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Abstract

The zooarchaeological research presented here investigates Neolithic and Chalcolithic (ca. 6500-5000 cal. BC) animal exploitation strategies at Uğurlu Höyük on the Turkish island of Gökçeada in the northeastern Aegean Sea. Toward this end, we first discuss the results of our analysis of the zooarchaeological assemblages from Uğurlu Höyük and then consider the data within a wider regional explanatory framework using a diachronic approach, comparing them with those from western and northwestern Anatolian sites. The first settlers of Gökçeada were farmers who introduced domestic sheep, goats, cattle and pigs to the island as early as 6500 years BC. Our results align well with recently published zooarchaeological data on the westward spread of domestic animals across Turkey and the Neolithization of southeast Europe. Using an island site as a case study, we independently confirm that the dispersal of early farming was a polynucleated and multidirectional phenomenon that did not sweep across the land, replace everything on its way, and deliver the same "Neolithic package" everywhere. Instead, this complex process generated a diversity of human-animal interactions. Thus, studying the dispersal of early farmers from southwest Asia into southeast Europe via Anatolia requires a rigorous methodological approach to develop a fine-resolution picture of the variability seen in human adaptations and dispersals within complex and rapidly changing environmental and cultural settings. For this, the whole spectrum of human-animal interactions must be fully documented for each sub-region of southwest Asia and the circum-Mediterranean.

Introduction

The revolutionary economic and social transformation of societies from foraging to farming in Southwest Asia shortly after 10,000 calibrated years BC (BC hereafter) and the subsequent spread of new genes, languages, ideologies, and domesticated cereals and livestock into Europe via a process called *Neolithization* from 10,000- 7000 BC have been the subjects of extensive scholarly debate since the 1970s (e.g., Ammerman & Cavalli-Sforza, 1971, 1973). Various models have drawn on multiple lines of converging evidence including genetics, linguistics, and archaeology to explain the global dispersal of early farming populations with fully developed agropastoral lifeways from primary to secondary centers of agricultural origin (e.g., Arbuckle et al., 2014; Bellwood, 2009; Borić & Price, 2013; Hofmanová et al., 2016; Orton, Gaastra, & Vander Linden, 2016; Özdoğan, 2005, 2011; C. Perlès, Quiles, & Valladas, 2013; Pinhasi, Fort, & Ammerman, 2005; Price, 2000b; Zeder, 2008, 2015).

Uğurlu Höyük is a Neolithic settlement on Gökçeada (Imbros in Greek), the largest Turkish island situated between Anatolia and the European continent in the Aegean Sea, and currently the only site with an early Neolithic component in the eastern Aegean. Thus, with its key geographical location between Southeast Europe and Southwest Asia and its early Neolithic strata, the results of zooarchaeological research presented here may have implications reaching beyond Anatolia and contribute to our understanding of the spread and development of agricultural societies in southeast Europe in general and the eastern Aegean in particular.

More specifically, this paper focuses on animal exploitation strategies at Uğurlu and adds new zooarchaeological data to the existing body of research on the spread of domesticated animals across Neolithic western Anatolia. We address the following specific questions:

(1) Did the islanders have a diverse subsistence strategy, including foraging and marine resource exploitation, or did they heavily rely on livestock management? How did the animal economy change through time?

(2) How did island habitation affect animal management decisions compared to the mainland Anatolia? Did the islanders manage cattle, sheep, goats, and pigs differently?

This paper employs an analytical approach similar to that of Arbuckle and colleagues (2014) in an attempt to (1) add a new site to the 'big data' corpus, (2) extend the scope of that database spatially to go beyond the mainland Anatolia, and (3) include an island settlement to compare and contrast animal exploitation strategies between the mainland Anatolia and the island of Gökçeada. Toward these goals, this paper compares the results of zooarchaeological analyses at Uğurlu Höyük with those from western and northwestern Anatolian sites such as Ulucak Höyük, Menteşe Höyük, Çukuriçi Höyük, Ilıpınar, Barçın Höyük, Fikirtepe, and Hoca Çeşme (See Fig 1 for site locations).

