaria italica*	Zhao, 2005
Dingjiazhai 丁家寨	China Shanxi	Yuanping County	38.967611	112.789883		Neolithic	Longshan	2500	1900	2200	*Panicum miliaceum; Setaria italica; Triticum aestivum*	Jiang, 2011
Dongpan	China Shandong	Linshu	34.926032	118.749682	ass	Neolithic	Longshan	2500	1900	2200	*Oryza sativa; Panicum miliaceum; Setaria italica*	Wang et al., 2012; d'Aploim Guedes et al., 2015
Luoshagang	China Guangdong		23.439974	111.708436	ass	Neolithic		2500	1900	2200	*Oryza sativa*	Xiang & Yao 2006

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罗沙岗												
Luowenchong 罗文冲	China Guangdong		23.407093,	111.719551	ass	Neolithic		2500	1900	2200	*Oryza sativa*	Xiang & Yao 2006
Wusaoling 乌骚岭	China Guangdong		23.406511	111.719045	ass	Neolithic		2500	1900	2200	*Oryza sativa*	Xiang & Yao 2006
Xijincheng 西金城	China Henan	Boai Xian	35.106029	113.108454	ass	Neolithic	Longshan	2500	1900	2200	*Oryza sativa; Panicum miliaceum; Setaria italica*	Chen et al., 2010
Yadi 崖底	China Shanxi	Yuanping County	38.671636	112.623052		Neolithic	Longshan	2500	1900	2200	*Oryza sativa; Panicum miliaceum; Setaria italica*	Underhill et al., 2008
Yueru 茹岳	China Shanxi	Yuanping County	38.999694	112.784895		Neolithic	Longshan	2500	1900	2200	*Panicum miliaceum; Setaria italica; Triticum aestivum; Hordeum vulgare*	Jiang, 2011
Zhouyuan 周原	China Shaanxi	Baoji Shi	34.413890	107.895836	C14	Neolithic	Longshan	2500	1800	2150	*Oryza sativa; Panicum miliaceum; Setaria italica*	Zhao & Xu, 2004
Haidong 海东	China Yunnan	Qilu Lake	24.924163	102.734562	ass	Neolithic		2500	1750	2125	*Oryza sativa*	He, 1990 Xiao, 2001 Zhang & Hung, 2010 Yao, 2010 D'Alpoim Guedes & Butler, 2014
Xinguang	China Yunnan	Yongping	25.460559	99.525447		Neolithic		2500	1750	2125	*Oryza sativa*	Yunnan, 2002 Yao, 2010

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新光												D'Alpoim Guedes & Butler, 2014
Zhongba	China Chongqing		30.28457	108.032	ass	Neolithic		2500	1500	2000	*Oryza sativa*	Flad, 2011
Huangguashan	China, Fujian		24.475022	119.552474	C14	Neolithic		2500	1400	1950	*Oryza sativa; Setaria italica; Panicum miliaceum*	Deng et al., 2018
Non Pa Wai	Thailand	Lopburi River	14.971100	100.678000	AMS Setaria	Neolithic	Phase 1	2470	2200	2335	*Setaria italica*	Weber et al., 2010
Laohuzui 罗胡咀	China Gansu	Zhenyuan	35.950000	107.116667	C14	Bronze Age	Qijia	2464	2210	2340	*Triticum aestivum*	Chen et al., 2015
Chengjiazhuang 程家庄	China Shanxi	Sushui River	35.405563	111.276222	ass	Neolithic	Longshan	2400	2150	2275	*Oryza sativa; Panicum miliaceum; Setaria italica*	Song, 2011
Hucun	China Shanxi	Sushui	35.490410	111.356865	ass	Neolithic	Longshan	2400	1900	2150	*Oryza sativa; Panicum miliaceum; Setaria italica*	Song, 2011
Jiaochangpu 教场铺	China Shandong	Chiping	36.409345	116.260948	ass	Neolithic	Longshan	2400	1900	2150	*Panicum miliaceum; Setaria italica; Triticum aestivum*	Zhao, 2005; d'Aploim Guedes et al. ,2015
Xiayukou 下峪口	China Shanxi	Sushui River	35.431583	111.392360	ass	Neolithic	Longshan	2400	1900	2150	*Oryza sativa; Panicum miliaceum; Setaria italica*	Song, 2011
Laoyuan	China, Guangdong		24.320239	114.5606	C14	Neolithic	Late Shixia	2400	1900	2100	*Oryza sativa*	Yang et al., 2018
Huangniangniangtai	China Gansu	Liangzhou, Wuwei	37.935545	102.605913	ass	Bronze Age	Qijia	2350	1850	2100	*Setaria italica; Triticum aestivum*	Jin, Guiyun, pers.comm. 2015

