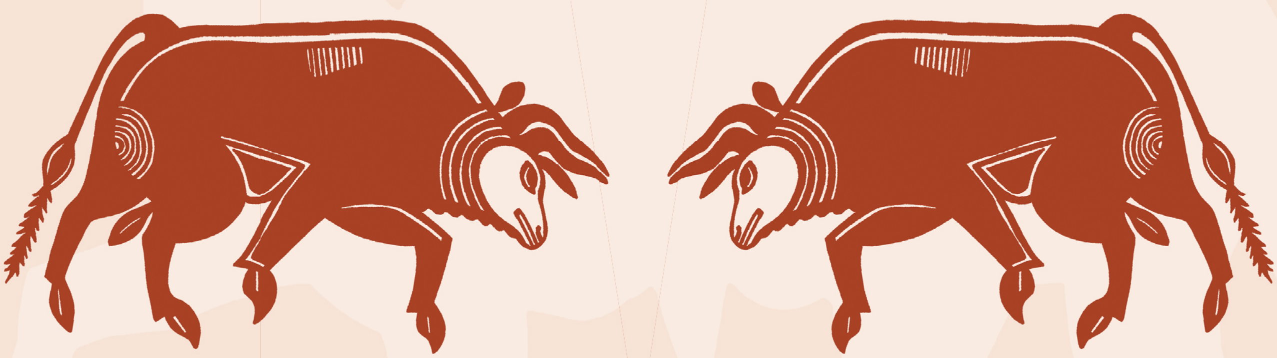
Archaeobiology 3

ARCHAEOZOOLOGY OF SOUTHWEST ASIA AND ADJACENT AREAS XIII



Proceedings of the Thirteenth International Symposium, University of Cyprus, Nicosia, Cyprus, June 7–10, 2017

edited by

Julie Daujat, Angelos Hadjikoumis, Rémi Berthon, Jwana Chahoud, Vasiliki Kassianidou, and Jean-Denis Vigne

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Group photo of the 13th ASWA[AA] meeting June 8th 2017
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Part 2: Subsistence Economies of Early and Late Complex Societies in Southwest Asia and Adjacent Areas

Part 3: Beyond Subsistence: Animals in the Symbolic World of Southwest Asia and Adjacent Areas

FOREWORD

The 13th ASWA conference was hosted by the University of Cyprus, one of the youngest of Europe's universities. In 2019, it was only thirty years since its foundation. Nevertheless, this is a thriving academic institution, which currently consists of eight faculties, twenty-two departments, and eleven research units.

In 1991, and just two years after the university's foundation, the Archaeological Research Unit (ARU) was founded by decree from the Government of the Republic of Cyprus, following the issuance of the dependent legislation by the House of Representatives. The decision to establish the ARU was based on the recommendation of the Interim Steering Committee of the University of Cyprus, which stated the following:

1. Cyprus is offered for primary research in the field of archaeology thanks to its distinctive cultural signature and history, as well as due to the fact that Cypriot archaeology and archaeological research on the island already has a distinguished tradition and international reputation;

2. The subsequent international recognition of the importance of archaeological research in Cyprus should comprise one of the first incentives for choosing the University of Cyprus as a center for postgraduate studies, and will pave the way for the exchange of students and academics between the University of Cyprus and academic institutions overseas.

The faculty members of the ARU, who are also part of the Department of History and Archaeology academic staff, have contributed immensely over the past 28 years to the achievement of the aforementioned objectives for the study and promotion of Cypriot cultural heritage through their research, their teaching, and the practical training they have been providing to students at undergraduate and postgraduate levels. The active study of other regions of the Mediterranean world have not been overlooked either, as members of the ARU academic staff have been carrying out excavations and research projects in Greece, Turkey, and France.

The members of the ARU are actively carrying out research in Pre- and Protohistoric Archaeology, Classical and Byzantine Archaeology but also Archaeometry and Environmental Archaeology, Maritime Archaeology, and Western Art. In the course of the past 28 years, the ARU has laid very stable foundations in all aforementioned specialisations of the archaeological discipline, none of which existed at academic level in Cyprus before the unit's establishment. Through their teaching at undergraduate and postgraduate levels, all members of the ARU academic staff have been contributing to the formation of a new generation of Cypriot archaeologists, equipped with all the necessary knowledge and practical experience needed to excel in this scientific field.

Over the years, the ARU has been very active in organizing international conferences and workshops. The ARU has organized over 50 international conferences, while members of the academic staff have published the proceedings of over 20 scientific meetings held at the ARU.

Thus, when Jean-Denis Vigne came to my office several years ago with the suggestion to co-organize the 13th Archaeozoology of Southwest Asia and Adjacent Areas conference I gladly accepted. The meeting in Nicosia brought together colleagues from all over the world and offered a venue where new results from the field or the laboratory could be presented and discussed. The publication of the conference proceedings enables colleagues who were unable to attend the conference to read about the latest developments in the archaeozoology of this culturally important region.

I would like to close by thanking all the members of the 13th ASWA organizing committee for all the work they have put into bringing so many scholars to Cyprus, many of them for the first time. I would also like to thank the co-editors of this volume for all the work they have put into the publication of the proceedings.

Professor Vasiliki Kassianidou
Director of the Archaeological Research Unit,
University of Cyprus
Nicosia, August 2019

EDITORS' PREFACE

Due to their location at the meeting point of the three Old World's continents—Africa, Asia, and Europe—Southwest Asia and its adjacent areas played a pivotal role in the history of humanity. They received successive waves of our species—*Homo sapiens*—out of Africa. Different processes in several areas of this large region brought about the transition to the Neolithic, and later on the urban revolution, the emergence of empires bringing with them important subsequent religious, cultural, social, and political consequences. Southwest Asia also played a major role in the interactions between East (Asia) and West (Europe) during the last two millennia. The unique importance of Southwest Asia in the history of humanity is strengthened by the, also related to its location, fact that this area is a hotspot of biodiversity, especially in mammals, which were—as everywhere in the world—tightly associated to the history of civilizations in a diversity of roles: game, providers of meat and milk, traded raw material, symbol of prestige and wealth, pets, etc.

Everywhere in the world, the biological and cultural interactions between humans and animals often remain under-evaluated in their heuristic value for understanding complex social and biological interactions and trajectories. This is why, almost half a century ago, archaeologists who were carrying out research and reflecting on such themes founded a very active nonprofit world organization named the International Council for Archaeozoology (ICAZ). This is also why the ICAZ working group "Archaeozoology of Southwest Asia and Adjacent Areas" (ASWA[AA]) was one of the first ones created within ICAZ, constituting one of the largest and most active of ICAZ's working groups.

The ASWA[AA] was formed during the 1990 ICAZ International Conference in Washington, D.C. Its purpose is to promote communication between researchers working on archaeological faunal remains from sites in western Asia and adjacent areas (e.g., Northeast Africa, Eastern Europe, Central Asia, and South Asia). It carries out its mandate mainly through the sponsoring of biennial international conferences. Since 1998, these meetings have alternated in being hosted in Europe or in Southwest Asia: Paris (1998), Amman (2000), London (2002), Ankara (2004), Lyon (2006), Al Ain (2008), Brussels (2011), Haifa (2013), Groningen (2015).

Ongoing armed conflicts and political tensions in several countries of Southwest Asia made it difficult to locate a safe and convenient place that would enable the organizing the 13th ASWA[AA] meeting in within that region. Although Cyprus is currently a member of the European Union, in (pre-)history Cyprus was embedded in the eastern Mediterranean "world." Because of its location, Cyprus was indeed at the confluence of African, Levantine, Anatolian, and Greek cultural streams and, as is common for islands, recombined them in different but always original ways all along its history. Archaeozoology recently provided one of the most convincing illustrations of the tight connection between Cyprus and Southwest Asia, demonstrating that the earliest domesticated mammals, especially cats, pigs, cattle, sheep, and goats, were introduced to the island very shortly after their first incipient domestication on the near continent, that is, during the ninth millennium BC. For all these reasons, Cyprus represented an ideal place to host the 13th ASWA[AA] conference.

Despite the illegal military occupation of part of its territory by a foreign country, the option of hosting the meeting in Cyprus was enthusiastically embraced by all members of the working group, especially because it is open to all nationalities and maintains good diplomatic relationships with a large majority of countries in Southwest Asia. These facts contributed towards the 13th ASWA[AA] meeting in Cyprus (June 7–9, 2017) becoming one of the best-attended ASWA[AA] meetings. It brought together 80 scientists coming from 25 different countries: from Southwest Asia (6 countries), Europe (14 countries), North America (2 countries), and Japan.

They presented their results in 36 oral and 32 poster presentations. They debated the long-term interactions between humans and biodiversity, about the beginning of animal domestication and husbandry, the strategies of animal exploitation from the Paleolithic to modern times, and the symbolic and funeral use of animals through time. They also greatly enjoyed the numerous social events organized, including a fantastic Cypriot mezze dinner, enhanced by a local folk-music band, and a nice excursion to the archaeological sites of Amathous, Kourion, and Khirokitia, and to the museums of Nicosia and Larnaca, which provided ample opportunities for scientific exchanges in a friendly atmosphere.

The hosting of the conference at the new campus of the University of Cyprus was another major reason to the meeting's success. This campus was a convenient and pleasant venue for such a conference, and the strong support of the University of Cyprus, as well as its valuable experience for the organization of such meetings were deeply appreciated by both the scientific organizers and the delegates. Several other partners contributed to the organization: the French archaeological mission "Neolithisation—Klimonas," which is itself strongly supported by the French School at Athens, the Cyprus Department of Antiquities, the French Institute of Cyprus, the French National Center for Scientific Research (Centre National de la Recherche Scientifique [CNRS]), and the French National Museum of Natural History (Muséum national d'Histoire naturelle [MNHN]).

The present volume brings together the texts of 18 of the 68 presentations of the meeting in Nicosia. The editorial board collected the papers and organized their review and editing. We are very grateful to Sarah Kansa (and Open Context), Justin Lev Tov, and Lockwood Press for their constant support in bringing this volume to fruition.