Fig 1. Location of the sites mentioned in the text.

Conceptual framework and theoretical background

In studying the dispersal of agricultural economies from southwest Asia to southeast Europe, archaeologists have used a dichotomized framework. The colonization or demic diffusion model entails replacement of foragers by advancing waves of farmers (Cunliffe, 2008; Deguilloux, Leahy, Pemonge, & Rottier, 2012; Catherine Perlès, 2003), whereas the indigenous adoption or cultural diffusion model argues for a process of acculturation instead of endemic population movement and replacement (Price, 2000b and references therein). The colonization or demic diffusion model hinges on the basis of the materialistic similarity with Anatolia, the general absence of Mesolithic occupation on the eastern Mediterranean islands, and clear genetic presence of the descendants of Near Eastern colonists in extant European populations (e.g., Cunliffe, 2008; Deguilloux et al., 2012; Özdoğan, 2007; Catherine Perlès, 2003; Price, 2000a).

The proponents of the latter model place emphasis on the explicit evidence for pre-pottery Neolithic with Mesolithic affinities (Price, 2000a and references therein).

There has been a recent movement, however, toward a consensus acknowledging the complexity of the processes that spread the Neolithic across Europe. Toward this end, it is now recognized that farming spread into Europe by a mixture of expansion, diffusion, and adoption as the predominant mechanisms (Gkiasta, Russell, Shennan, & Steele, 2003; Özdoğan, Başgelen, & Kuniholm, 2012, 2013; Catherine Perlès, 2014; Robb & Miracle, 2007; Souvatzi, 2013). Özdoğan (2011, 2013), Souvatzi (2013), and Perlès (2014) concur that different regions in southeast Europe followed different rates of adoption of agriculture and that multiple Neolithic packages successively spread from central and northwestern Anatolia to Europe.

Site description and Chronology

The island of Gökçeada lies about 17 km from the Gelibolu (Gallipoli) Peninsula of the Anatolian mainland, and covers an area of 289.5 square km. During the Last Glacial Maximum (ca. 20.000-18.000 BC), sea levels were about 120 m lower than the present sea level (Özbek, 2012; Van Andel & Lianos, 1983). The site of Uğurlu Höyük is a low mound covering an area of approximately 250 x 200 m on a gentle slope at the eastern foot of Mount Isa (Doğanlı) on the western part of the island. The site was first discovered in 1998 and a long-term project was started in the summer of 2009 by Burçin Erdoğu (Erdoğu, 2011). During the six excavation seasons, six main cultural phases, designated as I-VI from top to bottom, and at least 12 layers of occupation have been revealed (Erdoğu, 2016). The earliest three phases (VI-IV) date to the Neolithic period. Phase III is marked by the Neolithic-Chalcolithic transition, while the succeeding Phase II dates to Chalcolithic. Scattered sherds from the Early Bronze Age and

Medieval times have been found on the surface, Phase I. Thanks to a rigorous dating program, we have a well-dated and established chronology for the cultural sequence (Table S1). The earliest stratum Phase VI is dated to between 6700 and 6500, Phase V between 6500 and 6000, Phase IV between 5900 and 5500, and Phase III between 5400 and 4900 BC.

Zooarchaeological methodology

Permission to carry out the archaeological fieldwork that yielded the datasets used in this project was provided by the Turkish Ministry of Culture and Tourism. All the zooarchaeological specimens involved are under the auspices of the Turkish Ministry of Culture and Tourism and are permanently stored in the Uğurlu Höyük Excavation Project Dig House on the island.