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皇娘娘台												
Qiaocun 桥村	China Gansu	Lingtai County	35.151719	107.500322	ass	Bronze Age	Qijia	2350	1850	2100	*Oryza sativa; Panicum miliaceum; Setaria italica*	An et al., 2014,
Taosi 陶寺	China Shanxi		35.675150	111.401370	ass	Neolithic	Longshan	2300	2100	2200	*Oryza sativa; Panicum miliaceum; Setaria italica*	Zhao 2006 , Zhang et al. ,2010
Chaling	China, Guangdong	Pearl River	23.1828	113.3238	Ass	Neolithic	Late Shixia	2300	2000	2150	*Oryza sativa*	Yang et al., 2018
Baiyangcun 白羊村	China Yunnan	Binchuan	25.840397	100.593691	AMS	Neolithic		2200	2000	2100	*Oryza sativa; Panicum miliaceum; Setaria italica*	Dal Martello et al., 2018
Xiazhai	China Henan	Nanyang basin	33.016944	111.270278	ass	Neolithic	Late Longshan	2200	1900	2050	*Oryza sativa; Panicum miliaceum; Setaria italica*	Deng, et al. n.d
Baligang 八里岗	China Henan	Nanyang City, Dengzhou	32.690279	112.132440	AMS wheat	Neolithic	Longshan	2200	1800	2000	*Oryza sativa; Panicum miliaceum; Setaria italica*	Deng et al., 2015; Weisskopf, 2014
Huizui	China Henan		34.651850	112.741010	C14	Neolithic	Longshan, Late	2200	1800	2000	*Oryza sativa; Panicum miliaceum; Setaria italica*	Lee et al., 2007; Weisskopf, 2010
Jizhai 冀寨	China Henan		34.218640	113.338190	ass	Neolithic	Longshan, Late	2200	1800	2000	*Oryza sativa; Panicum miliaceum; Setaria italica*	Fuller & Zhang, 2007; Zhang et al., 2010
Wadian 瓦店	China Henan	Yuzhou, Ying Valley	34.187452	113.404943	C14	Neolithic	Longshan	2200	1800	2000	*Oryza sativa; Panicum miliaceum; Setaria italica*	Liu & Fang, 2010

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Wangchenggang 王城岗	China Henan	Ying	34.398287	113.124914	C14	Neolithic	Longshan	2200	1800	2000	*Oryza sativa; Panicum miliaceum; Setaria italica*	Zhao 2007; Yuan & Campbell, 2009; Flad et al., 2010
Wuwan 吴湾	China Henan	Ying Valley	34.398280	113.124920	ass	Neolithic	Longshan	2200	1800	2000	*Oryza sativa; Panicum miliaceum; Setaria italica*	Fuller & Zhang 2007,
Xiawu 下毋	China Henan	Ying	34.227220	113.381420	ass	Neolithic	Longshan	2200	1800	2000	*Oryza sativa; Panicum miliaceum; Setaria italica*	Fuller & Zhang, 2007
Xifandian 西范店	China Henan	Zhengzhou, Dengfeng	34.405307	113.084517	ass	Neolithic	Longshan	2200	1800	2000	*Oryza sativa; Panicum miliaceum; Setaria italica*	Fuller & Zhang, 2007; Zhang et al., 2010,
Youfangtou 油坊头	China Henan	Ying	34.378970	113.027530	ass	Neolithic	Longshan	2200	1800	2000	*Oryza sativa; Panicum miliaceum; Setaria italica*	Fuller & Zhang, 2007; Zhang et al., 2010
Liangchengzhen 两城镇	China Shandong		35.579030	119.571950	AMS	Neolithic	Longshan	2200	1700	1950	*Oryza sativa; Panicum miliaceum; Setaria italica; Triticum aestivum*	Crawford et al., 2005
Chaolaiqiao	Taiwan		22.847222	121.186319	C14	Neolithic		2200	2035	2117	*Oryza sativa*	Deng et al., 2018
Xiasunjiazhai 下孙家寨	China Qinghai	Xining	36.744397	101.757839		Bronze Age	Qijia	2140	1955	2050	*Panicum miliaceum; Hordeum vulgare*	Chen et al., 2015
Dadunzi 大墩子	China Yunnan	Yuanmou	25.712830	101.882100	AMS	Neolithic		2140	1630	1885	*Oryza sativa; Panicum miliaceum; Setaria italica*	Jin et al., 2014

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Huoshiliang 火石梁	China Gansu	Jiuquan	40.533307	98.147523	C14	Bronze Age	Siba	2135	1895	2050	*Panicum miliaceum; Setaria italica; Triticum aestivum; Hordeum vulgare?*	Dodson et al., 2013
Gongshijia 工什家	China Qinghai	Hualong	35.902654	102.653250	C14	Bronze Age	Qijia	2117	1893	2050	*Panicum miliaceum; Setaria italica; Hordeum vulgare*	Chen et al., 2015
Taosi 陶寺	China Shanxi		35.675150	111.401370	ass	Neolithic	Longshan, L	2100	2000	2050	*Oryza sativa; Panicum miliaceum; Setaria italica*	Zhao, 2006
Non Mak La	Thailand	Lopburi River	14.96395	100.67486				2100	1450	1775	*Setaria italica*	Pigott et al. 2006; Weber et al. 2010
Huangniangniangtai 皇娘娘台	China Gansu	Wuwei	37.935440	102.605228	C14	Bronze Age	Qijia	2043	1746	1950	*Panicum miliaceum; Setaria italica; Triticum aestivum; Hordeum vulgare*	Dodson et al., 2013
Huangguashan	China Fujian		26.79728333	119.9235389	AMS	Neolithic	Huangguashan	2030	1890	1960	*Oryza sativa; Panicum miliaceum; Setaria italica*	Deng et al., 2017
Ganggangwa 缸缸洼	China Gansu	Jiuquan	39.366167	99.991778	C14	Bronze Age	Siba	2026	1759	1950	*Panicum miliaceum; Setaria italica; Hordeum vulgare*	Dodson et al., 2013
Jinchankou 金禅口	China Qinghai	Huzhu	36.920327	102.539220	C14	Bronze Age	Qijia	2021	1891	1960	*Panicum miliaceum; Setaria italica; Triticum aestivum*	Chen et al., 2015

