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Zooarchaeological Evidence for Animal Exploitation at Earlier Neolithic Tsoungiza, Ancient Nemea

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# ZOOARCHAEOLOGICAL EVIDENCE FOR ANIMAL EXPLOITATION AT EARLIER NEOLITHIC TSOUNGIZA, ANCIENT NEMEA

## ABSTRACT

**Animal bones from the earlier Neolithic open-air settlement at Tsoungiza, Ancient Nemea, are dominated by sheep and secondarily by pigs and goats, with cattle scarce and dogs absent. Slaughter ages suggest management of sheep/goat for meat more than milk production. Sparse evidence for wild animals is restricted to foxes and hares. Domesticate carcasses were butchered into large segments, arguably for sharing between social groups larger than single households. In scarcity of game, dominance of sheep, emphasis on meat production, and low-intensity butchering, Tsoungiza resembles other earlier Neolithic sites in Greece, but preferential slaughter of young adult sheep/goats and selective anatomical treatment are distinctive features, perhaps related to collective commensality.**

Excavations during the 1970s and 1980s, coupled with the reevaluation of finds from the 1920s, have established that the Bronze Age site on Tsoungiza Hill at Ancient Nemea (Figs. 1, 2) overlaid an open-air Neolithic settlement scattered over an area of 2.6 ha (26,000 m$^2$). This underlying settlement was occupied from the Early Neolithic (EN) into the early Middle Neolithic (MN) and reoccupied in the Final Neolithic (FN) period. The faunal assemblage from the 1970s and 1980s excavations, although of modest size, sheds valuable light on the husbandry of livestock and the processing of their carcasses for consumption.

## CONTEXTS

Faunal remains of mainly earlier Neolithic date were examined from the following contexts at Tsoungiza:[1]

> Context 3 from the 1974–1975 excavations by the University of California at Berkeley (UCB) in area 1, including animal bone lots L1 (surface level), L10 (surface?), L11 (layer 1), and L13 (layer 3), which are dated by ceramics to EN–MN with minor FN contamination;

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[1] For an overview of Neolithic Tsoungiza, see Dabney et al. 2020. I am indebted to James C. Wright, for inviting me to study the zooarchaeological material from Tsoungiza; to Mary Dabney, for essential contextual information on the material reported here; and to Valasia Isaakidou, for comparative data from Knossos and, together with two anonymous referees, for critical comments on a draft of this article. The labeling of the excavation contexts discussed here follows Dabney et al. 2020.

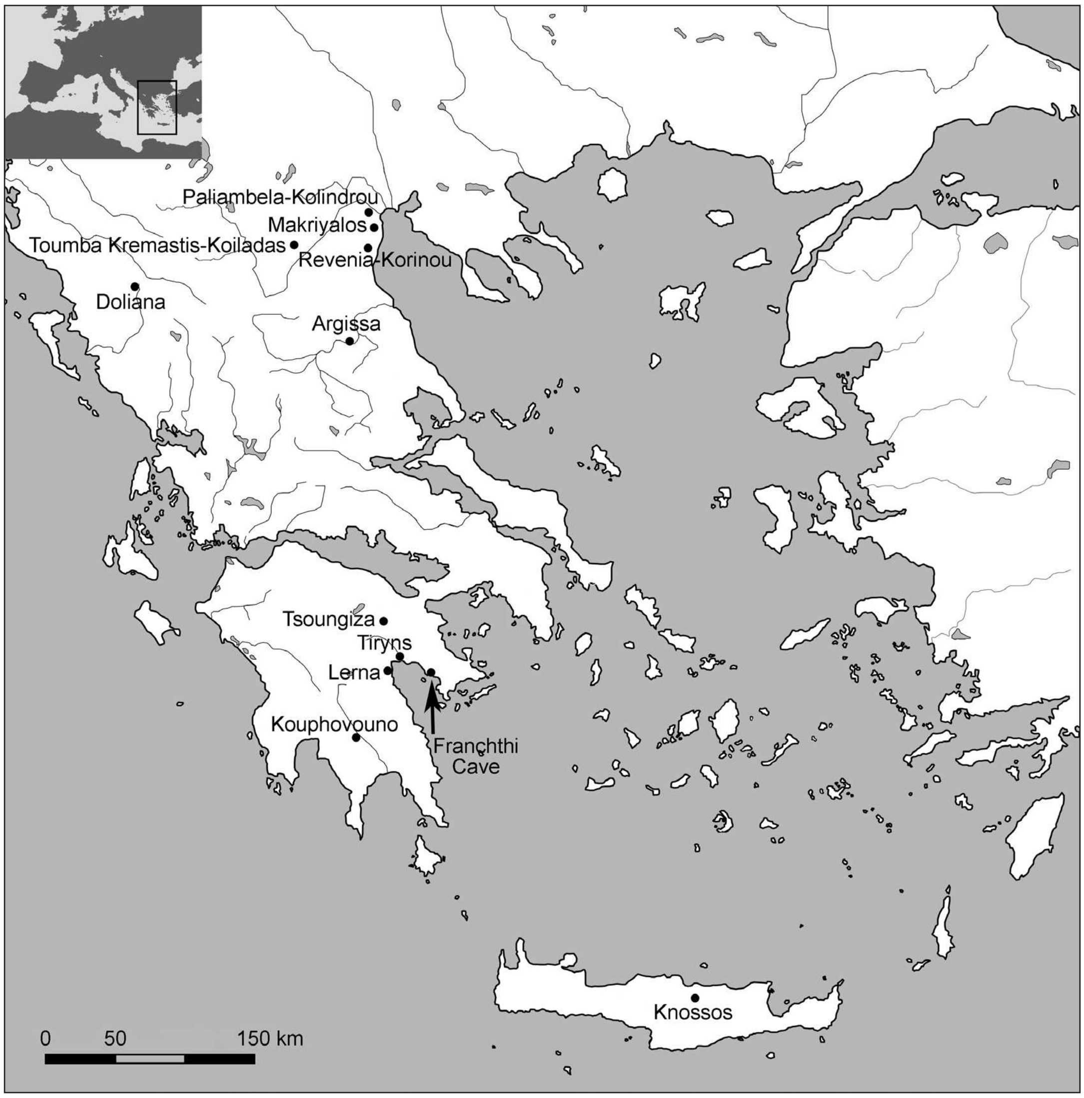

**Figure 1. Map of Greece showing location of Tsoungiza and other prehistoric sites mentioned in the text.** V. Isaakidou and N. Valasiadis

Context 5 from the 1974–1975 UCB excavations in area 3, including animal bone lots L3 and L17 (layer 1), L4, L5, and L18 (layer 2), and L19 (layer 3), which are dated by ceramics to EN–MN with minor FN contamination;

Context 6 from the 1982 UCB excavations, dated by ceramics to EN;

Context 7 from the Nemea Valley Archaeological Project (NVAP) EU (excavation unit) 4, including SU (stratigraphic unit) 604 and SU 606 (plow soil), SU 613 and SU 615 (cultural material redeposited by erosion), and SU 620–SU 621, SU 625–SU 628, and SU 631–SU 634 (refuse deposit), which are dated by ceramics to EN(–MN[?]);

NVAP context SU 2202,[2] representing EU 11 "pit 1," with ceramics primarily of EN date with some FN and Early Helladic (EH) III contamination;

NVAP contexts SU 2205, SU 2206, and SU 2207,[3] representing a fill in EU 11, with ceramics dated mostly to EN with a few FN–EH I pieces.