Recovery and sampling

Despite the lack of systematic dry- or wet-screening, all the excavated sediments were scrutinized to ensure full recovery of macro and microfaunal remains and to minimize the effects if recovery biases. Faunal assemblages from a total of 20 archaeological contexts representing strata V, IV, and III (9, 7, and 4 contexts, respectively) were sampled randomly, generating 6061 bone fragments. Of the three strata, Phase V has generated the largest sample (N=3967), as the faunal remains were densely packed in a small area of 2 x 4 m, enabling effective hand-picking.

Recording

The recording protocol employed in this work entailed general documentation of the entire assemblage for the purpose of characterization and included every element, element portion, and nonidentified splinter recovered (N=6061). No pre-sorting was practiced and all of the bones were packed and stored together in the storage area of the Uğurlu Höyük dig house. Every fragment was examined first by naked eye and then with a 10-15 x hand lens under strong light, if necessary, for bone surface modifications, while sub-samples were randomly chosen for recording variables such as fracture platform angle and percussion and notches. All the fragments were identified to the maximum degree possible, refitted and mended when possible, weighed, counted, labeled, assigned unique individual specimen numbers, measured when appropriate, and entered into an automated FileMaker database (Levent Atici, 2011). Recording took place at the project's facilities near the site on the island during field seasons 2011, 2013, and 2014 by Levent Atici, and in 2015 by Levent Atici and Suzanne Pilaar Birch.

Identification

Taxonomic and skeletal element identifications were carried out partly using a modern comparative reference collection assembled by the authors and partly using published manuals describing identification criteria. When the degree of certainty of identification was high, specimens were identified to the highest taxonomic category possible, i.e., species. When identification to a higher taxonomic category such as species, genus, or family was not possible, methodological categories, such as "medium artiodactyl" were used.

Quantification

Number of Fragments (NF), Number of Identified Specimens (NISP), Minimum Number of Elements (MNE), and Bone Weight (BW) were quantitative measures employed in this paper (Lyman, 2008). NF was used to document entire assemblages including non-specific skeletal part categories and NISP was used when fragments could be identified to skeletal element and at least to a taxonomic or size category (Lyman, 1994, 2008). For MNE, a combination of discrete landmarks (Morlan, 1994) and manual overlap approach (Bunn & Kroll, 1986) were used.

Following the age data, we present biometric data from Uğurlu Höyük following the standards (i.e., von den Driesch, 1976). We compare data from multiple western Anatolian Neolithic sites using primary data or raw measurements directly taken from the open access, peer reviewed data publishing system Open Context (http://opencontext.org), and/or the Logarithmic Size Index (LSI) values following Richard Meadow (1999). All the datasets used in this paper have citable DOIs/persistent identifiers that are listed in the appropriate supporting data tables and cited accordingly in the bibliography (Levent Atici, Released 2013-02-26, Released 2013-03-02; Buitenhuis, Released 2013-08-17; Canan Çakırlar, Released 2013-08-16; Galik, Released 2013-06-04a, Released 2013-06-04b; Gourichon & Helmer, Released 2014-05-12).

Results

Assemblage formation

Table S2 presents the general characteristics of the assemblages. The first step of the analysis reveals the taphonomic history. Bone surface modification analysis systematically included scrutiny of all skeletal parts for traces of carnivore gnawing, acid corrosion, and marks left by rodents, weathering, and root etching. The analysis of 6061 fragments weighing about 26 kg suggests that faunal assemblages from the three strata were all accumulated, modified, and destroyed largely by cultural processes.

A detailed analysis of bone surface modifications has revealed that rodent marks, weathering, and traces of root etching are extremely rare, indicating rapid burial events and intensive occupation and maintenance activities at the site. Direct and indirect traces of carnivore ravaging are almost absent from the Neolithic strata (V and IV), while the Neolithic-Chalcolithic transition phase (III) shows slightly increased carnivore activity at the site. The marginal number (N=5) of red fox bones from Phase V and a single dog bone from Phase III independently support the lack of carnivore involvement in the assemblage formation processes and can partially help account for the lack of their impact as a taphonomic agent. The lack of carnivore impact, in turn, indicates human processing as the primary taphonomic filter.