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Xintala 新塔拉	China Xinjiang	Bayingol	42.195520	86.968914		Bronze Age	Xintala	2005	1620	1830	*Panicum miliaceum; Triticum aestivum; Hordeum vulgare*	DebaineFrancfort 1988 , Dodson et al., 2013; Zhao et al., 2012
Taosi 陶寺	China Shanxi		35.675150	111.401370	ass	Neolithic	Longshan, L	2000	1900	1950	*Oryza sativa; Panicum miliaceum; Setaria italica*	Zhao, 2006
Khok Phanom Di	Thailand		13.58457	101.14089	c14			2000	1400	1700	*Oryza sativa*	Thompson, 1996
Trang Kenh, TK69	Vietnam		20.950163	106.749922	C14			1960	1450	1705	*Oryza sativa*	
Erlitou 二里头	China Henan	Yiluo River	34.703290	112.716640	ass	Bronze Age	Erlitou	1900	1600	1750	*Oryza sativa; Panicum miliaceum; Setaria italica; Triticum aestivum*	Zhao, 2007
Shaochai 稍柴	China Henan	Gongyi	34.703872	112.924690	ass	Bronze Age	Erlitou I	1900	1600	1750	*Oryza sativa; Panicum miliaceum; Setaria italica*	Lee et al., 2007
Tonglin 桐林	China Shandong		36.894350	118.225780	ass	Bronze Age	Erlitou	1900	1600	1750	*Oryza sativa; Panicum miliaceum; Setaria italica*	Song, 2011; Song, 2007
Donghuishan 东灰山	China Gansu		39.366172	99.991789	ass	Bronze Age	Siba	1900	1500	1700	*Panicum miliaceum; Setaria italica; Triticum aestivum; Hordeum vulgare*	Dodson et al., 2013
Guchengzhai 古城寨	China Henan	Xinmi	34.473131	113.858359	ass	Bronze Age	Xia	1900	1500	1700	*Panicum miliaceum; Setaria italica; Triticum aestivum*	Chen, 2010

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Huizui 灰嘴	China Henan	Yiluo River	34.651850	112.741010	AMS rice	Bronze Age	Erlitou	1900	1500	1700	*Oryza sativa; Panicum miliaceum; Setaria italica*	Lee et al., 2007
Jiajiabao (S) 加家堡 (南)	China Shanxi	Sushui River	35.507496	111.455956	ass	Bronze Age	Erlitou	1900	1500	1700	*Oryza sativa; Panicum miliaceum; Setaria italica*	Song, 2011
Luokou northeast 罗口东北	China Henan	Yiluo River	34.665550	112.998160		Bronze Age	Erlitou	1900	1500	1700	*Oryza sativa; Panicum miliaceum; Setaria italica*	Lee et al., 2007
Nanwa	China Henan		32.835494	111.770397	ass	Bronze Age		1900	1500	1700	*Triticum aestivum*	
Shaochai 稍柴	China Henan	Yiluo River	34.705350	112.930700		Bronze Age	Erlitou	1900	1500	1700	*Oryza sativa; Panicum miliaceum; Setaria italica*	Lee et al. 2007
Shidao 石道	China Henan		34.363000	112.873420	ass	Bronze Age	Erlitou	1900	1500	1700	*Oryza sativa; Panicum miliaceum; Setaria italica*	Fuller & Zhang 2007; Zhang et al. 2010
Wangchenggang 王城岗	China Henan	Ying	34.398287	113.124914	C14	Bronze Age	Erlitou	1900	1500	1700	*Panicum miliaceum; Setaria italica; Triticum aestivum*	Zhao 2007; Yuan & Campbell 2009; Flad et al. 2010
Zigan 子干	China Shanxi	Yuanping County	38.710405	112.836756	ass	Bronze Age	Erlitou	1900	1500	1700	*Oryza sativa; Setaria italica*	Jiang, 2011
Siwen 斯文	China Guangdong	Xinghua river	23.406511	111.719045	ass			1900	1000	1450	*Oryza sativa*	Xiang & Yao 2006

