A new and extensive ethnoarchaeological dung reference collection for investigating animal occupation, seasonality and diet in the past

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Abstract

The Neolithic (*c* 12,000-8000 BP) is a key period in human history when people for the first time domesticated plants and animals and began living in permanent villages. Understanding and pinpointing important transformations such as the domestication of animals in the Neolithic is challenging. Common methods to investigate animal domestication rely on interpretation of excavated archaeological remains. New dung studies demonstrate the potential to investigate important phenomena such as sedentarisation, animal domestication, secondary product use and animal diet. A new innovative multi-methodological research framework is currently being developed to integrate scientific analyses with ethnoarchaeological and archaeological datasets. Recent samples collected during a CBRL fellowship (2015-2016) will contribute to ethnoarchaeological research based on multi-method investigations into animal signatures using geochemistry, faecal spherulites, phytoliths and micromorphology. These reference collections will provide results which can be incorporated into future archaeological analysis and will be available for use as comparative data to understand archaeological sites in the Southern Levant. When this reference collection has been fully processed it will represent the biggest dung reference collection that exists worldwide.

Keywords

Neolithic, Dung, Ethnoarchaeology, Multi-methodology, Reference Collection

Background and Objectives

The Neolithic (*c* 12,000-8000 BP) is a key period in human history when people for the first time domesticated plants and animals and began living in permanent villages. This is one of the biggest changes in human history. This change occurred initially in the Middle East and subsequently spread into other regions. This transition led to complex societies where the environment could support population growth leading to the development and emergence of civilisations. The Neolithic is therefore an important period in history because the social and cultural changes that occurred ultimately led to the foundation of modern civilisation.

Understanding and pinpointing important transformations such as the domestication of animals in the Neolithic is challenging. Common methods to investigate animal

domestication rely on interpretation of excavated archaeological remains. The problem that researchers encounter with this period is that the sites and accompanying organic remains and material culture can be up to 12,000 years old often resulting in unfavourable preservation conditions. Biological remains such as animal bones and plants are often poorly preserved, fragmented or absent. Therefore, interpretation and understanding of this fundamental period of human history can be problematic. There are problems in identifying and understanding these archaeological sites and the associated remains which are crucial to our interpretation of what is termed the 'Neolithic Revolution'. Increasingly alternative markers are being implemented for detecting domestication. The identification of early animal management is difficult and it is now recognised that morphological changes in animal skeletons are not leading-edge indicators of domestication (Zeder 2006). However, new dung studies demonstrate the potential to investigate important phenomena such as sedentarisation, animal domestication, secondary product use and animal diet (Ghosh et al. 2008; Shahack-Gross 2011). Analysis of dung provides unique insights into early farming in the Neolithic and enables us to address the limitations encountered with traditional methods of archaeological investigation. For example, isolating compacted animal dung to detect animal penning and identifying micro-remains from dung which are a rich source of data for reconstructing past animal husbandry (grazing, fodder regimes, or past vegetation and seasonality). Utilising new proxies such as animal dung in conjunction with ethnoarchaeological reference collections will contribute to our understanding of animal occupation signatures in the Neolithic.

Methodology

A new innovative multi-methodological research framework is currently being developed to integrate scientific analyses with ethnoarchaeological and archaeological datasets to investigate sedentarisation, domestication, seasonality and diet. These methods involve the examination of animal signatures through microscopic analysis of dung deposits (Figure 1). A pilot project using ethnoarchaeological samples to help investigate Neolithic archaeological sites has been conducted using this new multi-methodology in Iraqi Kurdistan (Elliott et al 2015, Elliott 2015). However, additional reference collections and analyses need to be conducted to develop this pilot study, to extend the analyses with more samples, and to test the methods in another region to further assess their validity. This approach can be utilised in conjunction with traditional methods of archaeological investigation.

Recent samples collected during a CBRL fellowship (2015-2016) will contribute to ethnoarchaeological research based on multi-method investigations into animal signatures using geochemistry, faecal spherulites, phytoliths and micromorphology. These reference collections will provide results which can be incorporated into future archaeological analysis and will be available for use as comparative data to understand archaeological sites in the Southern Levant, which is one of the regions where sedentism and farming first developed.