Julie Daujat
Angelos Hadjikoumis
Rémi Berthon, Jwana Chahoud
Vasiliki Kassianidou
Jean-Denis Vigne

1.2 | Pigs in Between

Pig Husbandry in the Late Neolithic in Northern Mesopotamia

Max Price*

Abstract

Stuck between the agricultural and urban revolutions, the Late Neolithic (LN; seventh and sixth millennia BC) often receives less attention from zooarchaeologists than other periods. However, recent data suggest that this period was defined by agricultural intensification and new forms of livestock management. Data from pigs and wild boar—both referred to in this paper as *Sus scrofa*—add to the developing picture of dynamic agricultural systems in northern Mesopotamia and southern Anatolia. Survivorship data indicate a diversity of pig slaughter strategies. Meanwhile, increasing rates of linear enamel hypoplasia (LEH) and the continued reduction in dental size, which follows a different pattern than postcranial metrics, are argued to be evidence of pig husbandry becoming more intensive in the LN. That is, pigs were increasingly penned, foddered, and kept away from wild boar, although wild boars were still used as a stocking resource. These patterns represent a shift from the more extensive "free-range" pig husbandry systems that likely dominated the region in the Pre-Pottery Neolithic. Alongside other forms of agricultural changes, the shifts in pig husbandry in the LN may have been connected to evolving foodways, agricultural expansion, and incipient forms of social complexity in the LN period.

Keywords

pigs, Sus scrofa*, Late Neolithic, animal husbandry, linear enamel hypoplasia, biometrics, northern Mesopotamia, domestication, intensification, feasting*

Introduction

One of the most exciting features of archaeological research in today's age of expanded scientific methods is the prospect of detecting subtle revolutions in economics and human behavior that had previously flown under the radar. Perhaps no period in Southwest Asian prehistory has been as understudied as the Late Neolithic (LN; seventh–sixth millennia BC). Perhaps no major form of animal husbandry has been as passed over as that of the domestic pig—*Sus scrofa*.

This chapter will focus on pig husbandry in northern Mesopotamia, the region where pigs were first domesticated in the eighth millennium BC (Ervynck et al. 2001; Helmer 2008; Zeder 2011). This paper explores how pig husbandry evolved in the millennia after initial domestication. I present evidence that LN communities initiated a process of husbandry intensification that represented a key turning point in the long-term history of the pig, a transition from the loose, extensive types of management that characterized the earlier part of the Neolithic toward a form of pig production more attuned to intensive garden and cereal agriculture.

Unique Aspects of Pig Husbandry and Domestication

Physiologically and behaviorally, pigs are unique among the Old World mammalian domesticates. Omnivores capable of converting feed to meat calories more efficiently than sheep, goats, or cattle (Redding 2015:Table 3), pigs exhibit considerable

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dietary breadth. Dissections of wild boar stomach have revealed a variety of plants, animals, and fungi species, with a focus on high-calorie foods like nuts, mushrooms, insects, and seeds (Gimenez-Anaya et al. 2008). Pigs also mature and reproduce rapidly. Domestic sows can reach sexual maturity by around one year of age and produce two litters per year of ten or more piglets each (Bazer et al. 2001), while feral and wild sows usually produce one litter of four to six piglets per year beginning in their second year of life (Bazer et al. 2001; Bywater et al. 2010; Focardi et al. 2008; Mount 1968:35).

In terms of social behavior, wild and feral males tend to leave their natal herds at around one year old, remaining solitary or forming small bachelor herds (Spinka 2009). However, as pigs are only weakly territorial, males can wander into and out of sow groups—sounders—within relatively restricted home ranges of around 100–200 ha (Nowak 1999:1055). Sounders themselves are typically small, averaging around 2–5 sows and their offspring, usually about 20 pigs (Taylor et al. 1998).

Pigs can be managed in a number of ways. Under "intensive management," pigs are kept bound in sties for much or all of their lives. Such practices are ideal when land is scarce or when there is a desire to grow fat-rich meat quickly—such as for annual feasts or sale on the market (e.g., see Boyd 1985). "Extensive management" strategies describe those in which pigs are allowed to forage their own food, wandering into and out of villages and their neighboring catchment areas for much of their lives. Nevertheless, the bond with humans remains; extensively managed pigs typically return regularly to pens or human-provided food sources.

Several years ago, Redding and Rosenberg (1998) proposed that extensive pig husbandry best described the earliest domestic pigs in northern Mesopotamia, referring to a "New Guinea model" after the numerous cases of extensive husbandry in Papua New Guinea (for a full review, see Hide 2003). But modern examples of extensive pig husbandry derive from around the globe, including the Mediterranean region (Albarella et al. 2011; Hadjikoumis 2012; Halstead and Isaakidou 2011).

Zooarchaeological data corroborate Redding's hypothesis. The transportation of wild boar to Cyprus in the tenth millennium BC or earlier (Vigne 2015; Vigne et al. 2009) and the targeted hunting of juvenile males at Hallan Çemi (Peasnall et al. 1998; Rosenberg and Redding 1998) are indications of evolving relationships with *Sus scrofa* prior to morphological domestication. But the best data for pig domestication, occurring slowly in accordance with Redding's hypothesis, comes from the Pre-Pottery and Pottery Neolithic site Çayönü Tepesi. At Çayönü, Ervynck and others (2001) documented changes in suid biometrics, survivorship, and frequency of enamel hypoplasias. The authors showed three changes: a gradual reduction in body and dental size over the eighth through mid-seventh millennium BC, with a steady decrease in the smallest specimens at the site, likely domestic females; a trend toward younger kill-off, with most animals slaughtered between one and two years; and decreased rates of hypoplasias in the Pre-Pottery Neolithic—followed by an increase in the Pottery Neolithic. Ervynck et al. (2001) interpreted the slow rate of change and low rates of hypoplasias as indicative of extensive husbandry transitioning rather seamlessly from intensive hunting.

The Pottery Neolithic

The LN in northern Mesopotamia (Figure 1.2.1) is defined here as beginning with the first use of pottery, around 7000 BC, and ending with the termination of the Halaf tradition at 5200 BC (Table 1.2.1). This period, while frequently depicted only as a chronological bridge between the agricultural and urban revolutions, in fact saw major developments in village life that set the stage for the development of socioeconomic inequality in later periods (Wengrow 2010:54).

The onset of the Pottery Neolithic coincided with the disappearance at around 7000 BC of the "PPNB interaction sphere," a tradition defined by interregional commonalities in ritual and technology (Bar-Yosef and Belfer-Cohen 1989; Bar-Yosef and Meadow 1995). The seventh millennium saw the regionalization of ritual and technological traditions as well as increased separation between sedentary and mobile components of societies (Akkermans and Duistermaat 1996; Verhoeven 2002). Pottery was coincidental to these changes; evidence from Jarmo and Sabi Abyad indicate that ceramic technology was added gradually and without any interruption in settlement and architectural patterns (Adams 1983; Nieuwenhuyse et al. 2010).

While the introduction of pottery did not represent a major cultural upheaval, it did have major sociopolitical ramifications by allowing for new

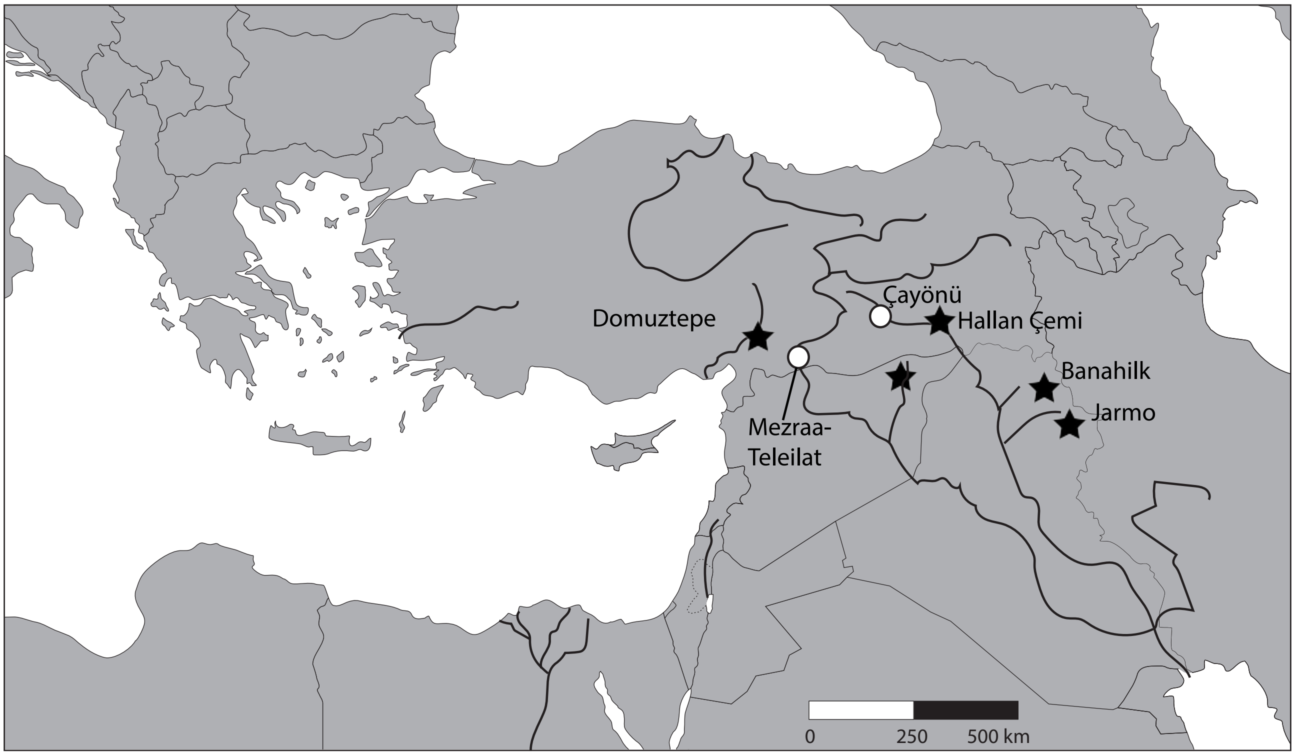

Figure 1.2.1. Map of northern Mesopotamia with sites used in this study.

Table 1.2.1. Chronology of the Late Neolithic in northern Mesopotamia, following summaries by Zeder (2011:S223), Aurenche et al. (2001), Campbell (2007), Hole (2001), Nieuwenhuyse et al. (2010), van der Plicht et al. (2011), Nishiaki and Le Mière (2005), Özdoğan et al. (2011).