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Site	Country, Province	Location	Latitude	Longitude	Dating Quality	Broad Cultural Period	Regional Cultural Period	Start Date BC	Finish Date BC	Est. Date Median BC	Cultigens	References
Zaojiaoshu 皂角树	China Henan	Yiluo River	34.649030	112.401120	ass	Bronze Age	Erlitou I	1880	1640	1760	*Oryza sativa; Panicum miliaceum; Setaria italica*	Zhao, 2005
Shangpo 上坡	China Henan	Xiping	33.495311	114.102030		Bronze Age	Erlitou I	1880	1590	1750	*Oryza sativa; Panicum miliaceum*	Wei et al., 2007
Pingfengshan	China Fujian		26.810525	119.9836712	AMS	Neolithic	Huangguash an	1875	1545	1710	*Oryza sativa; Panicum miliaceum; Setaria italica*	Deng et al., 2017
Xinzhai 新砦	China Henan		34.506560	113.415990	ass	Bronze Age	Xinzhai	1870	1750	1810	*Oryza sativa; Panicum miliaceum; Setaria italica*	Zhao, 2005, Shelach & Teng, 2013
Rach Nui	Vietnam Long An		10.539017	106.672517	AMS	Neolithic	Neolithic,	1845	1385	1615	*Oryza sativa; Setaria italica; Sedges*	Oxenham et al., 2014
Gumugou (Qäwrighul) 古墓沟墓地	China Xinjiang		40.815541	88.699920	ass	Early Bronze Age		1800	1700	1750	*Triticum aestivum*	Mair & Mallory, 2000
Zhaogezhuang 照格庄	China Shandong	Yantai, Muping	37.370145	121.616416		Bronze Age	Yueshi	1800	1600	1700	*Oryza sativa; Panicum miliaceum; Setaria italica; Triticum aestivum*	Zhao et al., 2008; An et al. 2013; d'Aploim Guedes et al., 2015
Zaojiaoshu 皂角树	China Henan	Yiluo River	34.649030	112.401120	ass	Bronze Age	Erlitou II	1740	1590	1665	*Oryza sativa; Panicum miliaceum; Setaria italica; Triticum aestivum*	Zhao, 2005
Xiaohe Cemetry	China Xinjiang		40.336667	88.563594	AMS Panicu	Bronze Age	~Shang	1725	1425	1600	*Panicum miliaceum; Triticum aestivum.*	Qiu et al. 2014

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Site	Country, Province	Location	Latitude	Longitude	Dating Quality	Broad Cultural Period	Regional Cultural Period	Start Date BC	Finish Date BC	Est. Date Median BC	Cultigens	References
小河墓地					m, wheat							
Pingfenshan	China, Fujian		26.483789	119.594537	C14	Neolithic		1700	1400	1550	*Oryza sativa; Setaria italica; Panicum miliaceum*	Deng et al., 2018
Ban Tha Kae	Thailand	Lopburi River	14.84342	100.61578	ass			1700	1100	1400	*Oryza sativa*	Rispoli et al., 2013
Ban Chiang	Thailand		17.50262	103.25591	c14			1650	1050	1350	*Oryza sativa*	Yen 1982; 1989; White 1982
Ban Non Wat	Thailand Nakhon Ratchasim a		15.26668	102.27736	AMS			1650	1050	1350	*Oryza sativa*	Castillo, 2013; Silva et al., 2015:
Haimenkou 1 海门口	China Yunnan	Jianchuan county	26.43333	99.91667	c14	Bronze Age	layers 108	1600	1400	1500	*Oryza sativa; Panicum miliaceum; Setaria italica*	Xue, 2010 Jin, 2013 Dal Martello, 2019
Erlitou 二里头	China Henan	Yiluo River	34.703290	112.716640	ass	Bronze Age	Erligang	1600	1450	1525	*Oryza sativa; Panicum miliaceum; Setaria italica; Triticum aestivum*	Zhao,2007
Fengzhai 冯寨	China Henan	Yiluo River	34.586409	112.869984	ass	Bronze Age	Erligang	1600	1450	1525	*Setaria italica; Triticum aestivum*	Lee et al. 2007,
Guchengzhai 古城寨	China Henan	Xinmi	34.473131	113.858359	ass	Bronze Age	Erligang	1600	1450	1525	*Panicum miliaceum; Setaria italica; Triticum aestivum*	Chen et al., 2012
Shangzhuang(cun)	China Henan	Yiluo River	34.612300	113.063740	C14	Bronze Age	Shang	1600	1450	1525	*Oryza sativa;*	Lee et al., 2007

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Site	Country, Province	Location	Latitude	Longitude	Dating Quality	Broad Cultural Period	Regional Cultural Period	Start Date BC	Finish Date BC	Est. Date Median BC	Cultigens	References
上庄											*Panicum miliaceum; Setaria italica*	
Tianposhuiku 天坡水库	China Henan	Yiluo River	34.645180	112.950050	C14	Bronze Age	Erligang	1600	1450	1525	*Oryza sativa; Panicum miliaceum; Setaria italica; Triticum aestivum*	Lee et al., 2007
Yueyabao	China Shanxi	Sushui River	35.079625	110.797851		Bronze Age	Erligang	1600	1450	1525	*Panicum miliaceum; Setaria italica; Triticum aestivum*	Song, 2011
Liujiazhuang (SE) 刘家庄	China Shanxi	Sushui	35.383873	111.456902	ass	Bronze Age	Shang	1600	1200	1400	*Oryza sativa; Panicum miliaceum; Setaria italica*	Song, 2011
Mopandi 磨盘地	China Yunnan	Yuanmou	26.053485	101.668087	ass	Neolithic		1600	1200	1400	*Oryza sativa*	Zhao, 2003
Liujiazhuang (SE) 刘家庄	China Shanxi	Sushui River	35.383873	111.456902	ass	Bronze Age	Shang	1600	1000	1300	*Oryza sativa; Panicum miliaceum; Setaria italica*	Song, 2011
Gaopo	China Sichuan	Liangshanyi autonomous region Mianning county	28.4376	102.1696	ass	Bronze Age		1600	1300	1400	*Oryza sativa; Panicum miliaceum*	Chengdu, 2011
Tonglin 桐林	China Shandong		36.894350	118.225780	ass	Bronze Age	Shang & Zhou	1600	256	928	*Oryza sativa; Panicum miliaceum; Setaria italica*	Song, 2011
Tù Son	Vietnam		21.1839	106.056	ass			1550	1250	1400	*Oryza sativa*	