Taxonomic composition and species trends

Table S3 elaborates taxonomic composition and relative abundance of taxa based on NF, MNE, and BW counts. The Uğurlu Höyük assemblages reveal that the Neolithic and Chalcolithic inhabitants of the island exploited a wide range of taxa in varying proportions. The remains of bovids dominate the entire cultural sequence, whereas specimens representing suids, cervids, leporids, carnivores, and avifauna are present in varying and insignificant proportions and are not ubiquitous. Hunted or wild taxa include large-bodied (red deer, fallow deer, and wild boar) and small game (European hare). Most of the game animals identified at Uğurlu Höyük come from the Neolithic strata, with level V yielding a majority of this subset. The wild cat, great bustard, and mackerel shark are each represented by a single specimen from stratum IV, whereas a duck/goose specimen from stratum V and a dog specimen from stratum III account for other one-of-a- kind ecofacts from Uğurlu Höyük.

The faunal assemblages from Uğurlu are dominated by three principal food animals—sheep, goats, and cattle—as their bones comprise ca. 95% of the Neolithic and 90% of the Neolithic-Chalcolithic strata (Fig 2). Among the three livestock species, caprines seem to be the primary focus of pastoral economy when NF and MNE counts are taken into account, as they are represented in a much higher proportion (varying from 75 to 83% of all the identified bones) than cattle are (varying from 10 to 20% of all the identified bones). When the bone weight data presented in Table S3 are taken into account, however, the patterning changes in favor of cattle, which provide the largest dietary contributions varying from 30 to 53%. Sheep outnumber goats throughout the sequence, although the latter progressively increase from 6% in stratum V to 22% in stratum III, whereas the exploitation of sheep and cattle visibly decline.

Fig 2. Ratio distribution of principal taxa at Uğurlu Höyük using NISP counts.

Fig 3. Ternary graph showing ratio distribution of principal taxa in western Anatolia faunal assemblages.

Ulucak VI, with strata dating to 7000-6500 BC range, represents the earliest Neolithic in the northern Aegean region. As Figs 6 and 7 show, Ulucak VI has a relatively even taxonomic composition compared to Öküzini V, with cattle represented by ca. 16% and pigs at about 7%, which indicates a multitaxic yet monodominant assemblage (sensu L. Atici, 2014). Thus, the earliest phase of Ulucak Höyük is also characterized by a specialized, caprine-focused pastoral economy.

Fig 4. Species trends in western Anatolian faunal assemblages (%NISP).

Figs 3 and 4 demonstrate a trajectory in the Aegean region toward progressively increasing taxonomic evenness during the 6500-6000 BC range. At Ulucak V, while there is a slight increase in the proportion of cattle from about 16 to 18%, the sharp increase in the proportion of pigs from about 7 to 19% is notable and at the expense of a similarly notable drop in caprine representation. Slightly later in date, Çukuriçi VIII, too, confirms the departure from a caprine-dominated pastoral economy in the Aegean region. Here, the remains of cattle and pigs account for about 47% (27 and 20%, respectively) of the three-tiered animal economy. When we move to the northwestern region, the three Marmara sites, Fikirtepe, Barçın Höyük, and Menteşe Höyük mirror this trajectory towards increased evenness in the taxonomic composition. Here, too, the departure from heavy reliance on caprine management is evident. But unlike the Western Anatolian region, the focus in the Marmara region shifts to cattle, not to pigs, whose representation drops back to 2%.

Animal exploitation: carcass management, demography of mortality, and body size

Table S5 shows that all main caprine and cattle body parts are present in the assemblages in varying proportions except for the total absence of axial elements for both taxa in stratum III. This could be a product of small sample size and/or density-mediated attrition targeting less dense axial elements, but even so, this does not indicate any clear patterning, nor does it suggest selective removal, transport or processing of carcasses to primarily focus on more nutritious and meaty skeletal elements. Thus, the analysis of body part distributions indicates that full caprine carcasses were accessed, processed, and consumed. However, small sample sizes and disparities among MNE counts do not permit meaningful body part ratio comparisons between caprines and cattle, pigs, wild boars, fallow deer, and red deer (Table S5).