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[2] *NVAP* I, pp. 22–24.

[3] *NVAP* I, pp. 22–24.

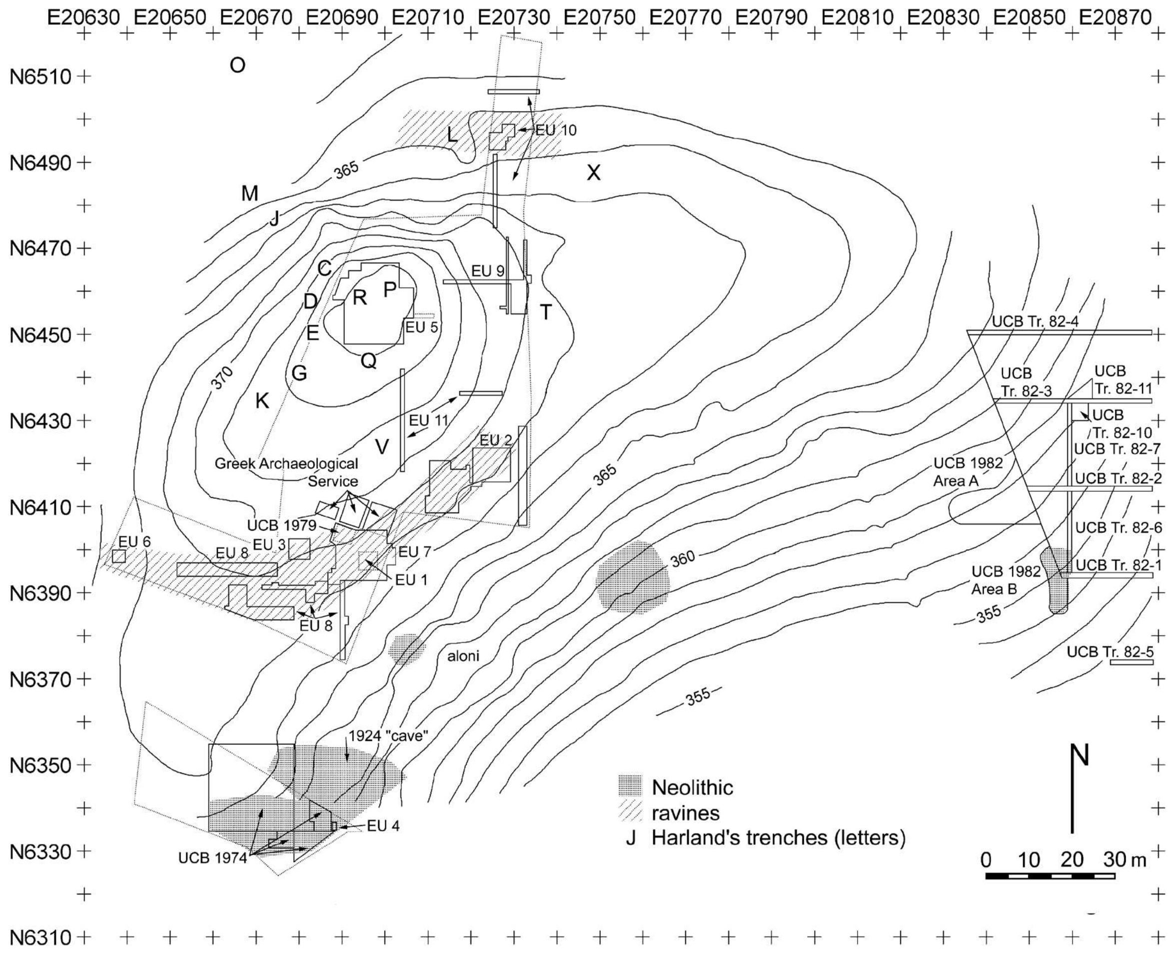

**Figure 2. Tsoungiza site plan showing Neolithic deposits.** W. Payne and J. Pfaff; Dabney et al. 2020, p. 2, fig. 1, after *NVAP* I, p. 5, fig. 1.5

These contexts represent hollows, containing mixed cultural material, in the underlying bedrock. On the basis of associated ceramics, the studied zooarchaeological assemblage is overwhelmingly of EN or EN–MN date (hereafter "earlier Neolithic"), with some possible admixture of later (FN and EH) material. The assemblage reported here is thus probably attributable to the late 7th–early 6th millennium B.C.[4] Despite the potential length of this overall time range, lack of detectable stratigraphy suggests that individual fills accumulated fairly rapidly, and so may represent relatively short-lived episodes or cycles of animal exploitation.

## METHODOLOGY

Methods of identification, quantification, and recording follow the protocols applied to the study of the EH material from the same site.[5] For a coarse overview of assemblage composition, all nonhuman mammalian bone,

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[4] See Perlès, Quiles, and Valladas 2013; Maniatis 2014; Mee, Cavanagh, and Renard 2014.

[5] The distinction between sheep and goat follows Boessneck (1969) and Kratochwil (1969) for postcranial bones, and Payne (1985) for juvenile teeth; ageing follows Silver (1969) for postcranial bones, and Payne (1973) and Bull and Payne (1982) for teeth; the sexing of sheep and goat pelves follows Boessneck (1969); the attribution of butchery marks to successive stages of carcass processing follows Binford (1981); and classification of fragmentation types is based on Binford (1981). For further details, see Halstead 2011b.

identifiable and not, was weighed in three anatomical categories: head, trunk, and limb. Detailed recording of individual specimens, identified to body part and taxon, was restricted to the following relatively durable, identifiable, and quantifiable anatomical units: horncore, mandibular cheek tooth row, scapula (glenoid and neck), humerus, radius, proximal ulna, metacarpal (only metacarpals 3 and 4 in the case of pig), pelvis (acetabular area), femur, tibia, astragalus, calcaneum, metatarsal (only metatarsals 3 and 4 in the case of pig), phalanx 1, phalanx 2, and phalanx 3; the proximal and distal halves of the "long bones" (humerus, radius, metacarpal, femur, tibia, and metatarsal) were recorded as separate anatomical units. These selected specimens were quantified in terms of both the total number of identified and recorded anatomical units (referred to as MaxAU) and the minimum number of anatomical units (MinAU). The MinAU, estimated by discounting any fragments that could potentially be derived from the same bone (or half of a long bone) as a previously recorded specimen from the same context, is used to calculate the relative abundance of different anatomical parts, taxa, and age groups; MaxAU is used, however, to explore assemblage modification by gnawing and fragmentation, since the specimens counted for MinAU tend to be more complete and less modified than those discounted.