The objectives of this project are to:

1/ Further develop new scientific inter-disciplinary methods and tools to investigate animal occupation signatures in Neolithic sites, building upon existing pilot studies. These new innovative methods involve micro-analysis of animal dung (geochemistry, faecal spherulites, phytoliths and micromorphology).

2/ Validate and refine the existing methodology by implementing/testing this developing approach in the field on wide ranging case studies in an area where farming and villages first occurred; the Levant.

3/ Benefit and impact archaeological research by providing a new platform approach or framework which can be extended and utilised by researchers within the discipline in other regions and archaeological periods.

This research will be conducted initially on extensive modern ethnoarchaeological reference material which can then be used to interpret archaeological samples. It is necessary to look at ethnoarchaeological studies to understand the patterning of human and animal micro-residues. It is vital to establish reference collections within the region of archaeological study, because the contents and components of dung varies according to the geological/vegetative conditions. To fulfil the objectives of this project there will be three major stages of the research:

1. Ethnoarchaeological dung samples have been collected from domesticated and wild animals from all four vegetation zones in Jordan and in all four seasons (2015-2016).
2. The reference collection of the modern animal dung, will be analysed using geochemistry, micromorphology, faecal spherulite and phytolith analysis to examine the micro-components of different dung types.
3. The micro-analysis of the reference collections will then employed to identify and interpret archaeological animal dung signatures from Neolithic archaeological contexts in the southern Levant.

The analysis and comparison of the modern dataset with archaeological datasets will establish how suitable the multi-method scientific analyses of animal occupation signatures are for interpreting Neolithic archaeology.

Reference Collections

The methodology to achieve the objectives of this project will be the scientific analysis of a range of modern ethnoarchaeological reference material and archaeological samples collected

from different sites and environmental contexts in Jordan. Jordan has been selected because it is one of the regions where earliest sedentism/domestication occurred. It also provides diverse environments to investigate the developing research methods and to answer questions about the crucial changes which occurred in the Neolithic. Samples collected from domesticated pigs on Cyprus (Figure 2) were also included in the reference collection due to the difficulties in obtaining these dung samples in Jordan where pigs are not consumed due to religious restrictions.

Domesticated (Figure 3) and wild animals (Figure 4) were targeted for sampling. All four vegetation zones were also targeted so that dietary components extracted from the dung can be compared against grazing conditions; Saharo Arabia, Irano-Turanian, Mediterranean and Sudanian. Dung samples were also taken throughout the year to establish whether seasonal grazing signatures can be observed in the dung deposits (Figure 5). Table 1 lists the full range of samples collected for the modern ethnoarchaeological dung reference collection for the Southern Levant.

Conclusions and Future Directions

When this reference collection has been fully processed it will represent the biggest dung reference collection that exists worldwide. Reference collections in dung studies are increasing, however, collections are often small and region or site specific. Some ethnographic reference collections focus on the botanical content of modern faecal material for example Anderson and Ertug-Yaras' study in Central Anatolia which analysed 21 modern samples (Anderson and Ertug-Yaras 1998). Other projects focus on the spherulite and phytolith content of faecal material, for example Portillo et al.'s analysis of 14 modern dung samples from Syria (Portillo et al. 2014) or Brochier et al.'s analysis of modern dung samples from Sicily (Brochier et al. 1992). In India Lancelotti and Madella analysed 12 modern dung cakes from India with a combination of spherulite, phytolith and geochemical analysis (Lancelotti and Madella 2012).

Another important reason to create new dung reference collections in relation to the study area is because previous studies have shown differences in dung signatures from different regions (Brochier et al. 1992; Portillo et al. 2014). Studies have shown that, for example, faecal spherulite production varies based on grazing locations particularly pH of the soil (Canti 1999) and therefore is likely to be linked to geology. Therefore, it is important to establish this region specific reference collection prior to the investigation of ancient dung deposits because of the regional variation in the micro-components of dung (faecal spherulites and phytoliths) based on the vegetation and geology of the study area.