Date (approx. BC)	Major ceramic traditions in northern Mesopotamia	Sites discussed in this paper
8000–7500?	Middle PPNB	Çayönü (Grill, Channel, Cobble), Mezraa–Teleilat (Phase V)
7500?–7000	Late PPNB	Çayönü Tepesi (Cell), Mezraa–Teleilat (Phase IV)
7000–6500?	Pottery Neolithic, Jarmo Ware, Pre-Proto–Hassuna, Amuq A–B, Final PPNB	Jarmo, Mezraa–Teleilat (Phases III and IIC), Çayönü Tepesi (Large Room and PN)
6500?–5900	Proto-Hassuna, Hassuna, Samarra, Amuq B	Mezraa–Teleilat IIB–A
5900–5200	Halaf, Amuq C	Umm Qseir, Domuztepe, Banahilk

methods of food storage, cooking, and presentation. Indeed, the use of pottery in the "commensal politics" of societies around the globe is well established (Bray 2003; Dietler 2001) and its introduction to northern Mesopotamia had major impacts on the social and political significance of food. Some of the earliest pottery in the region, for example, bears evidence of soot indicating cooking in clay pots (Nieuwenhuyse et al. 2010). New cooking methods, including stewing, boiling, and fermentation, would have been facilitated by pottery, altering what Wengrow (2010:44–49) has characterized as the roasting/bread-baking culinary culture of the Pre-Pottery Neolithic. Meanwhile, the elaboration of painted ceramics, especially during the Halaf (5900–5200 BC), suggests that this pottery facilitated new sociopolitical meanings of food presentation and consumption (Cruells and Nieuwenhuyse 2004; Nieuwenhuyse 2007; Nieuwenhuyse et al. 2010). In particular, feasting likely played an important social role throughout the Pottery Neolithic, serving to alleviate the risks of agricultural production and, perhaps, as a social-leveling mechanism through food sharing and reciprocity (Mottram 2016:46). This political use of food fits with our understanding of Pottery Neolithic societies' strong institutions of egalitarianism (Bernbeck 1995; Frangipane 2007).

In addition to new social uses of food, the LN was a period of expansion and crystallization of the "Neolithic Package" that cemented animal husbandry and intensive plant agriculture into the rhythms of daily life in northern Mesopotamia and neighboring regions (see Düring 2011:122). Beginning in the seventh millennium BC, domesticated crops and animals began appearing in southeastern Europe, Egypt, and South Asia (Arbuckle 2013; Zeder 2008). Within the core region of the Fertile Crescent, domestic animal and plant production took on a greater economic significance, although a few communities continued to rely heavily on hunting equids and gazelles—for example, Tell Zeidan (Grossman and Hinman 2013), Umm Qseir (Zeder 1994), and Umm Dabaghiyah (Bökönyi 1973). The LN also provides the first clear evidence for secondary product exploitation, including milk residues in ceramics (Evershed et al. 2008; Nieuwenhuyse et al. 2015), delayed kill-off of sheep and goats (Russell 2010), and the appearance of spindle whorls for spinning animal fibers (Rooijakkers 2012). Cattle husbandry, too, expanded dramatically in the sixth millennium BC (Arbuckle et al. 2016). Meanwhile, agricultural intensification is indicated by enrichment in $\delta^{15}N$ in plant seeds and animal bones recovered from LN sites, indicative of manuring (Bogaard 2005; Bogaard et al. 2007; Styring et al. 2017).

The communities that relied most on hunting were concentrated in or on the margins of the more arid grassland parts of northern Mesopotamia. These areas, receiving less average yearly rainfall than the hilly regions to the north and east, would have been particularly sensitive to climate change. The aridification at around 6200 BC—the "8.2 ka event"—represented a major challenge to village life in these areas, and communities may have adapted to the changes by relying more heavily on hunting grassland species. Climatic downturn probably also affected agricultural practices, including pig husbandry. At Tell Sabi Abyad, for example, Russell (2010) has argued that aridification led to the near abandonment of pig husbandry. But it is also possible that, at other sites, climate change and perhaps the retreat of forests (see Willett et al. 2016) pushed people to adopt more intensive forms of pig husbandry as ecosystems that supported the traditional extensive husbandry disappeared.

Pigs in the Late Neolithic

Pigs were typically a secondary or even tertiary component of the animal economy in LN northern Mesopotamia, making up 1–30% of the recovered mammalian fauna (Table 1.2.2). Domestic sheep and goats predominated, and cattle made significant contributions as well. Wild taxa, especially gazelle and onagers, were also exploited.

Methods Employed in the Documentation of Pig Husbandry

Globally, in most husbandry systems, the majority of pigs are culled between the ages of six months and two years. However, because pig populations grow rapidly, livestock owners do not need to manage their demographics as tightly as ungulates. As a result, slaughter patterns are often dictated by culturally contextual consumption goals, such as taste preference—for example, bacon hogs *versus* sucklings—or the scheduling of feasts/markets, rather than resource-maximizing production goals, strictly speaking, such as herd growth or efficiently achieving optimal slaughter weight. In other words, because pigs breed quickly and produce many offspring, humans can schedule their slaughter in a flexible manner. They need not follow economically "rational" models such as those that have proven so useful for modeling the management of ungulate species. Thus, while the most commonly employed zooarchaeological technique for understanding ancient husbandry practices is survivorship or kill-off analysis, this method tells us less about pig production strategies than it does for other animals.

An expanded zooarchaeological toolkit can shed significant light on pig husbandry. Biometrics and Geometric Morphometric Methods (GMM), especially of post-canine teeth, allow assessment of the

Table 1.2.2. Late Neolithic sites in northern Mesopotamia showing the NISP (Number of Identified Specimens) of *Sus* specimens and the relative abundance of pigs among the four domesticate species only—sheep, goat, cattle, pigs. Note that some sites, especially Umm Dabaghiyah and Umm Qseir, are dominated by wild taxa. Bold site names are those included in this study.

Site	Dates (BC)	NISPSus	%Sus	Reference
Feyda	Early 7th mil.	2	1%	Zeder 1998
Jarmo, JI levels 1–3; JII lev. 1–5	**7000–6500**	**241**	**8%**	**Stampfli 1983**
Umm Dabaghiyah	Early 7th mil.?	66	10%	Bökönyi 1973
Damishliyah	6600–6400	52	15%	Russell and Buitenhuis 2008
Matarrah	Late 7th mil.	37	30%	Stampfli 1983
Sabi Abyad	7th–6th mil.		4–16%	
Sabi Abyad I, Op. III A levels	6900–6200	1,181	9%	Russell 2010
Sabi Abyad I, Op. I levels 7–11	6500–6000	92	5%	Cavallo 2000
Sabi Abyad I, Op. III B levels	6200–5900	128	4%	Russell 2010
Sabi Abyad I, Op. I levels 4–6	6000–5900	164	8%	Cavallo 2000
Sabi Abyad I, Op. I levels 1–3	5900–5800	380	16%	Cavallo 2000
Sabi Abyad I, Op. III C levels	5900–5700	41	8%	Russell 2010
Kashkashok I	5800–5500	30	10%	Zeder 1998
Banahilk	**5700–5200**	**163**	**16%**	**Laffer 1983**
Hajji Firuz, A1–D	Early 6th mil.?	71	29%	Meadow 1975
Zeidan, Halaf phases	5900–5200	7	6%	Grossman and Hinman 2013
Umm Qseir, Halaf phases	**5900–5700**	**318**	**30%**	**Zeder 1994**
Kurdu, Trench 12&16, Amuq C	5500–5200	544	9%	Özbal et al. 2004
Shams ed-Din	6th mil.	11	2%	Uerpmann 1982
Domuztepe	**5900–5400**	**1,529**	**28%**	**Kansa et al. 2009**

dynamics of suid physiology, the effects of domestication, and, potentially, cases of hybridization and feralization (Albarella and Payne 2005; Balasse et al. 2016; Cucchi et al. 2009; Evin et al. 2013, 2014; Payne and Bull 1988; Rowley-Conwy et al. 2012).

Linear enamel hypoplasia (LEH) can provide insight into pig health, diet, and management (Dobney and Ervynck 2000; Dobney et al. 2002, 2004; Ervynck and Dobney 1999; Ervynck et al. 2001). LEH reflects the disruption of amelogenesis due to a number of possible stressors—such as incidence of disease, localized trauma, and heritable anomalies—but it is frequently associated with metabolic stress due to dietary deficiency (see Goodman and Rose 1990:64). Moreover, the location of LEH on teeth can indicate the timing of stressors in an animal's development (Dobney et al. 2004). Because stressors must be survived to be recorded on teeth, LEH is subject to the "osteological paradox" (Wood et al. 1992), whereby the observation of higher rates of pathologies can indicate one of two seemingly contradictory scenarios: (1) a population was under more stress, or (2) it was subjected to fewer incidents of lethal stress. In fact, both higher rates of stress and higher survivorship of stressor are expected to increase in a managed population, leading to a higher incidence of LEH.

Materials and Methods

In order to address more directly the problem of pig husbandry in the LN, I collected biometrical, survivorship, and LEH data from four sites:

Table 1.2.3. Collections analyzed in this study, their principal analysts, and their current location.

Site	Principal zooarchaeologist(s)	*Analysis ongoing?*	Location of collection
Jarmo	Hans Stampfli	No	Field Museum
Banahilk	Joanne Laffer	No	Field Museum
Domuztepe	Sarah Kansa and Hannah Lau	Yes	Kahramanmaraş Archaeological Museum
Umm Qseir	Melinda Zeder	No	Smithsonian Institution
Hallan Çemi	Richard Redding and Melinda Zeder	Yes	Smithsonian Institution

(1) Qalat Jarmo, a Final PPNB to Pottery Neolithic village (ca. 7000–6500 BC) located in the Zagros foothills (Braidwood 1983; Price and Arbuckle 2015; Stampfli 1983).
(2) Umm Qseir, a small Halaf pioneer settlement (ca. 5900–5700 BC) located on the banks of the Khabur River and adjacent to the grassland steppe of the Syrian Jezireh (Hole 2001; Zeder 1994).
(3) Gird Banahilk, a Halaf village (ca. 5700–5200 BC) located in the Zagros foothills (Laffer 1983; Lawn 1973; Watson 1983).
(4) Domuztepe, a large (20 ha) Halaf site (ca. 5900–5400 BC) located in a marshy area in the Kahramanmaraş Valley (Campbell 2007; Kansa et al. 2009; Lau and Kansa 2018).