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Site	Country, Province	Location	Latitude	Longitude	Dating Quality	Broad Cultural Period	Regional Cultural Period	Start Date BC	Finish Date BC	Est. Date Median BC	Cultigens	References
Wujiadaping	China, Guizhou		27.1325	103.4822	C14	Bronze Age		1521	1216	1350	*Oryza sativa*	Guizhou et al., 2006
Jiaoridang 交日党?	China Qinghai	Xunhua	35.733295	102.435454	C14	Bronze Age	Kayue	1513	1413	1450	*Panicum miliaceum; Setaria italica; Hordeum vulgare*	Chen et al., 2015
Aiqingya 艾青雅	China Qinghai	Gangcha	37.330891	100.128184		Bronze Age	Kayue	1505	1407	1450	*Triticum aestivum*	Chen et al., 2015
Sidaogou 四道沟	China Xinjiang	Urumqi	43.794862	87.510700		Bronze Age	Sidaogou	1500	1130	1315	*Setaria italica?; Triticum aestivum*	Dodson et al., 2013
Anninghe Basin	China Sichuan	Xichang county Lizhou	32.416149	105.856439	ass			1500	1000	1250	*Oryza sativa?*	Huang, 1982
Dalitaliha	China Qinghai		36.438532	96.455061		Bronze Age		1500	1000	1250	*Triticum aestivum*	Flad et al., 2010
Dugangsi 杜岗寺	China Henan	Yuzhou, Xuchang	34.116640	113.484690	ass	Bronze Age	Shang	1500	1000	1250	*Oryza sativa; Panicum miliaceum; Setaria italica; Triticum aestivum ; Hordeum vulgare*	Fuller & Zhang 2007
Shifodong 石佛东	China Yunnan	Lincang	23.365095	99.432395	ass	Bronze Age		1500	1000	1250	*Oryza sativa; Panicum miliaceum; Setaria italica*	D'Alpoim Guede & Butler 2014; Zhao 2010b
Zhonghai guojishequ 中海国际社区	China Sichuan	Chengdu Jinniu district	30.691268	104.052306	ass	Bronze Age	Shang	1500	1300	1400	*Oryza sativa; Panicum miliaceum; Setaria italica; Triticum aestivum*	Chengdu 2012

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Site	Country, Province	Location	Latitude	Longitude	Dating Quality	Broad Cultural Period	Regional Cultural Period	Start Date BC	Finish Date BC	Est. Date Median BC	Cultigens	References
Cho Ghênh	Vietnam		20.24694	105.99033			Wupaer	1500	500	1000	*Oryza sativa*	Nguyen, 1998
Changguogou 昌果沟	China Tibet		29.24802	91.771522		Bronze Age		1450	800	1125	*Setaria italica; Triticum aestivum; Hordeum vulgare*	Fu, 2001; Jin, 2007; d'Alpoim Guedes et al., 2014
Guanting Basin: various 官亭盆地:	China Qinghai	Minhe, Haidong	35.867590	102.794539	ass	Bronze Age	Xindian	1450	750	1100	*Panicum miliaceum; Setaria italica; Triticum aestivum; Hordeum vulgare*	Zhang, 2012
Non Mak La	Thailand	Lopburi River	14.963950	100.674860		Bronze Age	Phase 2	1450	700	1075	*Oryza sativa; Setaria italica*	Pigott et al., 2006; Weber et al., 2010
Tawendaliha 塔温达里哈	China Qinghai	Dulan	36.227181	97.310896	AMS	Bronze Age	Nuomuhong	1442	1306	1400	*Panicum miliaceum; Hordeum vulgare*	Chen et al., 2015
Xiariyamakebu 夏日亚马科布 (马克)	China Qinghai	Dulan	35.977319	97.447882	AMS	Bronze Age	Nuomuhong	1435	1297	1350	*Setaria italica; Hordeum vulgare*	Chen et al., 2015
Daxinzhuang 大辛庄	China Shandong	Licheng Qu, Jinan Shi	36.711332	117.106332		Bronze Age	Middle	1435	1220	1327.5	*Oryza sativa; Panicum miliaceum; Setaria italica; Triticum aestivum*	Chen, 2007
Luowalinchang 洛哇林场	China Qinghai	Jianzha	35.927581	101.873668		Bronze Age	Kayue	1419	1211	1320	*Panicum miliaceum; Setaria italica; Triticum aestivum; Hordeum vulgare*	Chen et al., 2015
Huidui 灰堆	China Qinghai	Ledu	36.366125	102.321983	C14	Bronze Age	Xindian	1416	1216	1320	*Triticum aestivum; Hordeum vulgare*	Chen et al., 2015