With this caveat in mind, the frequency distribution of game contrasts with that of domesticates. Stratum V, with the highest NF (3,967) and MNE (954) counts among the three strata, may provide the most representative picture of body part distribution for game taxa. Here, the elements of forelimb and hind limb comprise 71% of all boar bones, 73% of all fallow deer bones, and 50% of all red deer bones, while the elements of cranial and axial skeletons are either completely absent or significantly underrepresented. Though a smaller sample, Stratum IV, too, mimics the same pattern with the forelimb and hind limb elements comprising 100% of all boar bones, 100% of all hare bones, and the forelimb elements making up 80% of all red deer bones.

For cattle, the small sample size (N=87) imposed a cut-off point and permitted the assignment of cattle long bone epiphyseal specimens into either younger or older than 24 month age categories. The analysis of available epiphyseal fusion data for the small sample indicates that less than 30% of cattle survived beyond two years of age during stratum V with an upsurge in age at death to 70% and 50% during the succeeding strata IV and III, respectively. This may be due to the changing role of cattle in subsistence economy and a shift from a primary to secondary animal product-oriented pastoral economy with the institutionalization and intensification of farming during the late Neolithic and early Chalcolithic.

Although mean sheep LSI values from different Anatolian sub-regions vary conspicuously, the island populations from Gökçeada during the earlier two phases, V and IV, seem to align well with those from Barçın Höyük VI, Çukuriçi Höyük VIII, and Ulucak Höyük VIb (Fig 5; Table S6). When placed into a longer and wider spatiotemporal framework, it becomes even clearer that Uğurlu Höyük sheep represent one of the more intensively managed domestic phenotypes during the Neolithic. In contrast, sheep populations during the ensuing transitional Chalcolithic phase, III, must have gone through a selective process locally on the island that led to further size reduction to the extent that they sit at the lowest end of the size distribution.

Fig 5. Distribution of *Ovis* mean LSI values for western Anatolian sites.

A glance at Fig 6 (see also Table S7) reveals a similar patterning for goats with slightly greater variation. Similarly, goat populations from Gökçeada fit in the range, overlapping in size with other sub-regions and not representing the smallest size. Thus, it is plausible to assume that Neolithic goats from Gökçeada originated from western Anatolia.

Fig 6. Distribution of *Capra* mean LSI values for western Anatolian sites.

For cattle, two proximal metacarpus III + IV breadth measurements, one from stratum V and one from stratum IV, provide us with a glimpse into the *Bos* size range across western Anatolian sites and where Uğurlu Höyük specimens fall within that range. Although neither significant nor conclusive, the two specimens from Uğurlu Höyük are rather large, implying the presence of either large domestic males or aurochs transported from the mainland (Fig 7).

Fig 7. *Bos* spp. size distribution based on the measurement of proximal breadth (BP in mm) in metacarpus III + IV.