For a comparative assemblage, data were also collected from a fifth site, Epipaleolithic Hallan Çemi, which is located in the foothills of southern Anatolia (Peasnall et al. 1998; Rosenberg 1994). When available, I used published data from the PPN and PN sites of Çayönü Tepesi (Ervynck et al. 2001; Hongo and Meadow 1998) and Mezraa–Teleilat (İlgezdi 2008), both located in southern Anatolia (Figure 1.2.1).

The four LN sites and Hallan Çemi were chosen on the basis of:

(1) their high numbers of pig bones and teeth;
(2) accessibility, especially in light of the ongoing political turmoil in Syria and southern Turkey;
(3) their geographic spread, which includes sites in the foothills of the oak–pistachio belt of the Zagros (Jarmo, Banahilk) and Taurus Mountains (Hallan Çemi), the environments where pigs were first domesticated.

It should also be noted that I did not conduct preliminary analysis on the faunal assemblages, nor did I analyze nonsuid material. More thorough and standard zooarchaeological analyses of these assemblages have been conducted by other researchers and in some cases are ongoing (Table 1.2.3). Permission to analyze the material for this study was granted by the respective institutions in coordination with the principal zooarchaeologist, when possible.

A comparative study such as this can run into several analytical challenges. The first is the well-known palimpsest problem: archaeological data, especially those deriving from predominantly secondary contexts such as animal bones, represent the accumulation of discard activities taking place over the span of years or even decades (Bailey 2007; Lyman 2007). Drawing inferences from time-averaged deposits as if they were moments in time is problematic. The results presented here should be taken not as a concrete statement of the exact type of pig husbandry practiced at each site, which may have varied considerably, but rather a time-averaged estimate of pig-management strategies. Second, and related, is the analytical lumping of contexts potentially created by diverse activities. Indeed, two sites sampled here contain evidence for a mix of feasting and more mundane household refuse. The first is Hallan Çemi, where a large pit at the center of the site—located within excavation Square 6F—supplied over half the remains used in this study. The second is Domuztepe, where around 20% of the sampled remains derive from a deposit thought to be associated with feasting activity—the Ditch in Operation 1 (Lau 2016). Comparing these contexts to those containing everyday household waste is important, especially for understanding socioeconomic dynamics. However, for this study, I will only consider the data in aggregate.

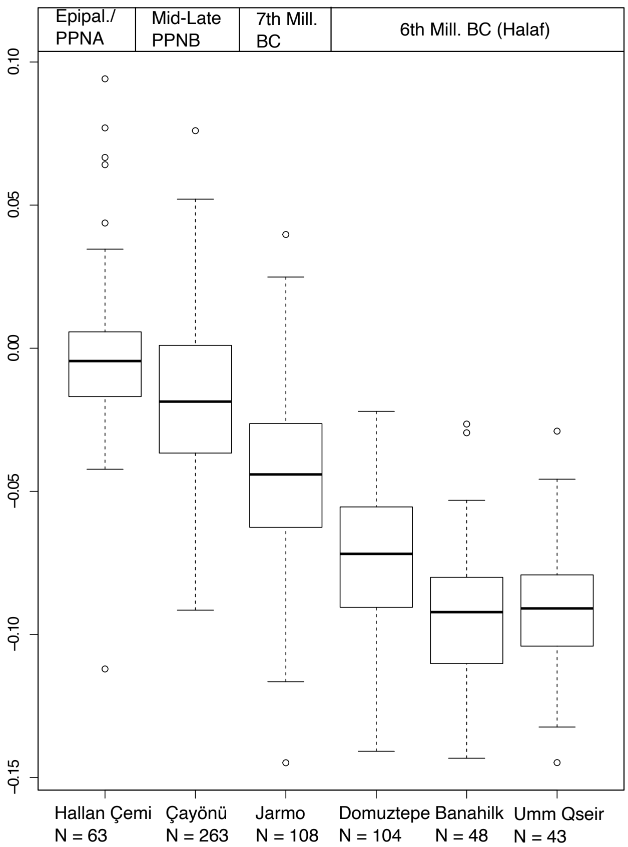

Figure 1.2.2. Log-Size Index (LSI) values for dental breadths (M1–M3 WA and WP) based on the standard values derived from wild boar from Kizilcahamam, Turkey, published by Payne and Bull (1988). Data from Çayönü published by Kusatman (1991).

Biometrics included postcranial and dental measurements published by Payne and Bull (1988) and later examined by Albarella and Payne (2005). Following these studies, dental breadths were used to estimate the proportions of wild and domestic pigs. To combine measurements, the Log-Size Index (LSI) method was used (Meadow 1999). Raw metrical and other data are available on Open Context (Price 2015).

For survivorship, I used Lemoine and colleagues' (2014) ageing classification system and their simplified–A age class assignment protocol. Most teeth were loose or in fragmented jaws. To maintain independence of specimens, I only considered jaws with either dP4s or M3s and took a maximum of right or left specimens assigned to each age class.

LEH was examined following the protocols set forth by Dobney and Ervynck (1998). LEH lines were recorded and measured from the cementum-enamel junction on first through third molars. Translating LEH features into meaningful statistics is complicated. The original calculation by Dobney and Ervynck (2000) that employs only mandibular teeth is cumbersome, but it takes into consideration variation in the numbers of different tooth types between teeth. A simpler metric of % teeth affected was also calculated using both mandibular and maxillary teeth.

Results

Biometrical Data

Size reduction in teeth and postcranial bones over the course of the LN indicates continued morphological change in pigs in the millennia after their initial domestication. Mean dental LSI declined from -0.043 at Jarmo, occupied in the early seventh millennium BC, to -0.082 for the combination of sixth-millennium Halaf-associated sites of Domuztepe, Umm Qseir, and Banahilk (Figure 1.2.2). This translates to a size decrease of about 9%, similar to that between Jarmo and the morphologically wild boar from Hallan Çemi (mean LSI = -0.002). Similarly, examination of the lower fences, which tracks size change in the smallest pigs in each assemblage (Ervynck et al. 2001), showed a steady reduction over time, with the smallest size achieved at LSI = -0.14 in the sixth-millennium assemblages (Price and Evin 2019).

There is, however some inter-site variability; mean dental size is smaller at Umm Qseir and Banahilk (mean LSI = -0.092) than at Domuztepe (mean LSI = -0.073). But on the whole, by the end of the LN, average pig dental size was about 20% smaller than the wild boar from Hallan Çemi. However, wild boar remained present in the assemblages. Domuztepe and, especially, Jarmo show a high degree of overlap with the dental size range of wild boar. In another paper, mixture modeling and linear discriminant analysis of geometric morphometric shape data were employed to estimate that wild boar—and probably hybrids—composed around 22–30% of the Domuztepe assemblage and 53–52% of the Jarmo assemblage (Price and Evin 2019).

Like teeth, the average size of the postcranial skeleton (Figure 1.2.3 and Figure 1.2.4) decreased about 20% from a mean LSI of 0.016 at Hallan Çemi to -0.072 at the sixth-millennium sites. However, unlike in the situation with teeth, there was only a

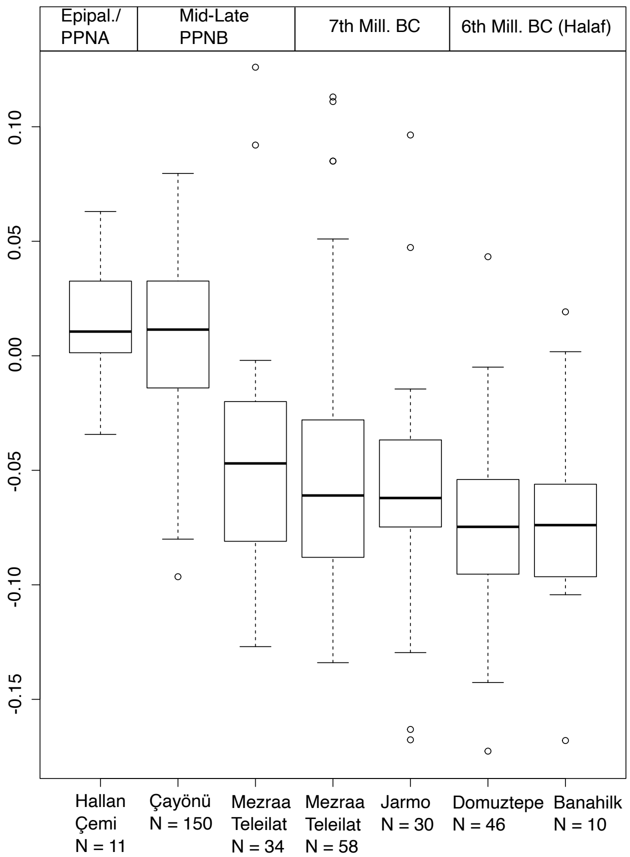

Figure 1.2.3. Log-Size Index (LSI) values for postcranial breadth and depth measurements. Çayönü data from Kusatman (1991), Mezraa–Teleilat data from İlgezdi (2008). LSI based on the standard values published by Payne and Bull (1988).

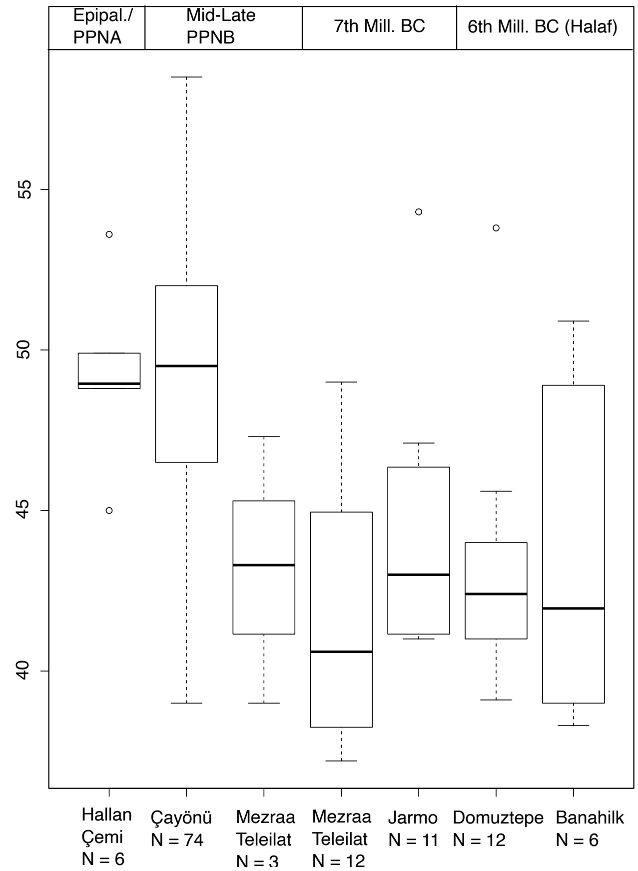

Figure 1.2.4. Astragalus GLl measurements (in mm). Çayönü data from Kusatman (1991), Mezraa–Teleilat data from İlgezdi (2008).

minor reduction in the postcranial skeleton between seventh-millennium Jarmo (mean LSI = -0.062) and the sixth-millennium sites (mean LSI = -0.072). Thus, while dental metrics suggest continued and gradual craniofacial shortening throughout the seventh and sixth millennia BC, postcranial metrics indicate that mean body size diminished rapidly in the earliest phases of domestication and then remained relatively stable during the succeeding millennia.