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Site	Country, Province	Location	Latitude	Longitude	Dating Quality	Broad Cultural Period	Regional Cultural Period	Start Date BC	Finish Date BC	Est. Date Median BC	Cultigens	References
Hongshanzuinanpo 红山咀男宝	China Qinghai	Wulan	36.981785	36.981785	AMS	Bronze Age	Nuomuhong	1415	1267	1340	*Setaria italica; Hordeum vulgare*	Chen et al., 2015
Qiezha 切扎	China Qinghai	Gonghe	36.386930		C14	Bronze Age	Kayue	1413	1265	1340	*Hordeum vulgare*	Chen et al., 2015
Lagalamaerma	China Qinghai	Gangcha	37.330891	100.128184	C14	Bronze Age	Kayue	1410	1260	1340	*Hordeum vulgare*	Chen et al., 2015
Haimenkou 2 海门口	China Yunnan		26.433330	99.916670	AMS	Bronze Age	Layers 7-6	1400	1100	1250	*Oryza sativa; Panicum miliaceum; Setaria italica; Triticum aestivum; Hordeum vulgare; Fagopyrum esculentum; Chenopodium*	Xiao, 1995; Xue, 2010; Jin, 2013; D'alpoim Guedes & Butler, 2014; Dal Martello, 2019
Tianposhuiku 天坡水库	China Henan	Yiluo River	34.645180	112.950050	C14	Bronze Age	Erligang	1400	1250	1325	*Oryza sativa; Panicum miliaceum; Setaria italica; Triticum aestivum*	Flad et al., 2010
Khok Charoen	Thailand		15.38266	100.82245		Bronze Age		1400	800	1100	*Oryza sativa*	Vincent 2002
Sangongtang 三宫堂	China Sichuan	Shuangliu county	30.532	103.8951	ass	Bronze/Iron Age	Late Shang to Han dyn	1400	200	800	*Oryza sativa; Panicum miliaceum; Setaria italica*	Chengdu 2013
Zhengjiaba 郑家坝	China Sichuan	Langzhong city	31.37063	105.56489	ass	Iron Age	Pre-Qin	1400	1200	1300	*Oryza sativa; Panicum miliaceum; Setaria italica; Hordeum vulgare*	Yan et al., 2013

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Site	Country, Province	Location	Latitude	Longitude	Dating Quality	Broad Cultural Period	Regional Cultural Period	Start Date BC	Finish Date BC	Est. Date Median BC	Cultigens	References
Ashaonao	China Sichuan	Jiuzhaigou National Park	33.256978	103.919155	AMS wheat	Neolithic		1400	1000	1250	*Triticum aestivum*	D'Alpoim Guedes et al., 2015
Shuang'erdong(ping) 双二东平	China Qinghai	Ledu	36.444489	102.512128		Bronze Age	Xindian	1390	1210	1300	*Panicum miliaceum; Setaria italica; Triticum aestivum; Hordeum vulgare*	Chen et al., 2015; Dong et al., 2014
Nil Kham Haeng	Thailand		14.95675	100.65593	ass	Bronze Age		1350	800	1075	*Setaria italica*	Pigott et al., 2006
Fengzhai	China Henan	Yilou	34.714068	113.157884	ass	Bronze Age	Erligang	1300	1000	1150	*Setaria italica; Triticum aestivum*	Flad et al., 2010
Guchengzhai 古城寨	China Henan	Xinmi	34.473131	113.858359	ass	Bronze Age	Shang	1300	1000	1150	*Panicum miliaceum; Setaria italica; Triticum aestivum*	Chen et al. 2012
Wangchenggang 王城岗	China Henan	Ying	34.398287	113.124914	C14	Bronze Age	Shang	1300	1000	1150	*Oryza sativa; Panicum miliaceum; Setaria italica; Triticum aestivum*	Zhao, 2007; Yuan & Campbell 2009; Flad et al., 2010
Luanzagangzi 乱杂岗子	China Xinjiang	Jimsar	43.758050	89.189062	ass	Bronze Age	Zhunge'er	1300	900	1100	*Setaria italica; Triticum aestivum; Hordeum vulgare*	Flad et al., 2010; Jia et al., 2011
Yanchi Gucheng	China Xinjiang		42.696441	93.951387		Bronze Age		1300	900	1100	*Triticum aestivum*	Flad et al., 2010
Jigongshan 鸡公山	China Guizhou	Weining County, Zhongshui	27.221556	103.802172	ass	Bronze Age	Shang (Early)/Zhou	1300	800	1050	*Oryza sativa; Panicum miliaceum?; Setaria italica?*	Guizhou et al. 2006; Zhang & Hung 2010;
Jinsha 5C 金沙	China Sichuan	Chengdu	30.683333	104.010833	ass	Bronze Age	Shang to Western	1250	700	975	*Oryza sativa;*	Jiang et al., 2011

