

SPECIAL ISSUE: COLLABORATIVE RESEARCH IN EAST AND SOUTHEAST ASIA

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The site of Prasat Thma Dap, Angkor Period. Located on Phnom Kulen mountain, Siem Reap province, Cambodia (Photo Alison Carter).

# HARVESTS FOR THE HUNTERS

## THE ORIGINS OF FOOD PRODUCTION IN ARID NORTHERN CHINA

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**T**he study of agricultural origins in northern China is complicated by the absence of archaeological evidence for the hunter-gatherers who invented agriculture and a poor record of plant or animal domestication. Recent work at the Dadiwan site provides important data for both. The product of many years collaboration between Chinese and American scholars, this work casts the evolution of agricultural life in a new light, and helps distinguish the process here from other parts of the world.

### Mind the Gap

In northern China, the independent origin of agriculture is marked by the sudden appearance of ceramics, ground stone, and semi-permanent domestic architecture in several different areas between 8500 and 7000 cal B.P. (Figure 1). Until quite recently, however, the archaeology of this period produced little direct evidence for agricultural subsistence. Equally problematic is a “gap” in the archaeological record of early Holocene China (~11,500–8500 cal B.P.), immediately prior to the Neolithic Revolution (Bettinger et al. 2007). While there are a few sites from this period near the Taihang Mountains that contain small amounts of pottery, milling equipment, and microblades (Zhang 1999), all are 300–1000 km from the earliest evidence of food production and none contain direct evidence for agriculture (e.g. plant remains, sickle blades, isotopic signatures, etc.). Where the earliest evidence for food production does exist, there is no clear evidence for a hunting and gathering antecedent. Together these facts suggest that North China’s agricultural Neolithic did not emerge in the areas where it eventually flourished.

### Off the Desert Road to Turkestan

In the late 1980s, a group of American and Chinese scholars began studying the surface archaeology of the Alashan Plateau using interpretive models developed for the American Great Basin (Bettinger et al. 1990). This collaborative survey project quickly led to new hypotheses about the con-

nections between arid-lands adaptive strategies and the evolution of agriculture (Bettinger et al. 1994; Madsen et al. 1996). Ultimately, the Pigeon Mountain site on the eastern slope of the Helan Mountains produced some of the earliest evidence for intensive plant processing, and a record of cultural change across the Pleistocene-Holocene boundary (Elston et al. 1997; Madsen et al. 1998). Of note, milling equipment appeared during the Bølling-Ållerød warm phase (~14.7–13.7 kcal B.P.), and microlithic technology became increasingly important through the Younger Dryas and into the earliest Holocene (~13.7–11.3 kcal B.P.). This desert record, however, is silent regarding the period immediately before the appearance of agriculture. As with other early Neolithic sites, terminal Pleistocene-early Holocene (TPEH) sites from the “Tengger Period” (Bettinger et al. 2007) in the northern deserts are also hundreds of kilometers away from the eventual North China agricultural core.

### Connecting Dots in the Western Loess Plateau

In 2002 we began a survey with Lanzhou University and the Gansu Provincial Institute of Cultural Relics and Archaeology to evaluate potential connections between TPEH desert foragers and the agriculturalists of the western Loess Plateau, best known from the Dadiwan archaeological site, the type site of the Laoguantai complex, the westernmost expression of early millet agriculture in north China (Figure 2). Following cursory explorations along the northern fringe of the known distribution of Neolithic sites, we started looking at some of the oldest Neolithic sites themselves for evidence of possible hunter-gatherer predecessors. Though these initial surveys produced almost nothing relevant to the story of hunter-gatherer intensification and the evolution of agriculture, we did identify a 60,000-year record of late Pleistocene forager strategies, particularly during marine isotope stage 3 and the Last Glacial Maximum (LGM) (Barton et al. 2007; Ji et al. 2005). Our 2002 survey was admittedly somewhat scattershot, but its results beg the question: if Paleolithic sites from the LGM were so easy to find, why was it