This reference collection is also important because wild species have not been extensively studied in previous dung reference collections from other regions. Once processed the reference materials will be available both in Jordan and the UK for researches to access. The results and photomicrographs of the microscopic remains will also be available on an online

database. By creating this reference collection for the Southern Levant one objective is to increase the visibility of dung studies and to encourage the implementation of this approach across archaeological research projects. Some archaeological projects in other regions and periods are starting to integrate dung studies as standard into research projects. Stiner *et al* (2014) investigated Aşıklı Höyük, the earliest known preceramic Neolithic mound site in Central Anatolia, with a combination of archaeozoological methods and dung studies. This research examined signs of pre-domestication management in the form of geoarchaeological approaches (micromorphology and phytolith analyses) in order to provide information on human-animal interactions within the confines of the settlement (Stiner et al. 2014). A research project in Tunisia included dung studies (phytoliths and faecal spherulites) in conjunction with archaeozoology to investigate grazing/browsing patterns and dung fuel use on a site dating from the 10th to 7th century BC (Portillo et al. 2012). In this study silica phytoliths are used to infer grazing and browsing practices from sediment samples when they were identified in conjunction with faecal spherulites. One of the conclusions made by Portillo et al. (2012) was that faecal spherulite numbers, phytoliths and faunal material were elevated in the same contexts suggesting a clear relationship between faecal material and archaeozoological evidence. The research also concluded that the integrated archaeobiological approach used in the characterisation of archaeological contexts at urban settlement sites have the potential to contribute significantly to the understanding of formation pathways, but also to reconstruct domestic activities at archaeological sites (Portillo et al. 2012).

This new innovative approach using dung studies to address a wide range of research questions can be integrated with archaeozoology to investigate animal management/domestication and can also be integrated with archaeobotany to investigate animal diet, seasonality, ecology and environment.

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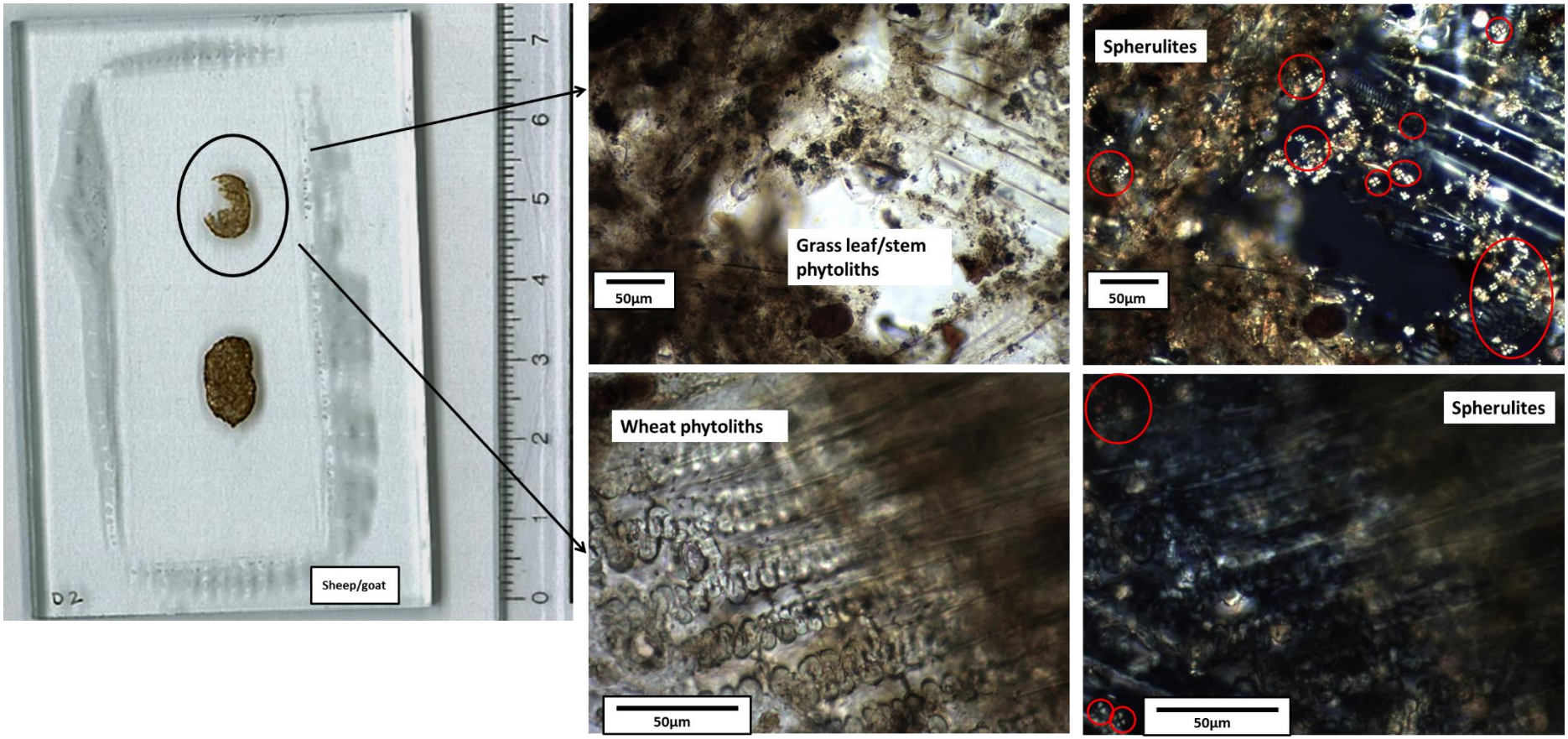