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Site	Country, Province	Location	Latitude	Longitude	Dating Quality	Broad Cultural Period	Regional Cultural Period	Start Date BC	Finish Date BC	Est. Date Median BC	Cultigens	References
							Zhou dynasties				*Panicum miliaceum; Setaria italica*	
Boluocun 菠萝村	China Sichuan	Chengdu	30.818084	103.882946	ass	Bronze Age		1250	800	1125	*Oryza sativa; Panicum miliaceum; Setaria italica*	Chengdu 2012b
Nanbiqiao	China Yunnan		23.5459	99.42761	ass	Bronze Age		1250	970	1110	*Oryza sativa*	An, 1999
Fengtai 互助丰台	China Qinghai	Huzhu	36.560394	101.565514	ass	Bronze Age	Kayue culture 900600 BC?	1250	850	1050	*Setaria italica; Triticum aestivum; Hordeum vulgare*	Jin, Guiyun, pser.comm. 2015
Daxinzhuang 大辛庄	China Shandong	Licheng Qu, Jinan Shi	36.711332	117.106332		Bronze Age	Shang	1220	1135	1177.5	*Oryza sativa; Panicum miliaceum; Setaria italica; Triticum aestivum*	Chen & Fang, 2008
Zahongluke 扎洪鲁克	China Xinjiang	Qiemo	38.099296	85.452677		Bronze Age		1200	700	950	*Panicum miliaceum; Setaria italica; Triticum aestivum; Hordeum vulgare*	Zhao et al., 2012; Flad et al., 2010; He, 1992
Wupaer 乌帕尔乡	China Xinjiang	Shufu, Kashgar	39.301826	75.550342		Bronze Age		1190	910	1050	*Triticum aestivum*	Dodson et al., 2013
Daxinzhuang 大辛庄	China Shandong	Licheng Qu, Jinan Shi	36.711332	117.106332		Bronze Age	Shang	1135	1050	1092.5	*Oryza sativa; Panicum miliaceum; Setaria italica*	Chen, 2008
Chenzhuang	China Shandong	Gaoqing	37.162878	117.764545	ass	Bronze Age	Western Zhou	1100	1000	1050	*Oryza sativa; Panicum miliaceum; Setaria italica*	Jin, 2012; d'Alpoim Guedes et al., 2015;

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												Wang 2010
Lo Gach	Vietnam		105.763955	10.915772	AMS			1100	700	900	*Oryza sativa*	Castillo, pers. comm 2018
Chawuhugou 察吾乎沟	China Xinjiang	Hejing	42.743358	86.307019		Bronze Age		1100	400	750	*Panicum miliaceum; Setaria italica; Triticum aestivum*	Zhao et al., 2012
Qunbake (Ranjiagou)/ Chong Bagh	China Xinjiang		41.860001	84.139873		Bronze Age		1100	400	750	*Triticum aestivum*	; DebaineFrancfort 1989, Flad et al., 2010
Zhongba	China Chongqing		30.284570	108.032000	ass	Bronze Age	Zhongba 3	1100	200	650	*Oryza sativa; Panicum miliaceum; Setaria italica*	D'Alpoim Guedes, 2013
Dongpan	China Shandong	Linshu	34.926032	118.749682	ass	Bronze Age	Xizhou	1050	770	910	*Oryza sativa; Panicum miliaceum; Setaria italica*	Wang et al., 2012; D'Alpoim Guedes et al., 2015
Ban Non Wat	Thailand Nakhon Ratchasima		15.264694	102.257917	AMS	Bronze Age	Bronze Age,	1050	420	735	*Oryza sativa; Setaria italica*	Castillo, 2013; Silva et al., 2015
Beiqian 北阡	China Shandong	Jinkou, Jimo city	36.600133	120.739182		Bronze Age	Zhou	1046	256	651	*Oryza sativa; Panicum miliaceum; Setaria italica; Triticum aestivum ; Hordeum vulgare*	Zhao, 2009; Jin & Wang, 2011; Wang & Luan, 2011; Wang & Jin, 2013
Tudun 土墩	China Xinjiang		44.148615	93.263616		Bronze Age		1000	800	900	*Triticum aestivum*	Flad et al., 2010

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Site	Country, Province	Location	Latitude	Longitude	Dating Quality	Broad Cultural Period	Regional Cultural Period	Start Date BC	Finish Date BC	Est. Date Median BC	Cultigens	References
Non Pa Wai	Thailand		14.971100	100.678000		Bronze Age 2	Phase2B	1000	700	850	*Oryza sativa; Setaria italica*	Pigott et al., 2006; Weber et al., 2010
Shirenzi 石人子	China Xinjiang	Kumul, Balikun	43.594075	93.245603		Bronze/Iron Age		1000	700	850	*Triticum aestivum*	DebaineFrancfort 1989; Zhao, 2009; Spengler & Willcox, 2013
Baligang 八里岗	China Henan	Nanyang City, Dengzhou	32.690279	112.132440	AMS wheat	Bronze Age		1000	400	700	*Oryza sativa; Panicum miliaceum; Setaria italica; Triticum aestivum*	Deng et al., 2015; Weisskopf, 2014
Ban Na Di	Thailand		17.25612	103.13399				900	500	700	*Oryza sativa*	Solheim, 1961 Castillo, 2013 Higham et al., 2015
Wupaer 乌帕尔乡	China Xinjiang	Shufu, Kashgar	39.301826	75.550342		Bronze Age	Wupaer	900	400	650	*Triticum aestivum*	Dodson et al., 2013
Nil Kham Haeng	Thailand		14.956750	100.655930		Bronze Age	Phase 2	800	500	650	*Oryza sativa; Setaria italica*	Pigott et al., 2006; Weber et al., 2010
Huoshaogou 火烧沟	China Gansu		39.949830	97.708792	C14	Bronze Age	Qijia	790	415	620	*Panicum miliaceum; Setaria italica; Triticum aestivum; Hordeum vulgare*	Dodson et al. 2013
Xiazhai	China Henan	Nanyang basin	33.016944	111.270278	AMS	Bronze Age	Eastern Zhou	790	375	582.5	*Oryza sativa; Panicum miliaceum; Setaria italica; Triticum aestivum*	Deng, et al., n.d.