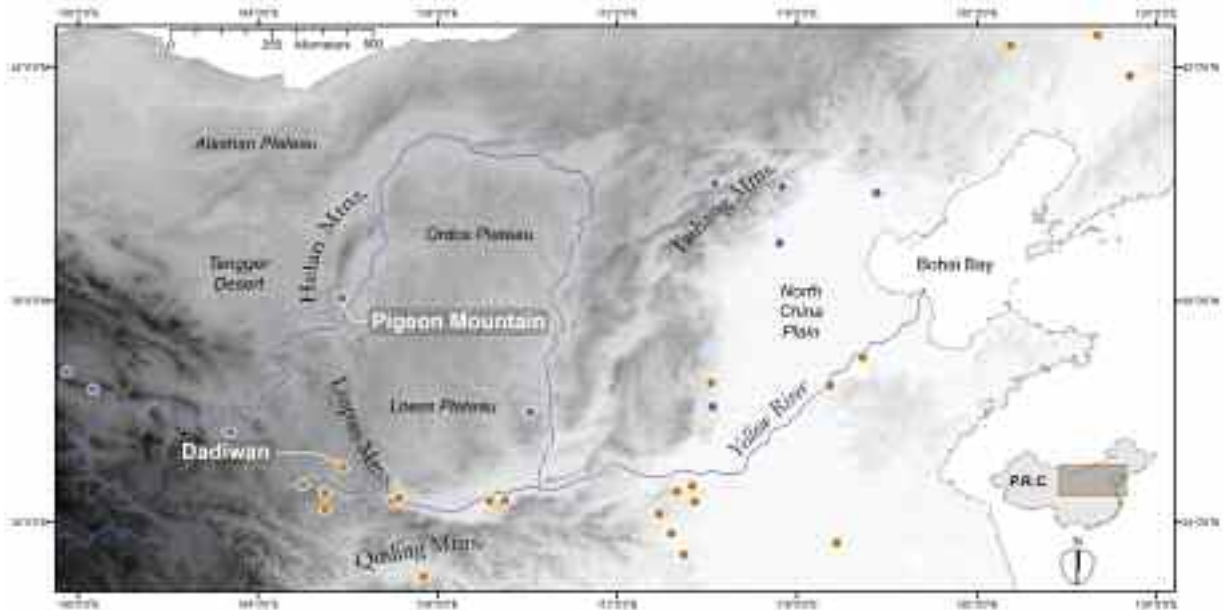


Figure 1. The theater of agricultural origins in North China. Blue dots represent dated terminal Pleistocene–early Holocene Microlithic or Early Neolithic pre-agricultural sites; orange dots Middle Neolithic, early agricultural sites of the Laoguantai, Baijia, Peiligang, Cishan, Houli, and Xinglongwa culture areas (from west to east). Not all known sites are represented.

so difficult to find Early Neolithic sites dating to the early Holocene, or for that matter, Middle Neolithic Laoguantai agricultural sites?

### Pre-agricultural Evidence at Dadiwan

In 2004, the Gansu Provincial Institute of Cultural Relics and Archaeology, Lanzhou University, The Dadiwan Museum, and the University of California conducted limited testing at Dadiwan, the oldest Neolithic site known from the western Loess Plateau. A single unit revealed a cryptic chipped-stone component beneath Neolithic cultural deposits, in strata previously considered sterile (Bettinger et al. 2005). In 2006, we returned to the site to expand and date this chipped-stone assemblage. Excavations in three adjacent 1-x-2-m units produced a stratified, 7.1 m-deep cultural sequence recording 60,000 years of human activity. Artifact types and frequencies justify division of this sequence into six cultural components, with age estimates based on a combination of absolute dates, stratigraphy, seriation, and climatic events (Barton 2009). That Dadiwan was occupied for so long surely attests to its locational advantages for both farming and hunting: proximity to water, good drainage, and for hunters especially its panoramic view of the surrounding landscape and strategic positioning relative to game, game trails, and seasonal migration routes between mountains to the north and river valleys to the south. The connection between hunting and the origin of agriculture is demonstrated by our discovery of a previously undocumented