Survivorship

Table 1.2.4 presents survivorship data. In general, the majority of pigs at Jarmo and Banahilk were killed prior to one year of age, with a third or more slaughtered in the first sixth months of life. Very few (ca. 10–15%) pigs at these two sites survived their second birthday. The situation is much different at Domuztepe, where half to two-thirds of pigs survived their first birthday, a pattern consistent with the wild boar at Epipaleolithic Hallan Çemi and also similar to the slaughter pattern at PPN levels at Çayönü, where around 50% survived their first birthday (Ervynck et al. 2001:54).

The data thus indicate diversity in slaughter timing in the LN. Some sites, like Domuztepe, contained higher numbers of older animals. To some extent, this might be due to the contribution of wild boar or hybrids noted in that assemblage by Price and Evin (2019). Combining the metrical data with the survivorship data, there is some evidence to suggest that wild/feral/hybrid *Sus* survived to older ages: of 15 lower M3s, those with wear stages a–b (7–8 in Lemoine et al. 2014)—indicating slaughter prior to about 30 months old—displayed a mean WA of 15.1 mm (N = 6), while those with wear stages c or older displayed a mean WA of 15.7 mm (N = 9). However, at Jarmo, which had a higher proportion of morpho-

Table 1.2.4. Survivorship data from four sites arranged in chronological order from Hallan Çemi (eleventh millennium BC) to Banahilk (sixth millennium BC). Percent indicates the proportion of animals that survived past each age class. Error ranges indicate 95% confidence interval limits. Number parentheses indicate number of mandibles assigned to each age class. Umm Qseir (sixth millennium BC) excluded due to small sample size.

Age class	Hallan Cemi (Epipal.)	Jarmo (PN)	Domuztepe (PN)	Banahilk (PN)
A (< 1 month)	95% ± 8 (2)	95% ± 7 (2)	96% ± 8 (1)	100% (0)
B (3–5 mos.)	80% ± 12 (6)	63% ± 14 (13)	83% ± 16 (4)	71% ± 22 (4)
C (6–12 mos.)	66% ± 14 (6)	30% ± 15 (10)	58% ± 21 (7)	43% ± 22 (4)
D (12–16 mos.)	59% ± 14 (3)	32% ± 15 (3)	46% ± 21 (3)	29% ± 22 (2)
E (16–30 mos.)	32% ± 14 (11)	12% ± 10 (8)	21% ± 13 (6)	14% ± 21 (2)
F (30–72 mos.)	15% ± 10 (7)	2% ± 5 (4)	4% ± 12 (4)	0 (2)
G (> 72 mos.)	0 (6)	0 (1)	0 (1)	0 (0)
Mandibles	**41**	**41**	**26**	**14**

logically wild boar, younger kill-off was not skewed toward smaller animals (see raw data in Price 2015). While differences in husbandry practices or the inclusion of hunted wild boar in the assemblages might explain these patterns, I suggest that taste or seasonal slaughter schedules likely had the largest impact.

Linear Enamel Hypoplasia (LEH)

The incidence of hypoplastic defects on domestic pigs is expected to be higher than in wild animals because (1) domestic animals are exposed to novel sources of stress compared to the wild and/or (2) under human care, higher proportions of animals are expected to have survived episodes of stress. Empirically, higher rates of LEH are seen on domestic pigs than wild boar: of 48 teeth dating to the eleventh–third millennium BC determined by GMM to wild or domestic status, 58% (18/34) of domestic specimens were affected by LEH and only 29% (4/14) of wild ones (Price 2016). One would also expect higher levels of LEH in pigs raised under more intensive conditions—they would be exposed to potentially more stressful environments, but also less vulnerable to extreme temperatures and predation.

Figure 1.2.5 shows the incidence of LEH, using two different quantification methods. The first is the index value described by Ervynck and Dobney (1999), which includes only lingual cusps of lower molars and accounts for the differing numbers of tooth types present. The second is a more straightforward ratio of molar teeth—upper and lower—with visible hypoplastic defects, which can be compared to the data published from Çayönü by Ervynck and others (2001).

Among the datasets studied here, the data show low levels of LEH at Epipaleolithic Hallan Çemi and seventh-millennium Jarmo, with roughly 20% of teeth affected by defects. Incidence of LEH increased in the sixth millennium BC (Halaf period), with the highest levels reached at Banahilk and Domuztepe. The ratio is much higher at Çayönü (reported in Ervynck et al. 2001) in both the PPN and the PN, with a large increase in the PN. In fact, the ratios at Çayönü are higher than any of the sites in this study. The difference is possibly an artifact of interanalyst variability in detecting LEH marks or, perhaps, the insecure dating of the PN levels at this site; there is at least one Halaf sherd in the ceramic assemblage (see Özdoğan and Özdoğan 1989:66). On the other hand, the pattern of LEH increase at PN Çayönü is generally consistent with the overall pattern of increasing proportions of teeth affected by hypoplasias.

Table 1.2.5 indicates that the higher rates of LEH disproportionately affected second and third molars. The pattern is clearer in the lower teeth than the upper teeth. In lower M1s (formed *in utero*–1 month), rates of LEH were consistently around 25%, indicating that peripartum levels of stresses/survivability remained consistent over time. LEH rates on the M2 (1–7 months) and M3 (3–13 months), however, in-

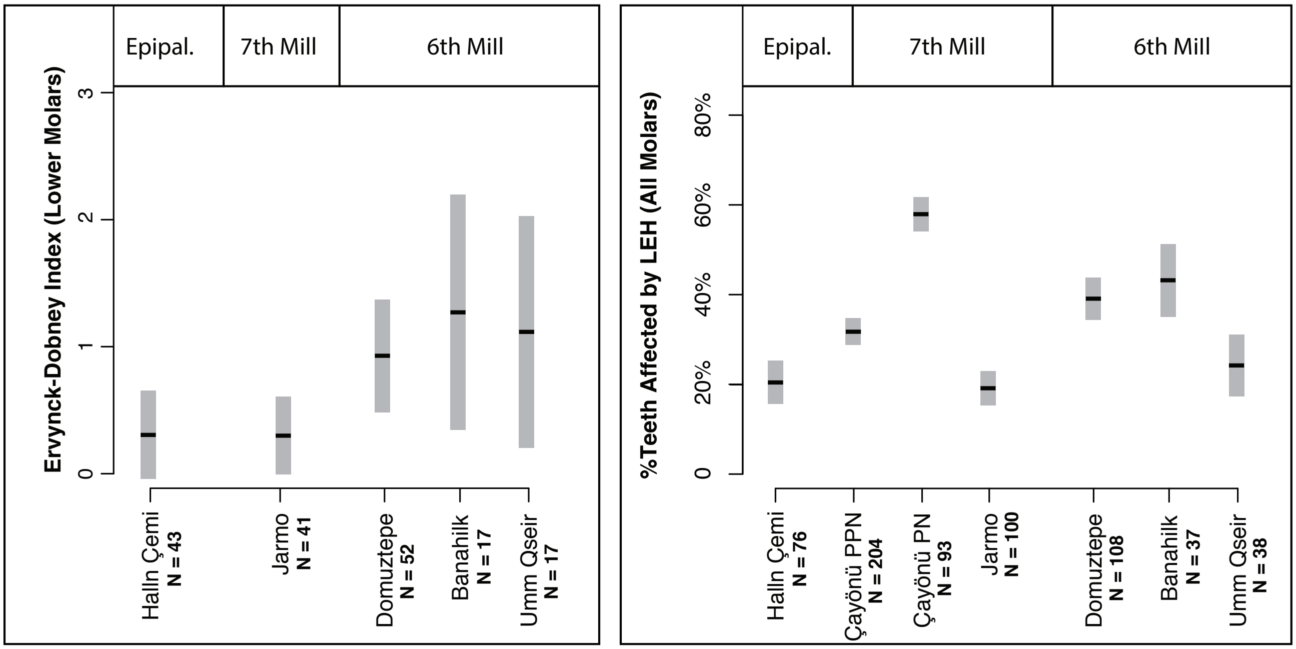

Figure 1.2.5. Rates of linear enamel hypoplasia (LEH) using the quantification method described by Ervynck and Dobney (1999; left) and the proportion of affected teeth in each assemblage (right). Çayönü data from Ervynck et al. (2001).

creased markedly from around 20–30% in the Hallan Çemi and Jarmo assemblages to 40–60% in the sixth millennium, with the exception of the Halaf pioneer settlement of Umm Qseir. This increase likely reflects greater survivability of stresses during weaning, perhaps provisioning of weaning foods by humans and their protection of weaker piglets from predation and hypothermia (cf. Ervynck and Dobney 1999), and/or greater stresses—for example, increased pathogen load—caused by confinement of growing pigs.

Discussion and Conclusions

The data indicate considerable dynamism in pig husbandry in northern Mesopotamia during the seventh and sixth millennia BC. I argue that these changes reflect a process of husbandry "intensification" in which pigs were increasingly confined to pens for longer periods of time. This shift was probably gradual, piecemeal, and intimately connected to other changes in LN agriculture and society.