Figure 1. Example of microscopic analysis of modern dung samples. Left: thin sectioned sheep/goat dung pellets. Top, middle: Microstructure of dung pellet in plain polarised light (PPL) showing grass leaf/stem phytoliths, spongey voids and organic matter. Top, right and bottom right: Dung pellet in crossed polarised light (XPL) showing calcareous faecal spherulites (circled in red). Bottom, middle: Dung pellet in plain polarised light (PPL) showing wheat phytoliths.

Figure 2: Foraging/free-ranging black pigs near to the Avakas Gorge (Lemba), Cyprus.

Figure 3: Domesticated sheep and goat in a temporary winter pen in Al Ma'tan, Jordan.

Figure 4: Wild gazelle, RSCN Shaumari nature reserve, Jordan.

Figure 5: Left: Sheep and goat grazing in the summer near to Adir (Karak), Jordan. Right: Goat grazing on Chenopodiaceae in the winter near to Al Ma'tan, Jordan. This Chenopodiaceae is only consumed by browsing animals in the winter because it is poisonous in the summer (pers. Comm, goat herder Al Ma'tan, Jordan).

Table 1. Full list of dung samples, fodder samples and plant samples collected.

Dung/Fodder/Plant sample	Sample details	Species	Location
Dung	Camel (old-collected April, already dried)	Camel	Wadi Faynan
Dung	Cow 1 (older)	Cow	Safi
Dung	Cow 2 (younger 8 months)	Cow	Safi
Dung	Dog, dried, near to tent	Dog	Wadi Faynan
Dung	Donkey-neighbours donkey	Donkey	Wadi Faynan
Dung	Gazelle dung early summer	Gazelle	Shaumari
Dung	Gazelle dung early summer (2nd)	Gazelle	Shaumari
Dung	Ma'tan goat winter dung	Goat	Ma'tan
Dung	Goat dung-early spring Ma'tan	Goat	Ma'tan
Dung	Goat dung_Mugayghat	Goat	Mugayghat near Madaba
Dung	Goat penning deposits-compacted from march	Goat	Wadi Faynan
Dung	Hedgehog-with insects. Early summer	Hedgehog	Azraq Wetlands
Dung	Horse dung Ma'tan	Horse	Ma'tan
Dung	Ibex dung. Find collection date	Ibex	Wadi Mujib (Al-M'rah)
Dung	Jackal dung-old dry sample. Early summer	Jackal	Azraq Wetlands
Dung	Jackal. Early summer	Jackal	Azraq Wetlands
Dung	Onager dung early summer	Onager	Shaumari
Dung	Oryx dung early summer	Oryx	Shaumari
Dung	Pig dung-20-50kg female	Pig	Larnaka
Dung	Pig dung-20-50kg male	Pig	Larnaka
Dung	Pig dung-80kg-female	Pig	Larnaka
Dung	Pig dung-80kg-male	Pig	Larnaka
Dung	Pig dung-110kg-female	Pig	Larnaka
Dung	Pig dung-110kg-male	Pig	Larnaka
Dung	Pig dung-sow-pregnant	Pig	Larnaka
Dung	Piglet dung	Pig	Larnaka