microlithic assemblage first appearing after the LGM, proliferating during the Younger Dryas, and persisting through the Laoguantai Neolithic. When the site is reoccupied a thousand years later by sedentary Late Neolithic farmers, the microlithic industry all but disappears. The Dadiwan microlithic is made entirely from exotic raw materials. Microlithic blades and blade cores are extremely small (Figure 3), smaller than anywhere reported in northern China. Both suggest the materials were transported over great distances and used to the point of exhaustion. The assemblage is morphologically consistent with the widespread and well-documented North China Microlithic (e.g., Chen 1984), of which Pigeon Mountain is the nearest well-dated example, 340 km to the north. These similarities suggest a connection between the Dadiwan microlithic and the hunting adaptations of the Tengger Desert and Helan Mountains.

### The Isotopic Identity of Domestication

There is little direct evidence for the earliest experiments with food production, and therefore little is known about plant or animal domestication in northern China. While historical and archaeobotanical evidence suggest that North China's agricultural complex was rooted in two different kinds of millet (*Setaria italica* and *Panicum miliaceum*), there are few data directly attesting to this. Since both of the proposed domesticates are C<sub>4</sub> plants, isotopically distinguishable from wild, mostly C<sub>3</sub> plants, millet consumption in northern China is visible in skeletal biochemistry just as



Figure 2. Shao Dian village and the Qingshui Valley of the eastern Longxi Basin. The Dadiwan site is in the trees on the east (right) edge of the village (Photo by C.T. Morgan).

maize is in many parts of the New World. Together with an isotopic index of meat/protein consumption ( $\delta^{15}\text{N}$ ), stable isotope biochemistry of human and animal bone reveals the strength of the domestic relationship between humans, plants, and animals (Barton et al. 2009). At Dadiwan, the earliest evidence for a persistent, year-round focus on millet comes from high  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  values in dogs at about 7500 cal B.P. ("Phase 1" in Figure 4). These dogs are distinct from wild-foraging animals like red deer and sika ("browsers/grazers" in Figure 4), as well as Phase 1 pigs and other canids. Animals living close enough to humans to consume millet regularly throughout the year consistently ate more meat (likely table scraps, offal, and human waste) than animals living on wild forage, producing a positive correlation between  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$ . The positive correlation between millet and meat, which signifies the strength of the domestic relationship, also applies to the transition to intensive agriculture during the Late Neolithic ("Phase 2" in Figure 4). Here, both dogs and millet are fully incorporated into the domestic farming sphere while pig diets vary from fully wild to fully domestic. This illustrates the plasticity of pig husbandry during the Late Neolithic, and suggests that dogs and millet were both critical to the domestication of the pig in northwest China (Barton 2009; Barton et al. 2009).

### An Emerging Picture of Agricultural Origins in Northern China

Dadiwan provides the first compelling link between late Pleistocene hunter-gatherer intensification and the transition to agriculture. Artifact similarities and long distance transport of exotic toolstone illustrate connections between the early Holocene hunting adaptations at Dadiwan and those of the northern deserts. That dogs show the earliest evidence for year-round millet consumption (at ~7500 kcal B.P.), attests both to the long-standing importance of dogs and to the increasing importance of storable plant products in the North China hunting economy.

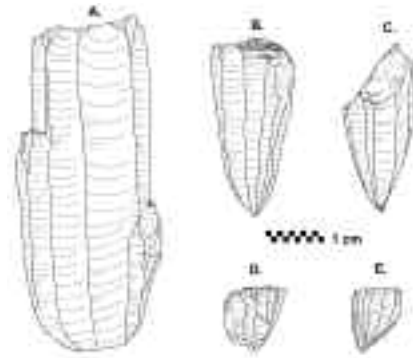


Figure 3. A comparison of microblade cores from northwest China. A, B and C are from the Toll Booth site, northwest of the Helan Mountains; D and E are from the 2006 excavations at Dadiwan.