The biometric data presented here for Suidae are rather complicated and must be interpreted with caution. On the basis of the mean LSI distributions presented in Fig 8 (see also Table S8), it is hard to accurately discriminate between wild boars and domestic pigs, since Epipaleolithic Öküzini V and the Cypriot Pre-Pottery Klimonas data attest to the presence of wild boars whose smaller phenotypes overlap with domestic pigs. The amount of variability within and among populations seems pronounced and the degree of overlap between wild boar and domestic pig sizes is large. Based on the LSI patterning, we would postulate that phenotypically wild and large hunted boar populations appear in the assemblages from the Marmara region: at the earliest level of Ilıpınar (X), early level of Menteşe Höyük, Barçın Höyük, and Fikirtepe. In contrast, all the other sub-regions indicate managed domestic pig populations. This patterning, however, would be an artifact of pooling all the measurements from multiple elements to overcome sample size-related biases at the expense of losing resolution. Alternatively, the presence of very large male phenotypes and female-focused hunting strategies may converge to skew the size distribution and make the wild, smaller female individuals fall in the domestic end of the continuum. In this case, a closer look at the osteometric analysis of a single element such as astragalus, which is shown in the box & whisker plot in Fig 9, could be useful. The plot shows suid astragali identified as domestic, wild, and domestic or wild from Ulucak Höyük, Çukuriçi Höyük, Ilıpınar, and Uğurlu Höyük. Data from the Aceramic Neolithic Klimonas from the island of Cyprus (Vigne et al., 2012) are also included to present an island wild boar population as a comparative reference. We must emphasize that the range of size distribution in domestic pigs at Ilıpınar covers domestic pigs from Ulucak Höyük and Çukuriçi Höyük and wild populations from the Cypriot Pre-Pottery Neolithic site of Klimonas and both domestic and wild individuals from Uğurlu Höyük. Therefore, the degree of overlap between the wild and domestic populations presented in the plot confirms that the biometric data are indeed nuanced, calling for careful interpretations.

Fig 8. Distribution of *Sus* mean LSI values for western Anatolian sites.

Fig 9. *Sus* spp. size distribution based on the measurement of greatest lateral length (GLl in mm) in astragalus.

Concluding discussion

The zooarchaeological research presented here has addressed the following specific questions to probe animal exploitation strategies at Uğurlu and to add new data to research in the spread of domesticated animals across Neolithic western Anatolia:

1. *Did the islanders have a diverse subsistence strategy, including foraging and marine resource exploitation, or did they heavily rely on livestock management? How did the animal economy change through time?*

Although the Neolithic and Chalcolithic inhabitants of Gökçeada exploited a wide range of taxa in varying proportions, remains of three principal food animals—sheep, goats, and cattle—dominate the three Uğurlu Höyük assemblages. Of the taxa, caprines in general and sheep in particular were the primary focus of pastoral economy throughout the cultural sequence. Sheep outnumber goats in all phases although the latter progressively increase and the exploitation of sheep and cattle visibly decline by Chalcolithic.

During the earliest phase of the Neolithic between 7000 and 6500 BC, a more specialized, caprine-dependent animal management regime seems to be represented by both sides of the Aegean Sea; on the mainland Anatolia as documented at Ulucak Höyük VI and Öküzini Cave V.

Between 6500 and 6000 BC, Gökçeada (Uğurlu V) had a three-tiered pastoral economy with a primary focus on caprines and a secondary focus on cattle; pig exploitation was marginal with a proportion around 2%. In contrast, a four-tiered pastoral economy with a primary focus on caprines and secondary, dual focus on cattle and pigs characterizes Çukuriçi VIII and Ulucak Höyük V in the western region. Here, the ratio of pigs increases sharply as a part of progressively increasing taxonomic evenness. A three-tiered animal management system with an equal focus on caprines and cattle, or a shifting primary focus on either caprines or cattle is evident in the Marmara and Turkish Thrace, two sub-regions of northwestern Anatolia, as documented at Fikirtepe, Barçın Höyük VI, Menteşe Höyük early and late levels from the former and Hoca Çeşme from the latter. The suids are represented in marginal proportions in both sub-regions.

During the latest phase of the Neolithic, between 6000-5500 BC, the species trend in the western region shows a conspicuous continuity with a four-tiered animal husbandry, whereas the sites in the Marmara Region show a greater taxonomic diversity with a sharp drop in cattle and increase in caprine exploitation. The fluctuations in the reconfiguration of taxa in each region and sub-region of western Anatolia mark changing roles of the four vital livestock species through time and across space. This, in turn, may reflect the transformation of Neolithic societies and their agropastoral economies following multiple pathways within a rapidly changing physical and sociopolitical world. As far as the changes identified at Uğurlu Höyük (IV) are concerned, slight but progressive increase in the exploitation of goats and decrease of sheep and cattle most likely reflect the realities of resource management and impacts of environmental circumscription on an island setting. Factors such as mobility, transhumance, and penning, as well as availability, accessibility, predictability, and quality of grazing pastures, water, and fodder must have determined animal management strategies that seem to have varied across taxa. For instance, spatial constraints of islands and resource availability and abundance may pose challenges when herding cattle.