## OVERVIEW OF THE ASSEMBLAGE

The combined assemblage, from all the contexts listed above, amounts to just under 9 kg of dried and cleaned bone (Table 1), including 345 MaxAU or 289 MinAU of identified and recorded specimens (Table 2), and is thus perhaps large enough for a reliable estimate of overall taxonomic composition, but too small for detailed context-by-context analysis. The assemblage is dominated by sheep, followed by pig and goat, and then cattle, with just minor contributions from fox and hare. Accordingly, the following analysis focuses primarily on the domesticates, and particularly on pig and combined sheep, goat, and sheep/goat rather than cattle; sheep and goat are for most purposes analyzed as a combined taxon, because only a minority of specimens could be identified to species (suggesting a ratio of approximately 2 sheep:1 goat) rather than to the generic level of "sheep/goat."

### TABLE 1. ANATOMICAL COMPOSITION (WEIGHT) BY CONTEXT, COMPARED WITH COMPLETE MODERN SKELETONS

| | *Context* | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *3* | | *5* | | *6* | | *7* | | *SU 2202* | | *SU 2205–2207* | | *Total* | | *Complete Modern Skeletons (%)*[1] |
| *Unit* | *g* | *%* | *g* | *%* | *g* | *%* | *g* | *%* | *g* | *%* | *g* | *%* | *g* | *%* | |
| Head | 2,860 | 56.1 | 320 | 21.1 | 315 | 29.3 | 140 | 37.8 | 10 | 9.5 | 115 | 15.3 | 3,760 | 42.2 | 14–32 |
| Trunk | 790 | 15.5 | 340 | 22.4 | 135 | 12.6 | 20 | 5.4 | 40 | 38.1 | 225 | 30.0 | 1,550 | 17.4 | 24–35 |
| Limb | 1,450 | 28.4 | 860 | 56.6 | 625 | 58.1 | 210 | 56.8 | 55 | 52.4 | 410 | 54.7 | 3,610 | 40.5 | 40–56 |
| *Total* | 5,100 | 100 | 1,520 | 100 | 1,075 | 100 | 370 | 100 | 105 | 100 | 750 | 100 | 8,920 | 100 | |

[1] After Halstead 2011b, p. 772, fig. 13.3:a.

## TABLE 2. TAXONOMIC COMPOSITION OF THE ASSEMBLAGE

| | *Context* | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *3* | | *5* | | *6* | | *7* | | *SU 2202* | | *SU 2205–2207* | | *Total* | | |
| *Taxa* | *Max AU* | *Min AU* | *Max AU* | *Min AU* | *Max AU* | *Min AU* | *Max AU* | *Min AU* | *Max AU* | *Min AU* | *Max AU* | *Min AU* | *Max AU* | *Min AU* | *% MinAU*[1] |
| Cattle | 8 | 8 | 3 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 4 | 4 | 16 | 15 | 5.2 |
| Pig | 18 | 17 | 16 | 15 | 18 | 16 | 8 | 8 | 1 | 1 | 17 | 15 | 78 | 72 | 24.9 |
| Sheep | 29 | 28 | 26 | 23 | 4 | 4 | 4 | 4 | 0 | 0 | 8 | 7 | 71 | 66 | 45.2 |
| Sheep/goat | 43 | 31 | 34 | 29 | 39 | 21 | 7 | 6 | 4 | 3 | 11 | 6 | 138 | 96 | – |
| Goat | 16 | 15 | 13 | 13 | 2 | 2 | 1 | 1 | 0 | 0 | 1 | 1 | 33 | 32 | 21.9 |
| Hare | 0 | 0 | 1 | 1 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 1.0 |
| Fox | 0 | 0 | 2 | 2 | 1 | 1 | 3 | 2 | 0 | 0 | 0 | 0 | 6 | 5 | 1.7 |
| *Total* | 114 | 99 | 95 | 85 | 67 | 47 | 23 | 21 | 5 | 4 | 41 | 33 | 345 | 289 | – |

[1] Specimens identified generically as sheep/goat have been assigned *pro rata* to sheep and goat.

## FORMATION PROCESSES

While most deposits investigated by NVAP were systematically sieved, this was not the case for the earlier UCB excavations, so the assemblage examined here was largely recovered without sieving. As a result, the smaller body parts, especially of the smaller taxa, are probably underrepresented due to recovery losses. Context 7, sieved by NVAP, confirms this expectation, as 6 of 23 MaxAU and 4 of 21 MinAU were recovered from the wet sieve, and these were indeed heavily biased to small body parts of small taxa: two third and one second phalanx of fox; one second phalanx of sheep/goat and one astragalus of sheep; and one metatarsal splinter of sheep/goat.

Although no specimens of dog were identified, traces of gnawing compatible with their presence were observed on about 7% of domesticate bones (excluding loose teeth, on which gnawing is not detectable) and were thus far less frequent than in EH (28%) and MH–LH (37%–39%) levels at Tsoungiza.[6] Consistent with this, the proportion by weight of "trunk" material (vertebrae and ribs), which is particularly vulnerable to attrition (whether by gnawing, trampling, or weathering), is much higher in the earlier Neolithic (17%) than in the Bronze Age (5%–11%) at Tsoungiza, albeit still somewhat lower than the 24%–35% of complete skeletons (see Table 1). Although the incidence of gnawing in the earlier Neolithic at Tsoungiza, ranging from about 9% in pigs to 7% in sheep/goats and 6% in cattle, does not differ significantly between taxa (Table 3), some selective destruction of the less robust body parts is likely to have occurred. Whole long bones are indeed very scarce and are outnumbered by shaft cylinders such as are commonly (although not exclusively) produced by carnivore attrition (Table 4). On the other hand, whole long bones were only encountered in pigs, and cylinders were more common in pigs than in sheep/goats or cattle, despite pigs tending to be killed much younger (see below), and their bones thus being more vulnerable to attrition by scavengers or trampling by people than those of the other domesticates. Although the small sample size demands caution, a

[6] Halstead 2011b, p. 763, table 13.24; in press.