The gradual and continual reduction in dental biometrics over time likely relates to two—probably interconnected—processes facilitated by increased use of penning. The first is the evolution in craniofacial morphologies toward shorter snouts, a trend consistent with the neoteny of domestic animals and perhaps a reflection of increased selection pressure for tameness (Price 1999). The second is the declining rate of wild boar admixture, which was inevitable once domestic pigs were confined to pens. Interestingly, the reduction in dental size followed a somewhat different pattern than that of postcranial size, which dropped rapidly in the earliest phases of the domestication process but only marginally afterwards. Postcranial growth, perhaps more plastic than dental size and shape, appears to have been under greater selection pressure early on but less in later periods. These divergent patterns highlight the need for zooarchaeologists and biologists to better understand the unique selective pressures involved in domestication.

The LEH data are another indication of husbandry intensification. The increase in hypoplasias, especially on the second and third molars indicates either heightened levels of stress or increased rates of stress survival—or both. Intensification can explain both patterns. As pigs were moved to pens, they would have become more heavily reliant on humans to supply their food. This could result in shortages, especially in periods of drought, harvest failure, or simply seasonal shortages. In these cases, the reversion to more extensive husbandry may

Table 1.2.5. Rates of teeth affected by LEH (Linear Enamel Hypoplasia) by type with sites arranged in chronological order. Numbers in parentheses indicate number of specimens.

Site	M_1	M_2	M_3	M^1	M^2	M^3
Hallan Çemi	23% (13)	36% (14)	19% (16)	7% (15)	25% (8)	40% (10)
Jarmo	26% (23)	23% (13)	20% (5)	13% (31)	17% (18)	20% (15)
Domuztepe	26% (20)	50% (12)	55% (20)	20% (25)	47% (19)	42% (12)
Banahilk	28% (7)	60% (5)	60% (5)	36% (11)	57% (7)	0% (2)
Umm Qseir	25% (12)	40% (5)	(0)	0% (8)	0% (8)	80% (5)

have been attractive, but the dangers posed by roaming pigs to crops and other livestock, not to mention the risk of losing pigs to poachers, may have led pig owners to keep their pigs penned even if doing so risked weight loss. Additionally, under greater protection from predators and the elements, vulnerable pigs were probably better able to survive episodes of stress within their pens. Both the increased vulnerability to food shortages and the increased ability to survive them explain the rise in LEH.

It remains unclear how new husbandry regimes impacted slaughter schedules. At first glance, there appears to be little impact; there was late slaughter of intensively raised pigs at Domuztepe, early slaughter of extensively managed pigs at Jarmo, and early slaughter of intensively managed pigs at Banahilk. I have suggested that other factors—taste or seasonality—may have been more determinative of slaughter practices. Still, the intertangled relationship between production and consumption would suggest that, in the long run, the movement to more intensive husbandry practices may have provided new opportunities and imposed new limitations on slaughter schedules. Future research should explore this question in greater depth.

Other studies, too, suggest pig husbandry intensification in the seventh–sixth millennia BC. Weber and Price (2016) identified gelatinized starch granules on teeth of morphologically domestic pigs from Domuztepe, suggesting the consumption of cooked food or food waste. Six others suid teeth from Domuztepe, including two from morphologically wild specimens, contained starch granules of oat (*Avena* sp.) and barley (*Hordeum* sp.) that had been damaged in a manner consistent with grinding/processing. Potentially, this suggests feeding household refuse to pigs and perhaps captured wild boar or hybrids. An alternative scenario is that wild boar scavenged village refuse.

More direct evidence for penning is the burnt pig skeletons found at Mezraa-Teleilat. These were found within the walls of a house: Building AY Phase IIB2, which dates to the mid–late seventh millennium BC (İlgezdi 2008; Özdoğan et al. 2011). These pigs included one animal aged two years, two one-year-olds, and two one-month-old piglets (İlgezdi 2008:161, Plates 195–101). Although it is possible that these represent ritual offerings, İlgezdi (2008) argues that they represent the remains of pigs raised within the house that were trapped in an accidental fire.

The question remains as to why people were intensifying pig husbandry in the LN. Deforestation may have limited the capacity of local environments to support extensive husbandry systems. Alternatively or at time same time, intensive pig husbandry might have been a response to the intensification of cereal production. Keeping pigs away from agricultural fields would be necessary to prevent both damage to crops and conflicts between pig owners and crop growers. The expansion of domestic cattle husbandry might also have reduced the space within a settlement's catchment area available for raising free-ranging pigs. Penned pigs, on the other hand, offer two advantages to an increasingly intensive agricultural regime. Not only does penning keep pigs out of fields, it also enables farmers to collect pig manure more easily and use it for intensive garden agriculture. Indeed, pigs' omnivorous diets make their feces particularly rich in nitrogen (e.g., Pratt and Castellanos 1981).

Intensive pig husbandry is also more productive than extensive forms. It is possible that the intensification of pig husbandry related to social demands for feasts of pork. In Papua New Guinea, the intensification of pig husbandry has been linked to feasting (Blanton and Taylor 1995; Boyd 1985). In one case, the entire village of Irakia Awa decided to shift to intensive pig husbandry in order to better supply feasts and enrich themselves through exchange—which they were able to achieve through an increase in pig herd size of around 30% following the adoption of intensive management strategies (Boyd 1985). The identification of discrete feasting deposits in the LN remains sparse, but feasting has been discussed at the Ditch feature at Domuztepe where pigs represented about 23% of the animal bones (Campbell et al. 2014:46).

The data presented here suggest that pig husbandry intensification occurred in the late seventh–sixth millennium BC. However, the hypothetical scenarios discussed above remain to be tested. More and different types of data are needed to understand the timing, spread, and impact of changing pig husbandry practices in the LN. Important will be more in-depth analyses of pig husbandry at other LN sites, especially those with large numbers of pig remains like Tell Sabi Abyad and Tell Kurdu. Was pig husbandry intensification a pan-regional phenomenon closely linked to the intensification of other forms of agriculture? How did the process of intensification unfold at each site? The expansion of new scientific methods in zooarchaeology, which open up new avenues for reconstructing ancient animal husbandry, are promising tools for answering these and other questions.

References Cited

Adams, R. M.
1983 The Jarmo Stone and Pottery Vessel Industries. In *Prehistoric Archeology along the Zagros Flanks,* edited by L. S. Braidwood, R. J. Braidwood, B. Howe, C. A. Reed, and P. J. Watson, pp. 209–232. Oriental Institute of the University of Chicago, Chicago.

Akkermans, P. M. M. G, and K. Duistermaat
1996 Of Storage and Nomads: The Sealings from Late Neolithic Sabi Abyad, Syria. *Paléorient* 22(2):17–44.

Albarella, U., F. Manconi, and A. Trentacoste
2011 A Week on the Plateau: Pig Husbandry, Mobility and Resource Exploitation in Central Sardinia. In *Ethnozooarchaeology: The Present and Past of Human–Animal Relationships*, edited by U. Albarella and A. Trentacoste, pp. 143–159. Oxbow Books, Oxford.

Albarella, U., and S. Payne
2005 Neolithic Pigs from Durrington Walls, Wiltshire, England: A Biometrical Database. *Journal of Archaeological Science* 32:589–599.

Arbuckle, B. S.
2013 The Late Adoption of Cattle and Pig Husbandry in Neolithic Central Turkey. *Journal of Archaeological Science* 40:1805–1815.

Arbuckle, B. S., M. D. Price, H. Hongo, and B. Öksüz
2016 Documenting the Initial Appearance of Domestic Cattle in the Eastern Fertile Crescent (Northern Iraq and Western Iran). *Journal of Archaeological Science* 72:1–9.

Aurenche, O., P. Galet, E. Régagnon-Caroline, and J. Évin
2001 The Proto-Neolithic and Neolithic Cultures in the Middle East—The Birth of Agriculture, Livestock Raising, and Ceramics: A Calibrated 14C Chronology 12,500–5500 cal BC. *Radiocarbon* 43:1191–1202.

Bailey, G.
2007 Time Perspectives, Palimpsests and the Archaeology of Time. *Journal of Anthropological Archaeology* 26:198–223.

Balasse, M., A. Evin, C. Tornero, V. Radu, D. Fiorillo, D. Popovici, A. Andreescu, K. Dobney, T. Cucchi, and A. Balasescu
2016 Wild, Domestic and Feral? Investigating the Status of Suids in the Romanian Gumelniţa (5th mil. cal BC) with Biogeochemistry and Geometric Morphometrics. *Journal of Anthropological Archaeology* 42:27–36.

Bar-Yosef, O., and A. Belfer-Cohen
1989 The Levantine "PPNB" Interaction Sphere. In *People and Culture in Change*, edited by I. Hershkovitz, pp. 59–72. BAR International Series Vol. 508. British Archaeological Reports, Oxford.

Bar-Yosef, O., and R. H. Meadow
1995 The Origins of Agriculture in the Near East. In *Last Hunters, First Farmers: New Perspectives on the Prehistoric Transition to Agriculture*, edited by T. D. Price and A. B. Gebauer. School of American Research, Santa Fe, New Mexico.

Bazer, F. W., J. J. Ford, and R. S. Kensinger
2001 Reproductive Physiology. In *Biology of the Domestic Pig*, edited by W. G. Pond and H. J. Mersmann, pp. 150–224. Cornell University Press, Ithaca, New York.

Bernbeck, R.
1995 Lasting Alliances and Emerging Competition: Economic Developments in Early Mesopotamia. *Journal of Anthropological Archaeology* 14:1–25.

Blanton, R. E., and J. Taylor
1995 Patterns of Exchange and the Social Production of Pigs in Highland New Guinea: Their Relevance to Questions about the Origins and Evolution of Agriculture. *Journal of Archaeological Research* 3:113–145.

Bogaard, A.
2005 "Garden Agriculture" and the Nature of Early Farming in Europe and the Near East. *World Archaeology* 37:177–196.

Bogaard, A., T. H. E. Heaton, P. Poulton, and I. Merbach
2007 The Impact of Manuring on Nitrogen Isotope Ratios in Cereals: Archaeological Implications for Reconstruction of Diet and Crop Management Practices. *Journal of Archaeological Science* 34:335–343.

Bökönyi, S.
1973 The Fauna of Umm Dabaghiyah: A Preliminary Report. *Iraq* 35:9–11.

Boyd, D. J.
1985 "We Must Follow the Fore": Pig Husbandry Intensification and Ritual Diffusion among the Irakia Awa, Papua New Guinea. *American Ethnologist* 12:119–136.