Dung	Pig dung-mixed m/f (1 month)	Pig	Larnaka
Dung	Pig dung free-ranging	Pig	Lipati Plateau
Dung	Pig dung free-ranging	Pig	Lipati Plateau
Dung	Pig dung free-ranging	Pig	Lipati Plateau
Dung	Pig dung-female poss. pregnant	Pig	Dali
Dung	Pig dung-female pregnant	Pig	Dali
Dung	Possible Red Fox	Poss. Red Fox	Azraq Wetlands
Dung	Red Fox dung early summer	Red Fox	Shaumari
Dung	Red Fox-definite. Two samples. Early summer	Red Fox	Azraq Wetlands
Dung	Red Fox-typical shape. Early summer	Red Fox	Azraq Wetlands
Dung	Red Fox-definite. Early summer	Red Fox	Azraq Wetlands
Dung	Possible red fox or Jackal	Red fox or Jackal	Azraq Wetlands
Dung	Sheep dung	Sheep	Adir near Karak
Dung	Sheep penning deposits-compacted from March	Sheep	Wadi Faynan
Dung	Sheep/goat mixed early spring	Sheep/goat	Ma'tan
Dung	Sheep/goat from Eastern Badia (summer)	Sheep/goat	Eastern Badia
Dung	Tropical Sudanian dung Safi	Sheep/goat	Safi
Dung	Mixed sheep/goat pen	Sheep/goat	Wadi Faynan
Dung	Water buffalo dung, early summer	Water buffalo	Azraq Wetlands
Dung	Wild boar (veg diet) from Ajloun Forest Reserve	Wild boar	Ajloun Forest Reserve
Dung	Wild boar (veg diet) from Ajloun Forest Reserve	Wild boar	Ajloun Forest Reserve
Dung	Wild boar (veg diet) from Ajloun Forest Reserve	Wild boar	Ajloun Forest Reserve
Dung	Wild boar (veg diet) from Ajloun Forest Reserve	Wild boar	Ajloun Forest Reserve
Dung	Wild boar (veg diet) from Ajloun Forest Reserve	Wild boar	Ajloun Forest Reserve
Dung	Wild boar (veg diet) from Ajloun Forest Reserve	Wild boar	Ajloun Forest Reserve
Fodder	Fodder from Safi sheep/goat	n/a	Safi
Fodder	Fodder from Ma'tan goats	n/a	Ma'tan
Fodder	Fodder Larnaka pigs	n/a	Larnaka
Fodder	Fodder Larnaka pigs	n/a	Larnaka
Fodder	Fodder Larnaka pigs	n/a	Larnaka
Fodder	Fodder Larnaka pigs	n/a	Larnaka
Fodder	Fodder Dali pigs	n/a	Dali
Fodder	Fodder Dali pigs	n/a	Dali
Fodder	Alef mix_fed to water buffalo	n/a	Azraq Wetlands
Fodder	Reed/cereal In Buffalo enclosure	n/a	Azraq Wetlands
Fodder	Sheep fodder for samples Karak	n/a	Adir near Karak
Fodder	Bran fodder for sheep, goat, donkey Wadi Faynan	n/a	Wadi Faynan
Fodder	Grain fodder for sheep, goat, donkey Wadi Faynan	n/a	Wadi Faynan
Date palm	Date palm sample from field near cows	Date palm	Safi
Juniper pods/seeds	Seeds from Juniper	Juniper	Ma'tan
Plant	Chenopodeae from Ma'tan	n/a	Ma'tan
Pods from tree_Mesquite	Pods from tree (grown for fodder)	*Prosopis glandulosa*	Safi