### TABLE 3. INCIDENCE OF GNAWING BY TAXON (MAXAU EXCLUDING LOOSE TEETH) FOR ALL CONTEXTS COMBINED

| *Gnawing* | *Cattle* | *Pig* | *Sheep/Goat* | *Total* |
|---|---|---|---|---|
| Not gnawed | 15 | 69 | 205 | 289 |
| Gnawed | 1 | 7 | 15 | 23 |
| Gnawed % | 6.3 | 9.2 | 6.8 | 7.4 |
| *Total* | 16 | 76 | 220 | 312 |
| $\chi^2$ test | $\chi^2$ 0.505, p = .777 | | | |

### TABLE 4. FRAGMENTATION OF LIMB BONES BY TAXON (DOMESTICATES ONLY, EXCLUDING NEONATAL SPECIMENS AND UNFUSED EPIPHYSES)

| | *Cattle* | | *Pig* | | *Sheep/Goat* | |
|---|---|---|---|---|---|---|
| *Fragmentation* | *MaxAu* | *%* | *MaxAu* | *%* | *MaxAu* | *%* |
| LONG BONES | | | | | | |
| Whole | 0 | 0.0 | 4 | 16.0 | 0 | 0.0 |
| End | 4 | 66.7 | 7 | 28.0 | 29 | 33.7 |
| End splinter | 2 | 33.3 | 2 | 8.0 | 20 | 23.3 |
| Shaft cylinder | 0 | 0.0 | 5 | 20.0 | 11 | 12.8 |
| Shaft splinter | 0 | 0.0 | 7 | 28.0 | 26 | 30.2 |
| *Total* | 6 | 100 | 25 | 100 | 86 | 100 |
| PHALANGES 1 AND 2 | | | | | | |
| Whole | 2 | 50.0 | 0 | 0.0 | 15 | 100.0 |
| Broken | 2 | 50.0 | 0 | 0.0 | 0 | 0.0 |
| *Total* | 4 | 100 | 0 | 0 | 15 | 100 |

*Note:* Long bones = humerus, radius, metacarpal, femur, tibia, metatarsal.

similar pattern is seen in Bronze Age deposits at Tsoungiza and in Neolithic material elsewhere,[7] including the large and well-recovered assemblage from EN Revenia-Korinou in northern Greece.[8] This greater fragmentation of the more robust specimens is most parsimoniously interpreted as the product primarily of deliberate anthropogenic breakage to extract marrow and perhaps bone grease (discussed further on pp. 201–202, below), with long bones of young pigs most frequently left intact by human butchers, and thus most attractive to scavengers (as the frequency of gnawing suggests) and offering the greatest potential for subsequent reduction to cylinders by attrition.[9]

Traces of burning, potentially the result of discard or cooking practices, are much more frequent than those of gnawing, averaging 28%, with little difference between the domestic taxa (Table 5). The incidence of burning is dramatically less frequent in context 6 (4.7%) than in the remaining bone groups (ranging between 26.1% and 41.5%) (Table 6), inviting interpretation in terms of discard, but striking irregularities also between body parts perhaps reflect a major role for cooking practices (discussed further on pp. 200–201, below).

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[7] For Tsoungiza, see Halstead 2011b, pp. 767–769; in press.

[8] See Isaakidou, Halstead, and Adaktylou 2018.

[9] See Yellen 1991, p. 186.

TABLE 5. INCIDENCE OF BURNING BY TAXON (MAXAU), FOR ALL CONTEXTS COMBINED

| *Burning* | *Cattle* | *Pig* | *Sheep/Goat* | *Total* |
|---|---|---|---|---|
| Not burned | 11 | 57 | 173 | 241 |
| Burned | 5 | 21 | 69 | 95 |
| Burned % | 31.3 | 26.9 | 28.5 | 28.3 |
| *Total* | 16 | 78 | 242 | 336 |
| $\chi^2$ test | $\chi^2$ 0.147, p = .929 | | | |

TABLE 6. INCIDENCE OF BURNING BY CONTEXT (MAXAU), FOR CATTLE, PIGS, AND SHEEP/GOATS COMBINED

| | *Context* | | | | | | |
|---|---|---|---|---|---|---|---|
| *Burning* | *3* | *5* | *6* | *7* | *SU 2202* | *SU 2205–2207* | *Total* |
| Not burned | 73 | 68 | 61 | 12 | 3 | 24 | 241 |
| Burned | 41 | 24 | 3 | 8 | 2 | 17 | 95 |
| Burned % | 36.0 | 26.1 | 4.7 | 40.0 | 40.0 | 41.5 | 28.3 |
| *Total* | 114 | 92 | 64 | 20 | 5 | 41 | 336 |
| $\chi^2$ test | $\chi^2$ 26.311, p = .000 | | | | | | |

## CARCASS PROCESSING, COOKING, AND CONSUMPTION

In terms of bone weight, vertebrae and ribs ("trunk") are underrepresented in the earlier Neolithic assemblage as a whole, probably because of attrition (see above). Variability in composition between individual contexts is doubtless due, at least in part, to small sample sizes, but context 3, the largest, diverges somewhat from the rest of the assemblage in comprising rather less limb and rather more head than expected (see Table 1).

Turning to the evidence of recorded identified specimens, the rare bones of hare and fox are mainly derived from the foot, and so may have been introduced to the site with skins rather than edible carcass parts,[10] although a burned distal tibia of hare may have been food waste (and was clearly not introduced to the site by a burrowing fox). Conversely, and despite the small sample sizes, all body parts are represented for sheep/goat and almost all for pig (Table 7; Figs. 3, 4). Two body parts stand out, however, as overrepresented, especially in sheep/goats but also in pigs: pelves and, secondarily, mandibles. Mandibles of these taxa are usually well represented in Neolithic assemblages from Greece, partly because teeth are exceptionally robust and identifiable and partly because, being more precisely ageable than postcranial bones, they are less likely to be discounted in the estimation of MinAU. The abundance of pelves of both sheep/goats and pigs, however, is very unusual and, since they are far less durable than mandibles,[11] implies either that pelves were selectively discarded in the excavated areas of the site or that other anatomical parts were selectively destroyed. A possible practical rationale for the former scenario is that, being a slender flat bone

[10] See, e.g., Val and Mallye 2011.

[11] See Brain 1981, p. 23, fig. 18:a.

## TABLE 7. ANATOMICAL REPRESENTATION BY TAXON (ALL CONTEXTS COMBINED)

| | *Cattle* | | *Pig* | | *Sheep/Goat* | | *Hare* | | *Fox* | |
|---|---|---|---|---|---|---|---|---|---|---|
| *Anatomical Unit* | *MaxAU* | *MinAU* | *MaxAU* | *MinAU* | *MaxAU* | *MinAU* | *MaxAU* | *MinAU* | *MaxAU* | *MinAU* |
| Horn | 2 | 2 | 0 | 0 | 11 | 10 | 0 | 0 | 0 | 0 |
| Mandible | 0 | 0 | 12 | 11 | 35 | 22 | 0 | 0 | 0 | 0 |
| Scapula | 0 | 0 | 5 | 5 | 13 | 13 | 0 | 0 | 0 | 0 |
| Humerus, proximal | 0 | 0 | 3 | 3 | 9 | 8 | 0 | 0 | 0 | 0 |
| Humerus, distal | 1 | 1 | 7 | 7 | 19 | 13 | 0 | 0 | 0 | 0 |
| Radius, proximal | 0 | 0 | 0 | 0 | 14 | 11 | 0 | 0 | 0 | 0 |
| Ulna, proximal | 1 | 1 | 8 | 8 | 6 | 6 | 0 | 0 | 0 | 0 |
| Radius, distal | 0 | 0 | 1 | 1 | 4 | 4 | 0 | 0 | 0 | 0 |
| Metacarpal, proximal | 1 | 1 | 3 | 3 | 7 | 7 | 1 | 1 | 0 | 0 |
| Metacarpal, distal | 2.5 | 2.5 | 3 | 3 | 7 | 7 | 1 | 1 | 0 | 0 |
| Pelvis | 1 | 1 | 15 | 12 | 47 | 34 | 0 | 0 | 0 | 0 |
| Femur, proximal | 0 | 0 | 2 | 1 | 5 | 5 | 0 | 0 | 0 | 0 |
| Femur, distal | 0 | 0 | 4 | 4 | 10 | 9 | 0 | 0 | 0 | 0 |
| Tibia, proximal | 0 | 0 | 5 | 4 | 5 | 4 | 0 | 0 | 0 | 0 |
| Tibia, distal | 0 | 0 | 5 | 5 | 9 | 8 | 1 | 1 | 2 | 2 |
| Astragalus | 0 | 0 | 2 | 2 | 2 | 2 | 0 | 0 | 0 | 0 |
| Calcaneum | 0 | 0 | 2 | 2 | 7 | 7 | 0 | 0 | 0 | 0 |
| Metatarsal, proximal | 1 | 1 | 1 | 1 | 6 | 4 | 0 | 0 | 0 | 0 |
| Metatarsal, distal | 1.5 | 1.5 | 0 | 0 | 5 | 4 | 0 | 0 | 0 | 0 |
| Phalanx 1 | 4 | 3 | 0 | 0 | 14 | 10 | 0 | 0 | 1 | 1 |
| Phalanx 2 | 1 | 1 | 0 | 0 | 2 | 2 | 0 | 0 | 1 | 1 |
| Phalanx 3 | 0 | 0 | 0 | 0 | 5 | 4 | 0 | 0 | 2 | 1 |
| *Total* | 16 | 15 | 78 | 72 | 242 | 194 | 3 | 3 | 6 | 5 |