2. *How did island habitation affect animal management decisions compared to the mainland Anatolia? Did the islanders manage cattle, sheep, goats, and pigs differently?*

The analysis of body part distribution reveals nuanced and complicated data that need to be interpreted cautiously. Due to sample size-related analytical biases, it is not possible to present a diachronic analysis of carcass management for each livestock and game species. Still, with a closer look at the earliest phase of Neolithic, Uğurlu Höyük V, somewhat representative interpretations can be inferred.

Based on the archaeologically documented material exchanges between early farming populations, it is plausible to hypothesize a process in which animals and their parts and products were traded for goods among early farmers across western Anatolia. To further complicate the matter, as archaeologically documented for pigs, hundreds of years of introgression between feralized domestic stock and wild herds would manifest itself in the form of variable mix of traits and sizes (Rowley-Conwy & Zeder, 2014: 836). This, in turn, further exacerbates the situation, since a mixture of wild and domestic genetic and morphological characteristics would be osteologically reflected in the zooarchaeological record. As Albarella, Dobney, and Rowley-Conwy (2009) have documented, using biometry alone to accurately discriminate between wild and domestic forms will not generate comparable and consistent results due to population-specific intra-species size variation (see also Rowley-Conwy & Zeder, 2014: 837). Albarella and colleagues (2006) note that in the islands of Corsica and Sardinia wild, feral, free-range and fully domestic pigs interbreed regularly and thus create a biological continuum that could not possibly be identified morphologically or biometrically, but behaviorally. As such, they treat all specimens from the family Suidae as a single biological entity without attempting to assign them "wild" or "domestic" status (U. Albarella et al., 2006: 292). In addition, application of multiple exploitation strategies, hunting, and seasonal mobility and transhumance, may lead to distorted biometric and demographic patterning that further complicates our understanding of Neolithic animal management systems and obscure zooarchaeological signatures (Arbuckle & Atici, 2013).

The clarification of the family Suidae's status on the island of Gökçeada and particularly the verification of the presence of domestic pigs may potentially shed new light on the timing and directionality of the dispersing farming populations. All four livestock species, including domestic pigs with distinctively small phenotypes, are documented in the Aegean region at Ulucak VI during the early seventh millennium BC, alluding to a rapid westward movement of domestic animals across southern Turkey following a coastal route by sea or land (Arbuckle et al., 2014).

Arbuckle and colleagues (2014 :8) further argue for the presence of two distinct colonization pathways corresponding with distinctive animal economies and ceramic technology: 1) caprines, cattle, and pigs and the initial Aceramic expansion of Neolithic lifeways and with later Red Slipped Burnished Ware horizon during the late eight-seventh millennium BC into coastal and inland SW and western Turkey; and 2) domestic caprines and cattle associated with Dark Faced Burnished Ware tradition from the interior Anatolian Plateau. Thus, would the presence of domestic pigs alone place Uğurlu Höyük within the first colonization pathway and directly link it to southwest and western Anatolian domain? Or would the absence of domestic pigs suffice to establish spatiotemporal relationships between the Marmara and Thrace regions and Gökçeada? The answers to these questions are nuanced and would have to incorporate more than presence or absence of taxa and/or ceramic techno-typology.