We contend that the earliest forays into food production in arid northern China were to support an increasingly fragile hunting pattern. The intensive harvest, storage, and perhaps cultivation of quick-growing annual grasses reduced local variations in resource abundance connected with animal migrations, and thus the risk of hunting in marginal environments. Both the hunting pattern and the intensive use of plants were introduced to Dadiwan by hunters from the arid regions between the Yellow River, the Tengger Desert, and the Helan Mountains, who moved south during periodic TPEH cold-dry climatic reversals. The use of both dogs and millet intensified with this southern movement: dogs became more useful for flushing game from the riparian gallery forests of the western Loess Plateau and greater precipitation produced better harvests in floodplain valleys like those near Dadiwan. Better harvests reduced conflicts with the hunting calendar, and enabled hunters at Dadiwan to devote more time to accessing game—a pursuit for which the site had always been well-positioned. This promoted longer stays, leading to more regular consumption of semi-domesticated foods otherwise reserved for occasional short-falls. This in turn amplified their dependence upon storable, predictable resources, likely maintaining the selective pressures necessary for changing the morphological and molecular composition of plant and animal populations. We suspect that this same basic pattern holds throughout much of north China. Hunters on the southern fringe of the North China Microlithic frequently experimented with millet cultivation to support their traditional hunting economy as they periodically expanded south into new and unfamiliar territory to escape climatic downturns. These scattered experiments represent the origins of early millet agriculture in northern China.

*Acknowledgments.* The collaborative, multidisciplinary agenda of modern archaeology owes much to the mid-twentieth-century pursuit of agricultural origins. Our work in northern

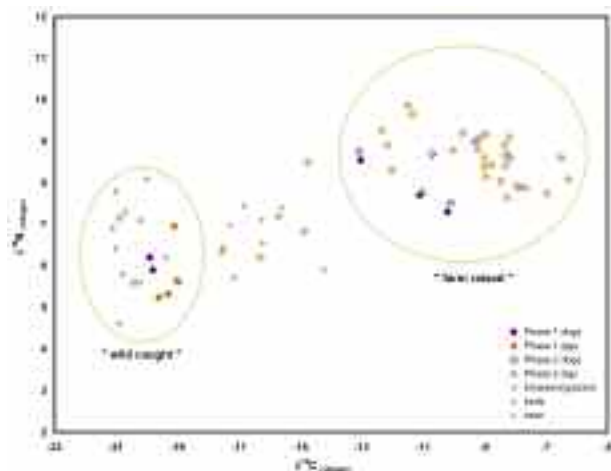


Figure 4. Stable isotope chemistry of Dadiwan fauna. “Phase 1” denotes the Middle Neolithic at Dadiwan; “Phase 2” the Late Neolithic seen throughout the Wei and Yellow River Valleys. The strength of the domestic relationship increases dramatically from Phase 1 to Phase 2.

China follows in this tradition and represents a truly collaborative effort, from start-to-finish, between laboratories at the Center for Arid Environment and Paleoclimate Research at Lanzhou University, the Carnegie Institution of Washington, D.C., the Center for Accelerator Mass Spectrometry at the Lawrence-Livermore National Laboratories in California, the Gansu Provincial Institute of Cultural Relics and Archaeology, and the Department of Anthropology at the University of California, Davis. Major contributions come from: Chen Fahu, Ji Duxue, An Chengbang, Wang Hui, Rao Zhiguo, Zhao Jian Long, Zhang Dongju, Wei Heitao, Lü Yanbin, Zhao Hui, Zhang Pingyu, Wang Zongli, Jin Ming, Seth Newsome, Tom Guilderson, Bob Elston, Jeff Brantingham, David Madsen, David Rhode, John Olsen and Jack Oviatt. Visit us at <http://www.anthro.ucdavis.edu/card/usprc>.

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