*Note:* Phalanges 1–3 include both forelimb and hind limb phalanges.

of modest fat content, the pelvis is relatively likely (in stark contrast to the marrow-rich long bones) to be left with attached muscle, and so to be discarded at a different time and perhaps place, if meat is preserved by drying or smoking.[12] A possible rationale for the latter scenario is that intensive splintering of long bones and phalanges 1 and 2, to extract marrow and grease, was detrimental to the retrieval and/or identification of these skeletal parts, while the pelvis, being almost devoid of marrow,[13] was discarded relatively intact. Perhaps significantly, in the case of sheep/goats, the relatively fragile and marrow-poor scapula is also better represented than usual, being as abundant at Tsoungiza as the very robust (and usually much better represented) distal humerus. In both the meat preservation and marrow extraction scenarios, however, the contrasting quantities of within-bone nutrients would be responsible for the differential treatment of pelvis and scapula versus long bones, so anatomical representation alone cannot clarify which, if either, of these alternatives is valid. Consideration of patterns of butchery, burning, and fragmentation may help to resolve this issue.

[12] See Binford 1978, pp. 94–101.
[13] See, e.g., Binford 1978, p. 43.

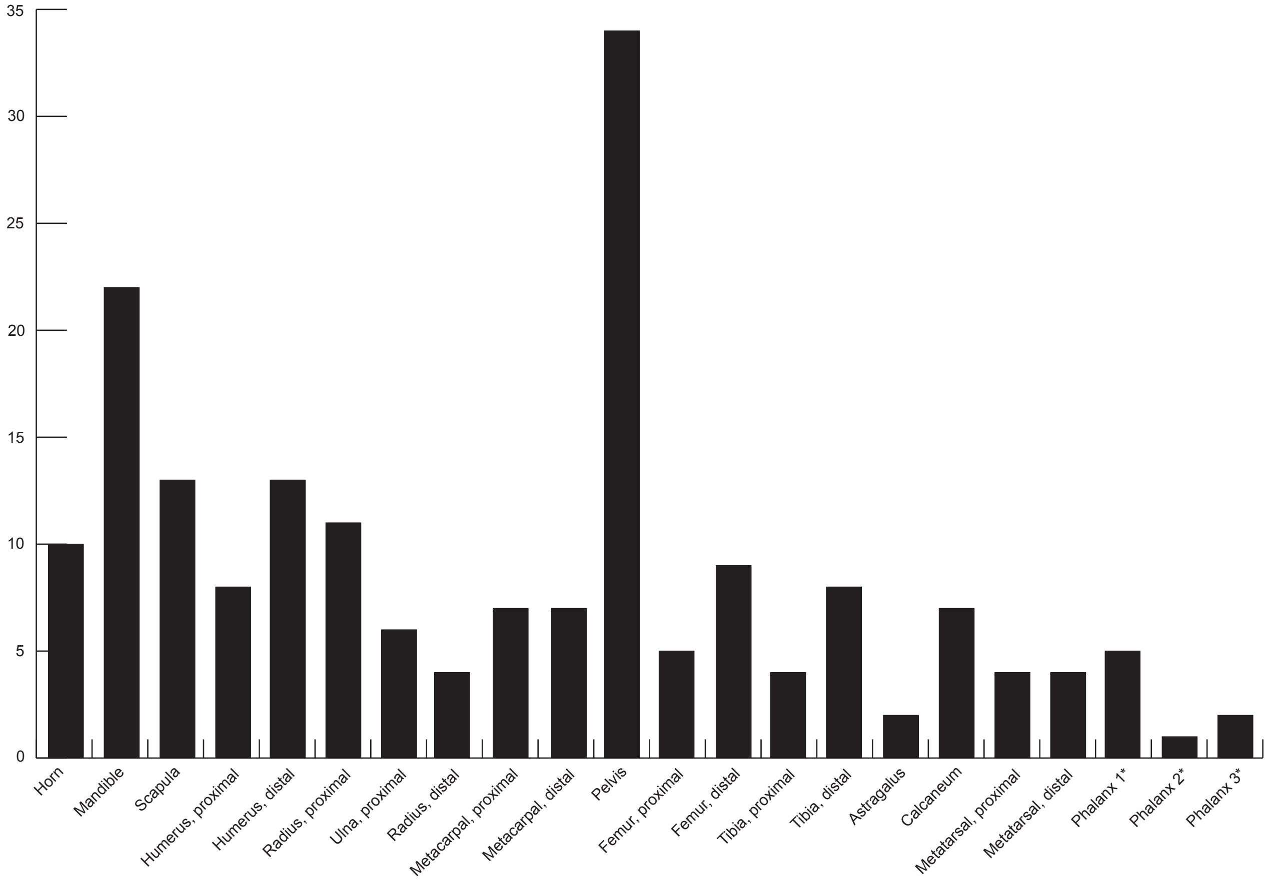

**Figure 3. Anatomical representation (MinAU) of sheep/goats at Tsoungiza. An asterisk (*) indicates the number of phalanges (including those of both forelimbs and hind limbs) divided by two for comparability with other body parts.**