Braidwood, R. J.
1983 The Site of Jarmo and Its Architectural Remains. In *Prehistoric Archeology along the Zagros Flanks*, edited by L. S. Braidwood, R. J. Braidwood, B. Howe, C. A. Reed, and P. J. Watson, pp. 155–207. Oriental Institute of the University of Chicago, Chicago.

Bray, T. L.
2003 The Commensal Politics of Early States and Empires. In *The Archaeology and Politics of Food and Feasting in Early States and Empires*, edited by T. L. Bray, pp. 1–13. Kluwer Academic, New York.

Bywater, K. A., M. Apollonio, N. Cappai, and P. A. Stephens
2010 Litter Size and Latitude in a Large Mammal: The Wild Boar *Sus scrofa*. *Mammal Review* 40:212–220.

Campbell, S.
2007 Rethinking Halaf Chronologies. *Paléorient* 33(1):103–136.

Campbell, S., S. W. Kansa, R. Bichener, and H. Lau
2014 Burying Things: Practices of Cultural Disposal at Late Neolithic Domuztepe, Southeast Turkey. In *Remembering the Dead in the Ancient Near East*, edited by B. W. Porter and A. T. Boutin, pp. 27–60. University Press of Colorado, Boulder.

Cavallo, C.
2000 *Animals in the Steppe: A Zooarchaeological Analysis of Later Neolithic Tell Sabi Abyad, Syria.* BAR International Series Vol. 891. British Archaeological Reports, Oxford.

Cruells, W., and O. Nieuwenhuyse
2004 The Proto-Halaf Period in Syria: New Sites, New Data. *Paléorient* 30(1):47–68.

Cucchi, T., M. Fujita, and K. Dobney
2009 New Insights into Pig Taxonomy, Domestication and Human Dispersal in Island South East Asia: Molar Shape Analysis of *Sus* Remains from Niah Caves, Sarawak. *International Journal of Osteoarchaeology* 19:508–530.

Dietler, M.
2001 Theorizing the Feast: Rituals of Consumption, Commensal Politics, and Power in African Contexts. In *Feasts: Archaeological and Ethnographic Perspectives on Food, Politics, and Power*, edited by M. Dietler and B. Hayden, pp. 65–114. Smithsonian Institute Press, Washington, DC.

Dobney, K., and A. Ervynck
1998 A Protocol for Recording Linear Enamel Hypoplasia on Archaeological Pig Teeth. *International Journal of Osteoarchaeology* 8:263–273.
2000 Interpreting Developmental Stress in Archaeological Pigs: The Chronology of Linear Enamel Hypoplasia. *Journal of Archaeological Science* 27:597–607.

Dobney, K., A. Ervynck, U. Albarella, and P. Rowley-Conwy
2004 The Chronology and Frequency of a Stress Marker (Linear Enamel Hypoplasia) in Re-

cent and Archaeological Populations of *Sus scrofa* in North–West Europe, and the Effects of Early Domestication. *Journal of Zoology* 264:197–208.

Dobney, K., A. Ervynck, and B. La Ferla
2002 Assessment and Further Development of the Recording and Interpretation of Linear Enamel Hypoplasia in Archaeological Pig Populations. *Environmental Archaeology* 7:35–46.

Düring, B. S.
2011 *The Prehistory of Asia Minor, from Complex Hunter–Gatherers to Early Urban Societies*. Cambridge University Press, Cambridge.

Ervynck, A., and K. Dobney
1999 Lining Up on the M1: A Tooth Defect as a Bio-indicator for Environment and Husbandry in Ancient Pigs. *Environmental Archaeology* 4:1–8.

Ervynck, A., K. Dobney, H. Hongo, and R. H. Meadow
2001 Born Free? New Evidence for the Status of *Sus scrofa* at Neolithic Çayönü Tepesi (Southeastern Anatolia, Turkey). *Paléorient* 27(2):47–73.

Evershed, R. P., S. Payne, A. Sherratt, M. S. Copley, J. Coolidge, D. Urem-Kotsou, K. Kotsakis, M. Özdoğan, A. E. Özdoğan, O. Nieuwenhuyse, P. M. M. G. Akkermans, D. Bailey, R.-R. Andeescu, S. Campbell, S. Farid, I. Hodder, N. Yalman, M. Özbaşaran, E. Bıçakçı, Y. Garfinkel, T. E. Levy, and M. M. Burton
2008 Earliest Date for Milk Use in the Near East and Southeastern Europe Linked to Cattle Herding. *Nature* 455:528–531.

Evin, A., T. Cucchi, A. Cardini, U. S. Vidarsdottir, G. Larson, and K. Dobney
2013 The Long and Winding Road: Identifying Pig Domestication through Molar Size and Shape. *Journal of Archaeological Science* 40:735–743.

Evin, A., T. Cucchi, G. Escarguel, J. Owen, G. Larson, U. S. Vidarsdottir, and K. Dobney
2014 Using Traditional Biometrical Data to Distinguish West Palearctic Wild Boar and Domestic Pigs in the Archaeological Record: New Methods and Standards. *Journal of Archaeological Science* 43:1–8.

Focardi, S., J.-M. Gaillard, F. Ronchi, and S. Rossi
2008 Survival of Wild Boars in a Variable Environment: Unexpected Life-History Variation in an Unusual Ungulate. *Journal of Mammalogy* 89:1113–1123.

Frangipane, M.
2007 Different Types of Egalitarian Societies and the Development of Inequality in Early Mesopotamia. *World Archaeology* 39:151–176.

Gimenez-Anaya, A., J. Herrero, C. Rosell, S. Couto, and A. Garcia-Serrano
2008 Food Habitats of Wild Boars (*Sus scrofa*) in a Mediterranean Coastal Wetland. *Wetlands* 28:197–203.

Goodman, A. H., and J. C. Rose
1990 Assessment of Systemic Physiological Perturbations from Dental Enamel Hypoplasias and Associated Histological Structures. *American Journal of Physical Anthropology* 33(S11):59–110.

Grossman, K. M., and M. Hinman
2013 Rethinking Halaf and Ubaid Animal Economies: Hunting and Herding at Tell Zeidan (Syria). *Paléorient* 39(2):201–219.

Hadjikoumis, A.
2012 Traditional Pig Herding Practices in Southwest Iberia: Questions of Scale and Zooarchaeological Implications. *Journal of Anthropological Archaeology* 31:353–364.

Halstead, P., and V. Isaakidou
2011 A Pig Fed by Hand is Worth Two in the Bush: Ethnoarchaeology of Pig Husbandry in Greece and Its Archaeological Implications. In *Ethnozooarchaeology: The Present and Past of Human–Animal Relationships*, edited by U. Albarella and A. Trentacoste, pp. 160–174. Oxbow Books, Oxford.

Helmer, D.
2008 Révision de la faune de Cafer Höyük (Malatya Turquie): Apports des méthodes de l'analyse des mélanges et de l'analyse de kernel à la mise en évidence de la domestication. In *Archaeozoology of the Near East VIII: Actes des huitièmes Rencontres internationales d'Archéozoologie de l'Asie du Sud-Ouest et des régions adjacentes*, Vol. 1, edited by E. Vila, L. Gourichon, A. M. Choyke, and H. Buitenhuis, pp. 169–195. Travaux de la Maison de l'Orient méditerranéen Vol. 49. Maison de l'Orient et de la Méditerranée, Lyon.

Hide, R.
2003 *Pig Husbandry in New Guinea: A Literature Review and Bibliography.* Australian Centre for International Agricultural Research, Canberra.

Hole, F.
2001 A Radiocarbon Chronology for the Middle Khabur, Syria. *Iraq* 63:67–98.
Hongo, H., and R. H. Meadow
1998 Pig Exploitation at Neolithic Çayönü Tepesi (Southeastern Anatolia). In *Ancestors for the Pigs*, edited by S. Nelson, pp. 77–98. The Museum Applied Science Center for Archaeology (MASCA) Research Papers in Science and Archaeology Vol. 15. University of Pennsylvania Museum of Archaeology and Anthropology, Philadelphia, Pennsylvania.
İlgezdi, G.
2008 The Domestication Process in Southeastern Turkey: The Evidence of Mezraa-Teleilat. PhD dissertation, Geowissenschaftliche Fakultät, Eberhard-Karls-Universität Tübingen, Tübingen.
Kansa, S. W., A. Kennedy, S. Campbell, and E. Carter
2009 Resource Exploitation at Late Neolithic Domuztepe. *Current Anthropology* 50:897–914.
Kusatman, B.
1991 The Origins of Pig Domestication with Particular Reference to the Near East. PhD dissertation, University College London, London.
Laffer, J. P.
1983 The Faunal Remains from Banahilk. In *Prehistoric Archeology along the Zagros Flanks*, edited by L. S. Braidwood, R. J. Braidwood, B. Howe, C. A. Reed, and P. J. Watson, pp. 629–648. Oriental Institute of the University of Chicago, Chicago.
Lau, H.
2016 Mobility, Cooperation, and Emergent Social Complexity in the Late Neolithic Near East. PhD dissertation, Archaeology Interdepartmental Program, University of California, Los Angeles.
Lau, H., and S. W. Kansa
2018 Zooarchaeology in the Era of Big Data: Contending with Interanalyst Variation and Best Practices for Contextualizing Data for Informed Reuse. *Journal of Archaeological Science* 95:33–39.
Lawn, B.
1973 University of Pennsylvania Radiocarbon Dates XV. *Radiocarbon* 15(2):367–381.
Lemoine, X., M. A. Zeder, K. J. Bishop, and S. J. Rufolo
2014 A New System for Computing Dentition-Based Age Profiles in *Sus scrofa*. *Journal of Archaeological Science* 47:179–193.
Lyman, R. L.
2007 Archaeology's Quest for a Seat at the High Table of Anthropology. *Journal of Anthropological Archaeology* 26:133–149.
Meadow, R. H.
1975 Mammal Remains from Hajji Firuz. In *Archaeozoological Studies*, edited by A. Clason, pp. 261–283. North Holland, Amsterdam.
1999 The Use of Size Index Scaling Techniques for Research on Archaeozoological Collections from the Middle East. In *Historia Animalium ex Ossibus*, edited by C. Becker, H. Manhart, J. Peters, and J. Schibler, pp. 285–300. Marie Leidorf, Rahden/Westfalen.
Mottram, M.
2016 When the Going Gets Tough: Risk Minimization Responses to the 8.2 ka Event in the Near East and Their Role in the Emergence of the Halaf Cultural Phenomenon. In *Climate and Cultural Change in Prehistoric Europe and the Near East*, edited by P. Biehl and O. Nieuwenhuyse, pp. 37–66. State University of New York Press, Albany.
Mount, L. E.
1968 *The Climatic Physiology of the Pig*. Arnold, London.
Nieuwenhuyse, O.
2007 *Plain and Painted: The Rise of Late Neolithic Ceramic Styles on the Syrian and Northern Mesopotamian Plains*. Brepols, Brussels.
Nieuwenhuyse, O., P. M. M. G. Akkermans, and J. van der Plicht
2010 Not So Coarse, Nor Always Plain—The Earliest Pottery of Syria. *Antiquity* 84:71–85.
Nieuwenhuyse, O., M. Roffet-Salque, R. P. Evershed, P. M. M. G. Akkermans, and A. Russell
2015 Tracing Pottery Use and the Emergence of Secondary Product Exploitation through Lipid Residue Analysis at Late Neolithic Tell Sabi Abyad (Syria). *Journal of Archaeological Science* 64:54–66.
Nishiaki, Y. and M. Le Mière
2005 The Oldest Pottery Neolithic of Upper Mesopotamia: New Evidence from Tell Seker al-Aheimar, the Khabur, Northeast Syria. *Paléorient* 31(2):55–68.