Domestication of animals is a complex phenomenon that involves a continuum between resource management, domestication or morphological changes associated with management, and fully-developed animal husbandry or intentional and intensive human management of animals (e.g., Arbuckle, 2013; Zeder, 2015). The study of this phenomenon, in turn, requires approaches beyond binary status assignment and using single lines of evidence and/or monocausal explanatory frameworks. It is difficult to clearly establish domestic status when a full suite of morphological and genetic characteristics is unavailable. In the same vein, studying the dispersal of early farmers from southwest Asia into southeast Europe via Anatolia requires a rigorous methodological approach to develop a fine-resolution picture of the variability seen in human adaptations and dispersals within complex and rapidly changing environmental and cultural settings. For this, the whole spectrum of human-animal interactions must be fully documented for each sub-region of southwest Asia and circum-Mediterranean. Building upon and adding to the high-resolution regional-scale project spearheaded by Arbuckle and colleagues (2014) to document the westward spread of domestic animals across Neolithic Turkey, Uğurlu Höyük on the island of Gökçeada in the northeastern corner of the Aegean Sea, an area previously underinvestigated and neglected, offers us an additional piece of evidence and new data elaborating the nature of the Neolithic dispersals.

The results of zooarchaeological research presented here align well with the findings of Arbuckle and Atici (2013) and Arbuckle and colleagues (2014) in that the initial diversity in animal management systems of the Pleistocene-Holocene transition in southwest Asia continued deep into the Neolithic and Chalcolithic with the dispersal of fully developed agropastoral lifeways of early farming populations into southeast Europe. The first settlers of Gökçeada were agriculturalists and they introduced domestic sheep, goats, cattle and pigs to the island as early as 6500 years BC. The early Neolithic has signs of continuity, but the cultures of island and mainland clearly diverge. Differences in material culture may be deliberate expressions of local identities within a wider cultural setting.

Supporting information

Table S1. Radiocarbon dates from Uğurlu Höyük with lab references numbers, sample numbers, materials dated, and BC calibration limits for one standard error (XLSX).

Table S2. General characteristics detailing the taphonomic histories of the three Uğurlu Höyük assemblages (XLSX).

Table S3. Taxonomic composition in the three Uğurlu Höyük assemblages using Number of Fragments, Minimum Number of Elements, and Bone Weight in grams (XLSX).

Table S4. List of sites used in this paper with data including region, phase, chronology, author, and relative abundance of *Ovis*, *Capra*, *Bos* and *Sus* based on %NISP (After Arbuckle et al. 2014) (XLSX).

Table S5. Frequency distributions of body parts based on %MNE counts in main taxa (XLSX).

Table S6. Mean LSI values and standard deviations for sheep from late Pleistocene-early Holocene sites in western Anatolia. Author information and links to online databases are also included (XLSX).

Table S7. Mean LSI values and standard deviations for goats from late Pleistocene-early Holocene sites in western Anatolia. Links to online databases are also included (XLSX).

Table S8. Mean LSI values and standard deviations for *Sus* from late Pleistocene-early Holocene sites in western Anatolia. Author information are also included (XLSX).

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Fig 1. Location of the sites mentioned in the text: 1=Uğurlu Höyük, 2=Hoca Çeşme, 3=Yeni Kapı, 4=Fikirtepe, 5=Ilıpınar, 6=Menteşe Höyük, 7=Barçın Höyük, 8=Orman Fidanlığı, 9=Ulucak Höyük, 10=Çukuriçi Höyük, and 11=Karain B and Öküzini caves.

Fig 2. Ratio distribution of principal taxa at Uğurlu Höyük using NISP counts.

Fig 3. Ternary graph showing ratio distribution of principal taxa in western Anatolia faunal assemblages. Assemblages represented are as follows: OK5=Öküzini Cave V; UG 5, 4, 3= Uğurlu Höyük V, IV, III, respectively; UL 6, 5, 4=Ulucak Höyük VI, V, IV, respectively; IPX= Ilıpınar X; HC= Hoca Çeşme; MHE=Menteşe Höyük Early; MHM=Menteşe Höyük Middle; MHL=Menteşe Höyük Late; BH6=Barçın Höyük VI; CH8=Çukuriçi Höyük VIII; FT=Fikirtepe.

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