Cut marks are very scarce, being observed on only seven specimens or 2.3% of the recorded material (excluding loose teeth). This incidence of butchery traces is lower than in several other assemblages, for which the same recording and quantification protocols were used: 2.9% for EN Revenia-Korinou,[14] 4.1% for Late Neolithic (LN) Toumba Kremastis-Koiladas,[15] 4.1% for LN Makriyalos I and 6.4% for FN Doliana,[16] and 11.1% for EH Tsoungiza.[17] These are all consistent with previous suggestions that carcasses were butchered much less intensively in the Neolithic than in the Bronze Age.[18] It is less clear how far the particularly low frequency of cut marks in the earlier Neolithic at Tsoungiza and Revenia-Korinou is due to the very low proportion of cattle (which tend to be butchered more intensively than the smaller domesticates) and to heavy bone breakage (which results in more numerous fragments lacking traces of cutting). In either event, the scarcity of cut marks suggests that, at earlier Neolithic Tsoungiza, animals were butchered for cooking in large segments, thus in pits or ovens or on open fires—an inference also consistent with the lack of evidence that ceramic vessels were used for this purpose. The seven recorded cut marks, all suggestive of butchery with a chipped-stone knife rather than a heavier axe, are distributed between context 3 (dismembering of a sheep distal humerus [from the radius] and of a goat distal metacarpal [from phalanx 1], and filleting of a sheep/goat distal tibia), context 5 (dismembering of a pig distal humerus [from the radius] and of a pig pelvis [from the femur], and filleting of a goat distal humerus), and context 6 (dismembering of a pig pelvis [from the femur]).

[14] Isaakidou, Halstead, and Adaktylou 2018, p. 116.

[15] Tzevelekidi 2012, p. 51, table 4.6.

[16] Halstead 2007, p. 37, table 3.2.

[17] Halstead 2011b, p. 773, table 13.34.

[18] See Halstead 2007, p. 37, table 3.2; Isaakidou 2007, p. 17, table 2.1.

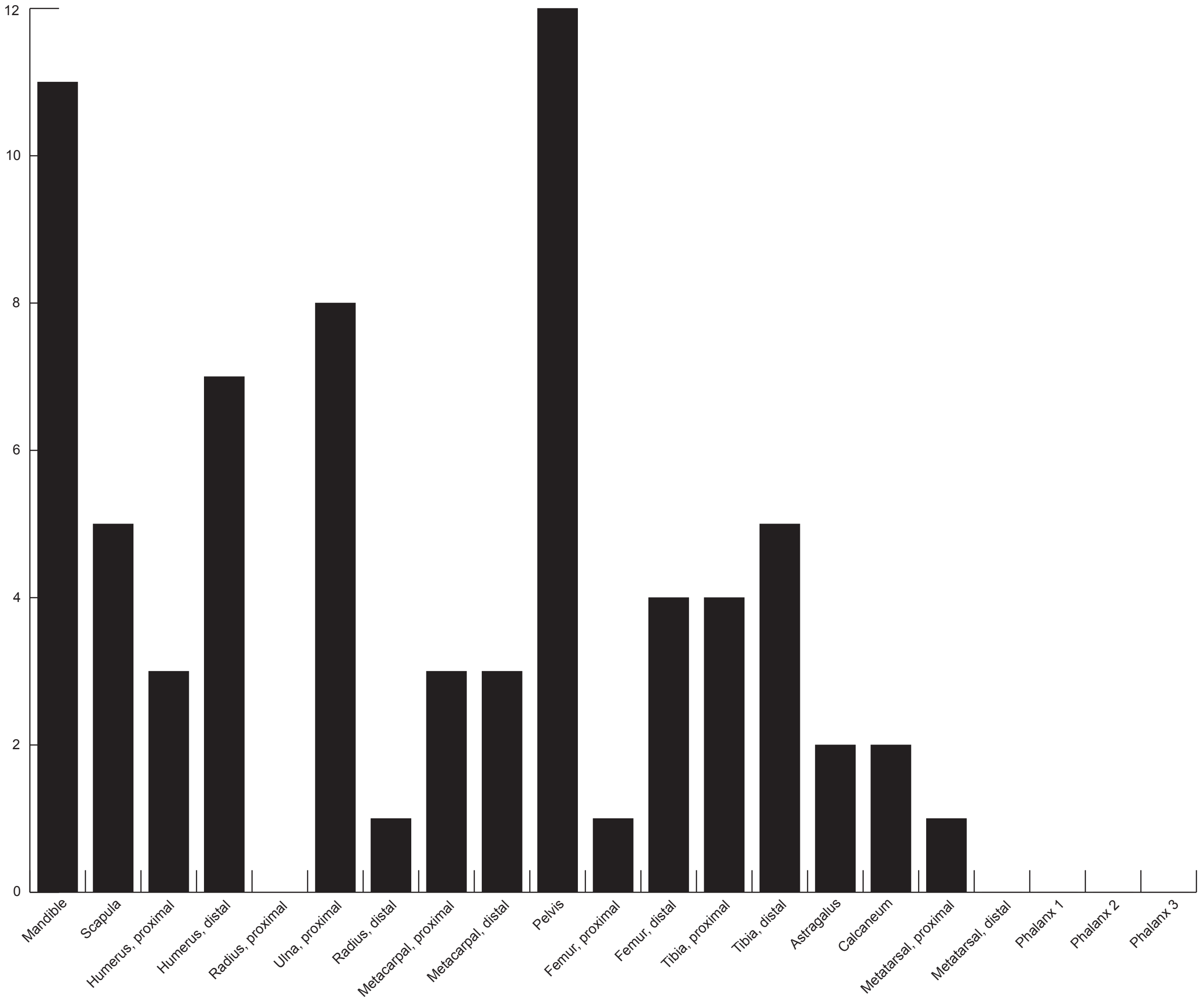

**Figure 4. Anatomical representation (MinAU) of pigs at Tsoungiza.**

Unsurprisingly, given how few were observed, cut marks are restricted to the two commonest taxa, sheep/goats and pigs, while evidence of dismembering from the femur in two cases (albeit of pig rather than sheep/goat) renders slightly more plausible the inference that the pelvis was processed separately from the rest of the hind limb. If differential treatment of sheep/goat pelves (and perhaps scapulae) involved drying or smoking of meat, however, whether on or off the bones, then these body parts might be expected to bear traces of filleting, which is not the case (although this may be due to small sample size).

As noted above, the anatomical distribution of burning traces is also very uneven (Table 8). In the case of the two most abundant body parts, burning is very frequent among pelves (64% burned), but not mandibles (11%), of sheep/goat, and, conversely, among mandibles (67%), but not pelves (27%), of pig. Preferential burning of pig mandibles is encountered at other sites and may be due to the jaws or entire head being roasted on an open fire (e.g., at EN Revenia-Korinou and also at MH–LH Tsoungiza).[19] Unfortunately, the author's notes (taken more than three decades ago) on

[19] See Isaakidou, Halstead, and Adaktylou 2018, p. 120; Halstead, in press.