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Dayingzhuang 大营庄	China Yunnan	Kunming	24.84	102.53		Bronze Age	Dian	780	550	650	*Oryza sativa; Panicum miliaceum; Setaria italica; Triticum aestivum ; Hordeum vulgare*	Dal Martello, 2019
Shizhaishan 石寨山	China Yunnan	Dian Basin	24.709996	102.693002		Bronze Age	Dian	780	490	600	*Oryza sativa Setaria italica; Triticum aestivum*	Zhao, 2010
Wangchenggang 王城岗	China Henan	Ying	34.398287	113.124914	C14	Iron Age	Spring & Autumn	770	475	622.5	*Oryza sativa; Panicum miliaceum; Setaria italica; Triticum aestivum*	Zhao, 2007; Yuan & Campbell 2009; Flad et al. 2010
Anjiang	China Yunnan	Dian Basin	24.771577	102.783353		Bronze Age	Dian	770	430	575	*Oryza sativa; Setaria italica; Triticum aestivum*	Yao et al., 2015
Haimenkou 3 海门口	China Yunnan		26.433330	99.916670	AMS	Bronze Age	layers 53	750	400	575	*Oryza sativa; Panicum miliaceum; Setaria italica; Triticum aestivum ; Hordeum vulgare; Chenopodium*	Xue, 2010; Jin, 2013; Dal Martello, 2019
Hebosuo 河伯所	China Yunnan		24.26	103.18		Bronze Age	Dian	730	40 AD	300	*Oryza sativa; Panicum miliaceum; Setaria italica; Triticum aestivum ; Hordeum vulgare*	Yang, 2016

Appendix 7. List of sites shown in fig. 8-14 Chapter 8.

Site	Country, Province	Location	Latitude	Longitude	Dating Quality	Broad Cultural Period	Regional Cultural Period	Start Date BC	Finish Date BC	Est. Date Median BC	Cultigens	References
Shilinggang 石岭岗	China Yunnan	Lushui county Nujiang district	25.643529	98.883886	AMS	Bronze Age		723	339	531	*Oryza sativa; Setaria italica*	Li et al., 2016
Guanfentou 光坟头	China Yunnan	Jiantuan country	24.338333	102.863333	ass	Iron Age	Dian	700	400	550	*Oryza sativa; Panicum miliaceum; Setaria italica; Triticum aestivum ; Hordeum vulgare*	Li, 2016
Xiaoguancheng	China Yunnan	Dian Basin	24.905978	102.829989		Bronze Age	Dian	700	300	500	*Oryza sativa; Setaria italica; Triticum aestivum*	Yao et al., 2016
Xueshan 学山	China Yunnan	Chengjiang country	24.641137	102.942584	ass	Iron Age	Dian	700	300	500	*Oryza sativa; Panicum miliaceum; Setaria italica; Triticum aestivum ; Hordeum vulgare*	Wang, 2014
Yubeidi 玉碑地	China Yunnan		25.42	102.22		Bronze Age	Dian	700	300	500	*Oryza sativa; Panicum miliaceum; Setaria italica; Triticum aestivum*	Yang, 2016
Non Hua Raet	Thailand		15.291111	102.257917				500	0 AD	250	*Oryza sativa*	Castillo, pers. comm 2018
Phromtin Thai	Thailand		14.990556	100.62139	AMS	Early Historic		500	900 AD	200 AD	*Oryza sativa; Setaria italica*	D'alpoim Guedes et al., 2018
Ashaonao	China Sichuan	Jiuzhaigou National Park	33.256978	103.919155	AMS wheat	Iron Age	Iron Age/PreHan	400	200	300	*Triticum aestivum; Hordeum vulgare; Setaria* cf.	D'Alpoim Guedes et al., 2015

Appendix 7. List of sites shown in fig. 8-14 Chapter 8.

Site	Country, Province	Location	Latitude	Longitude	Dating Quality	Broad Cultural Period	Regional Cultural Period	Start Date BC	Finish Date BC	Est. Date Median BC	Cultigens	References
Khao Sam Kheo	Thailand		10.528300	99.185000	AMS/C14	Metal Age	Metal Age,	400	100	250	*Oryza sativa; Setaria italica*	Castillo 2013; Castillo & Fuller, 2010; Castillo et al., 2018
Ban Don Ta Phet	Thailand		14.189764	99.725883	c14	Early Historic		300	100	200	*Oryza sativa*	Castillo, 2013
Mawangdui 馬王堆	China Hunan	Changsha	28.208611	113.021667	ass	Early Historic	Han	186	145	165.5	*Oryza sativa; Panicum miliaceum; Setaria italica*	Yu, 1977
Phu Khao Thong	Thailand		9.38066	98.4221	AMS	Early Historic		175	125	150	*Oryza sativa*	Castillo, 2013

Compiled from OWCAD (Old World Cereal Archaeobotanical Database) Fuller, et al. (unpublished).