Nowak, R. M.
1999 *Walker's Mammals of the World*. 6th ed. Johns Hopkins University Press, Baltimore, Maryland.

Özbal, R., F. Gerritsen, B. Diebold, E. Healey, N. Aydin, M. Loyet, F. Nardulli, D. S. Reese, H. Ekstrom, S. Sholts, N. Mekel-Bobrov, and B. Lahn
2004 Tell Kurdu Excavations 2001. *Anatolica* 30:37–107.

Özdoğan, A., N. Karul, and E. Özdoğan
2011 2002 Mezraa-Teleilat Excavations. In *Salvage Project of the Archaeological Heritage of the Ilısu and Carchemish Dam Reservoirs Activities in 2002*, Vol. 1, edited by N. Tuna and O. Doonan, pp. 35–96. Middle East Technical University, Ankara.

Özdoğan, M., and A. Özdoğan
1989 Çayönü: A Conspectus of Recent Work. *Paléorient* 15(1):65–74.

Payne, S., and G. Bull
1988 Components of Variation in Measurements of Pig Bones and Teeth, and the Use of Measurements to Distinguish Wild from Domestic Pig Remains. *Archaeozoologia* 2:27–66.

Peasnall, B. L., R. Redding, M. R. Nesbitt, and M. Rosenberg
1998 Hallan Çemi, Pig Husbandry, and Post-Pleistocene Adaptations along the Taurus–Zagros Arc (Turkey). *Paléorient* 24(1):25–41.

Pratt, P. F., and J. Z. Castellanos
1981 Available Nitrogen from Animal Manures. *California Agriculture* July–August 1981:24.

Price, E. O.
1999 Behavioral Development in Animals Undergoing Domestication. *Applied Animal Behaviour Science* 65:245–271.

Price, M. D.
2015 Northern Mesopotamian Pig Husbandry (Late Neolithic–EBA). M. D. Price (Ed.). Open Context, https://opencontext.org/projects/d1c85af4-c870-488a-865b-b3cf784cfc60, accessed September 21, 2021.
2016 Pigs and Power: Pig Husbandry in Northern Mesopotamia during the Emergence of Social Complexity (6500–2000 BC). PhD dissertation, Graduate School of Arts & Sciences, Harvard University, Cambridge, Massachusetts.

Price, M. D., and B. S. Arbuckle
2015 Early Domestic Pigs in the Zagros Flanks: Reanalysis of the Fauna from Neolithic Jarmo, Northern Iraq. *International Journal of Osteoarchaeology* 25:441–453.

Price, M. D., and A. Evin
2019 Long-Term Morphological Changes and Evolving Human–Pig Relations in the Northern Fertile Crescent from 11,000 to 2000 cal. BC. *Archaeological and Anthropological Sciences* 11:237–251.

Redding, R.
2015 The Pig and the Chicken in the Middle East: Modeling Human Subsistence Behavior in the Archaeological Record Using Historical and Animal Husbandry Data. *Journal of Archaeological Research* 23:325–368.

Redding, R., and M. Rosenberg
1998 Ancestral Pigs: A New (Guinea) Model for Pig Domestication in the Middle East. In *Ancestors for the Pigs*, edited by S. Nelson, pp. 65–76. MASCA Research Papers in Science and Archaeology Vol. 15. University of Pennsylvania Museum of Archaeology and Anthropology, Philadelphia, Pennylvania.

Rooijakkers, C. T.
2012 Spinning Animal Fibres at Late Neolithic Tell Sabi Abyad, Syria? *Paléorient* 38(1–2):93–109.

Rosenberg, M.
1994 Hallan Çemi Tepesi: Some Further Observation Concerning Stratigraphy and Material Culture. *Anatolica* 20:121–141.

Rosenberg, M., and R. Redding
1998 Early Pig Husbandry in Southwestern Asia and Its Implications for Modeling the Origins of Food Production. In *Ancestors for the Pigs*, edited by S. Nelson, pp. 55–64. MASCA Research Papers in Science and Archaeology Vol. 15. University of Pennsylvania Museum of Archaeology and Anthropology, Philadelphia, Pennsylvania.

Rowley-Conwy, P., U. Albarella, and K. Dobney
2012 Distinguishing Wild Boar from Domestic Pigs in Prehistory: A Review of Approaches and Recent Results. *Journal of World Prehistory* 25:1–44.

Russell, A.
2010 Retracing the Steppes: A Zooarchaeological Analysis of Changing Subsistence Patterns in the Late Neolithic at Tell Sabi Abyad, Northern Syria, c. 6900 to 5900 BC. PhD dis-

sertation, Faculty of Archaeology, Leiden University, Leiden.

Russell, A., and H. Buitenhuis
2008 Tell Damishliya Faunal Bone Report. *Anatolica* 34:315–338.

Spinka, M.
2009 Behaviour of Pigs. In *The Ethology of Domestic Animals*, edited by P. Jensen, pp. 177–191. 2nd ed. CAB International, Wallingford.

Stampfli, H. R.
1983 The Fauna of Jarmo with Notes on Animal Bones from Matarrah, the Amuq, and Karim Shahir. In *Prehistoric Archeology along the Zagros Flanks*, edited by L. S. Braidwood, R. J. Braidwood, B. Howe, C. A. Reed, and P. J. Watson, pp. 431–484. Oriental Institute of the University of Chicago, Chicago.

Styring, A. K., M. Charles, F. Fantone, M. M. Hald, A. McMahon, R. H Meadow, G. K. Nicholls, A. K. Patel, M. C. Pitre, and A. Smith
2017 Isotope Evidence for Agricultural Extensification Reveals How the World's First Cities Were Fed. *Nature Plants* 3(6):nplants201776.

Taylor, R. B., E. C. Hellgren, T. M. Gabor, and L. M. Ilse
1998 Reproduction of Feral Pigs in Southern Texas. *Journal of Mammalogy* 79:1325–1331.

Uerpmann, H.-P.
1982 Faunal Remains from Shams ed-Din Tannira, A Halafian Site in Northern Syria. *Berytus* 30:3–20.

van der Plicht, J., P. M. M. G. Akkermans, O. Nieuwenhuyse, A. Kaneda, and A. Russell
2011 Tell Sabi Abyad, Syria: Radiocarbon Chronology, Cultural Change, and the 8.2 ka Event. *Radiocarbon* 53:229–243.

Verhoeven, M.
2002 Transformations of Society: The Changing Role of Ritual and Symbolism in the PPNB and the PN in the Levant, Syria and South-East Anatolia. *Paléorient* 28(1):5–13.

Vigne, J.-D.
2015 Early Domestication and Farming: What Should We Know or Do for a Better Understanding? *Anthropozoologica* 50:123–150.

Vigne, J.-D., A. Zazzo, J.-F. Saliège, F. Poplin, J. Guilaine, and A. Simmons
2009 Pre-Neolithic Wild Boar Management and Introduction to Cyprus More Than 11,400 Years Ago. *Proceedings of the National Academy of Sciences* 106(38):16135–16138.

Watson, P. J.
1983 The Soundings at Banahilk. In *Prehistoric Archeology along the Zagros Flanks*, edited by L. S. Braidwood, R. J. Braidwood, B. Howe, C. A. Reed, and P. J. Watson, pp. 545–613. Oriental Institute of the University of Chicago, Chicago.

Weber, S. L., and M. D. Price
2016 What the Pig Ate: A Plant Microfossil Study of Pig Dental Calculus from 10th–3rd Millennium BC Northern Mesopotamia. *Journal of Archaeological Science: Reports* 6:819–827.

Wengrow, D.
2010 *What Makes Civilization? The Ancient Near East and the Future of the West.* Oxford University Press, Oxford.

Willett, P. T., I. Franz, C. Kabukcu, D. Orton, J. Rogasch, E. Stroud, E. Rosenstock, and P. Biehl
2016 The Aftermath of the 8.2 Event: Cultural and Environmental Effects in the Anatolian Late Neolithic and Early Chalcolithic. In *Climate and Cultural Change in Prehistoric Europe and the Near East*, edited by P. Biehl and O. Nieuwenhuyse, pp. 95–115. State University of New York Press, Albany.

Wood, J. W., G. R. Milner, H. C. Harpending, and K. M. Weiss
1992 The Osteological Paradox: Problems of Inferring Prehistoric Health from Skeletal Samples. *Current Anthropology* 33:343–370.

Zeder, M. A.
1994 After the Revolution: Post-Neolithic Subsistence in Northern Mesopotamia. *American Anthropologist* 96:97–126.
1998 Environment, Economy, and Subsistence in Northern Mesopotamia. *Bulletin of the Canadian Society for Mesopotamian Studies* 33:55–67.
2008 Domestication and Early Agriculture in the Mediterranean Basin: Origins, Diffusion, and Impact. *Proceedings of the National Academy of Sciences* 105(22):11597–11604.
2011 The Origins of Agriculture in the Near East. *Current Anthropology* 52(S4):S221–S235.