## TABLE 8. INCIDENCE OF BURNING BY BODY PART FOR PIGS AND SHEEP/GOATS ONLY

| | *Pig* | | | *Sheep/Goat* | | |
|---|---|---|---|---|---|---|
| *Anatomical Unit* | *Unburned MaxAU* | *Burned MaxAU* | *Burned %* | *Unburned MaxAU* | *Burned MaxAU* | *Burned %* |
| Horn | – | – | – | 11 | 0 | 0.0 |
| Mandible | 4 | 8 | 66.7 | 31 | 4 | 11.4 |
| Scapula | 5 | 0 | 0.0 | 9 | 4 | 30.8 |
| Humerus, proximal | 2 | 1 | 33.3 | 9 | 0 | 0.0 |
| Humerus, distal | 6 | 1 | 14.3 | 18 | 1 | 5.3 |
| Radius, proximal | 0 | 0 | – | 14 | 0 | 0.0 |
| Ulna, proximal | 8 | 0 | 0.0 | 6 | 0 | 0.0 |
| Radius, distal | 1 | 0 | 0.0 | 4 | 0 | 0.0 |
| Metacarpal, proximal | 3 | 0 | 0.0 | 7 | 0 | 0.0 |
| Metacarpal, distal | 3 | 0 | 0.0 | 6 | 1 | 14.3 |
| Pelvis | 11 | 4 | 26.7 | 17 | 30 | 63.8 |
| Femur, proximal | 0 | 2 | 100.0 | 2 | 3 | 60.0 |
| Femur, distal | 0 | 4 | 100.0 | 1 | 9 | 90.0 |
| Tibia, proximal | 5 | 0 | 0.0 | 3 | 2 | 40.0 |
| Tibia, distal | 4 | 1 | 20.0 | 7 | 2 | 22.2 |
| Astragalus | 2 | 0 | 0.0 | 1 | 1 | 50.0 |
| Calcaneum | 2 | 0 | 0.0 | 7 | 0 | 0.0 |
| Metatarsal, proximal | 1 | 0 | 0.0 | 6 | 0 | 0.0 |
| Metatarsal, distal | 0 | 0 | – | 4 | 1 | 20.0 |
| Phalanx 1 | 0 | 0 | – | 4 | 10 | 71.4 |
| Phalanx 2 | 0 | 0 | – | 1 | 1 | 50.0 |
| Phalanx 3 | 0 | 0 | – | 5 | 0 | 0.0 |
| *Total* | 57 | 21 | 26.9 | 173 | 69 | 28.5 |

*Note:* Phalanges 1–3 include both forelimb and hind limb phalanges.

the burning of sheep/goat pelves are insufficiently detailed to determine whether this was the result of cooking (for example, at an open fire in the manner of Cretan *antikrysta*) or of subsequent discard, but in either case, the differential treatment of this body part is confirmed.

In the case of bone fragmentation, it is unfortunate that cattle are so scarce at earlier Neolithic Tsoungiza, since their robust and marrow-rich long bones might have provided an informative contrast to those of the smaller domesticates, which are more fragile and contain smaller volumes of within-bone nutrients. Nonetheless, the fragile long bones of mostly young pigs are less intensively fractured and more frequently gnawed than those of the generally older sheep/goats, making clear that deliberate human action was the major cause of bone breakage at Tsoungiza. Such breakage was presumably undertaken to extract within-bone marrow and perhaps bone grease—an interpretation consistent with the generally greater marrow yields from adults than juveniles.[20]

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[20] See, e.g., Blumenschine and Madrigal 1993, p. 573; see also Prabhakar, Ershler, and Longo 2009, p. 385. A popular Greek saying, “The old hen has the juice/gravy,” makes the same point, albeit often used with other connotations.

Fragmentation of long bones appears to have been substantially more intensive at EN Knossos on Crete, Revenia-Korinou in northern Greece, and perhaps Argissa in central mainland Greece than at LN Makriyalos I or Toumba Kremastis-Koiladas in northern Greece.[21] Moreover, at EN sites with sufficiently intensive recovery and sufficiently detailed recording of bones to assess the issue, fragmentation seems to have extended to systematic breakage of phalanges 1 and 2 even of sheep and goats (e.g., 81% broken at EN Revenia-Korinou).[22] At earlier Neolithic Tsoungiza, all specimens of sheep/goat phalanges 1 and 2 are intact (see Table 4), but it would be rash to treat this as firm evidence for low-intensity fragmentation: these small body parts are underrepresented, and so they were either discarded away from the excavated areas or overlooked during excavation (and splintered phalanges would have been particularly prone to loss, given predominantly unsieved recovery). The Tsoungiza sample of long bones is rather bigger, and, for these larger body parts, the likelihood of recovery even of fragmented specimens is greater. The complication of differences in fragmentation between taxa can be avoided by focusing on long bones of sheep/goat, the largest component of the Tsoungiza assemblage (and most other Greek Neolithic ones). Specimens for which the entire cross section is present ("whole," "end," and "shaft cylinder") make up 47%, and splinters 53% (see Table 4), compared with a very imbalanced 11% and 89% at EN Revenia-Korinou. Similarly, among surviving articulations of broken sheep/goat long bones, whole "ends" are more frequent (29 = 59%) than "end splinters" (20 = 41%) at Tsoungiza, in marked contrast to EN Revenia-Korinou, where whole ends (15%) are far less frequent than end splinters (85%). On this basis, exploitation of within-bone nutrients was apparently less intensive at Tsoungiza and focused on marrow rather than, as at Revenia-Korinou, on both marrow and grease.[23] If so, overrepresentation of pelves at Tsoungiza was probably not due to splintering of other body parts to a degree that prevented their recovery and/or identification. Sample size is modest at Tsoungiza, however, while poorer recovery may have contributed to the contrast with Revenia-Korinou, and if most long bones were discarded elsewhere (as the bone weight data suggest at least for the large context 3), then fragmentation of the minority discarded within the excavated areas may have been atypical.

In either case, pelves are strikingly more frequent than all other sheep/goat body parts in both of the two largest contexts (contexts 3 and 5, with sheep/goat total MinAU of 74 and 65, respectively) and are more frequent than all body parts other than mandible in the third largest sample (context 6, sheep/goat MinAU of 27) (Table 9). This pattern is also evident when contexts 3 and 5 are broken down into their constituent layers. Leaving aside horns (absent in some animals) and phalanges (most vulnerable to partial recovery), pelves would make up 1⁄18 or 5.6% of the assemblage if carcasses were discarded intact and not then subject to biased survival or recovery. Instead, they consistently make up 17%–43% of each layer: 3 out of 7 in the surface level, 7 out of 26 in layer 1, and 5 out of 27 in layer 3 of context 3; and 3 out of 18 in layer 1, 7 out of 20 in layer 2, and 5 out of 17 in layer 3 of context 5. The recurrent overrepresentation of pelves both

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[21] See Tzevelekidi 2012, pp. 62–63; Halstead and Isaakidou 2013, p. 135, table 7.3.

[22] Isaakidou, Halstead, and Adaktylou 2018, p. 116, table 7. A similar pattern was observed in smaller EN assemblages at Knossos (Isaakidou 2004, pp. 196–200; pers. comm.) and in northern Greece at Paliambela-Kolindrou (currently under study by P. Halstead).

[23] Extraction of grease requires splintering of the cancellous articular ends of bones; see Binford 1978, pp. 154, 157–159; Church and Lyman 2003; Janzen et al. 2014.

### TABLE 9. ANATOMICAL REPRESENTATION OF SHEEP/GOATS IN CONTEXTS 3, 5, AND 6 (MINAU), HIGHLIGHTING PELVES

| | *Context* | | |
|---|---|---|---|
| *Anatomical Unit* | *3* | *5* | *6* |
| Horn | 9 | 0 | 0 |
| Mandible | 8 | 6 | 5 |
| Scapula | 5 | 4 | 1 |
| Humerus, proximal | 1 | 6 | 0 |
| Humerus, distal | 5 | 6 | 2 |
| Radius, proximal | 3 | 3 | 3 |
| Ulna, proximal | 2 | 4 | 0 |
| Radius, distal | 2 | 1 | 1 |
| Metacarpal, proximal | 3 | 2 | 1 |
| Metacarpal, distal | 4 | 2 | 0 |
| Pelvis | 15 | 14 | 4 |
| Femur, proximal | 3 | 0 | 1 |
| Femur, distal | 3 | 1 | 2 |
| Tibia, proximal | 1 | 1 | 1 |
| Tibia, distal | 3 | 3 | 2 |
| Astragalus | 0 | 1 | 0 |
| Calcaneum | 2 | 2 | 3 |
| Metatarsal, proximal | 1 | 1 | 0 |
| Metatarsal, distal | 2 | 0 | 1 |
| Phalanx 1 | 2 | 5 | 0 |
| Phalanx 2 | 0 | 1 | 0 |
| Phalanx 3 | 0 | 2 | 0 |
| *Total* | 74 | 65 | 27 |

*Note:* Phalanges 1–3 include both forelimb and hind limb phalanges.

horizontally (contexts 3 and 5 are at least 3 m apart at their closest points) and vertically implies spatially and temporally persistent structuring of carcass processing and bone discard—perhaps on a community scale.

The evidence for carcass processing at earlier Neolithic Tsoungiza can thus tentatively be summarized as follows. Carcasses were butchered into, and cooked in, large sections, perhaps suitable in the case of adult animals for consumption by social groups larger than a small family household.[24] The heads or mandibles of pigs were probably roasted separately from the rest of the carcass, but the same is not evident for sheep and goats. Subsequently (after the removal of cooked meat, judging by the scarcity of butchery marks), long bones at least were systematically broken open to extract marrow and possibly grease. The pelves and, perhaps to some extent, the scapulae followed different processing and discard pathways from the

[24] See Halstead 2007, p. 34.

remaining large limb bones, in the course of which the pelves of sheep/goats were often burned. This divergence is probably not related to the suitability of the pelvis and scapula for drying/smoking (given the lack of the expected filleting marks), but it is unclear whether it may reflect their limited value for marrow extraction, or cultural rather than practical perceptions of the utility of different carcass parts. Because "marrow bones" for the most part were apparently discarded away from the excavated areas, the intensity with which these were normally fragmented is unknown, and so it is unclear whether bone breakage was geared to extraction of grease or just marrow.

## LIVESTOCK HUSBANDRY

An important clue to management priorities for domestic livestock is the age at which animals were killed, as reflected in the development of both postcranial bones and mandibular cheek teeth of pigs and sheep/goats; evidence for cattle is also tabulated but is too sparse to deserve comment. Table 10 presents the proportions of neonatal (up to just a few weeks of age) and older-than-neonatal postcranial bones. Neonatal deaths seem to have been less frequent in sheep/goats than pigs. This is consistent with the larger litters and more precocious births of the latter, as a result of which the natural infant mortality of pigs is almost inevitably higher and the deliberate slaughter of infants surplus to requirements or exceeding the capacity for rearing is more likely. There is no indication, however, that infants of either of these taxa died or were culled with the frequency that might be expected if livestock were corralled in this part of the site (as was done with sheep/goats in Franchthi Cave) or were exploited intensively for milk.[25]

### TABLE 10. POSTCRANIAL EVIDENCE FOR NEONATAL MORTALITY BY TAXON (DOMESTICATES ONLY)

| | *Cattle* | | *Pig* | | *Sheep/Goat* | |
|---|---|---|---|---|---|---|
| *Age* | *MaxAU* | *%* | *MaxAU* | *%* | *MaxAU* | *%* |
| Older than neonatal | 13 | 100.0 | 55 | 90.2 | 154 | 97.5 |
| Neonatal | 0 | 0.0 | 6 | 9.8 | 4 | 2.5 |
| *Total* | 13 | 100 | 61 | 100 | 158 | 100 |

Tables 11–13 present the evidence of postcranial epiphyseal fusion for post-neonatal mortality. Although samples are small, it seems that most pigs were slaughtered young (dying post-neonatally but before fusion of even the earliest fusing epiphyses at just a few months of age), leaving few mature adults. Conversely, most sheep/goats survived to early adulthood.[26] Mandibular evidence provides a picture of mortality that is basically similar to that of epiphyseal fusion (Table 14). For pigs, two mandibles represent deaths within a few weeks of birth (roughly equivalent to the postcranial neonatal stage), five later in the first year, and two in the second year, with only one example of a mature adult. In the case of sheep and goats, a larger but still modest sample includes 28% immature (latter first and second

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[25] For the corralling of animals at Franchthi, see Munro and Stiner 2015, p. 599. For use as a source of milk, see Payne 1973, pp. 281, 283, fig. 2. Intensive dairying requires culling of infant male lambs that would otherwise compete for the mothers' milk.

[26] The two species are combined here because most unfused specimens, being less diagnostic, have been identified to the generic level of sheep/goat.

### TABLE 11. EPIPHYSEAL FUSION EVIDENCE FOR POST-NEONATAL MORTALITY IN CATTLE

| *Fusion Stage (mos.)*[1] | *Unfused MinAU*[2] | *Fused MinAU* | *Fused %* | *Indeterminate MinAU* |
|---|---|---|---|---|
| 7–10 | 0 | 0 | – | 1 |
| 18 | 0 | 5 | 100.0 | 0 |
| 24–36 | 2 | 2 | 50.0 | 0 |
| 36–48 | 0 | 0 | – | 1 |

[1] Following Silver (1969):
7–10 months: fusion of scapula, pelvis;
18 months: fusion of distal humerus, proximal radius, proximal phalanx 1, proximal phalanx 2;
24–36 months: fusion of distal metacarpal, distal tibia, distal metatarsal;
36–48 months: fusion of proximal humerus, distal radius, proximal ulna, proximal femur, distal femur, proximal tibia, calcaneum.

[2] Including unfused diaphyses, unfused epiphyses, fusing specimens, and those of unambiguously immature size and/or texture.

### TABLE 12. EPIPHYSEAL FUSION EVIDENCE FOR POST-NEONATAL MORTALITY IN PIGS

| *Fusion Stage (mos.)*[1] | *Unfused MinAU*[2] | *Fused MinAU* | *Fused %* | *Indeterminate MinAU* |
|---|---|---|---|---|
| 12 | 10 | 7 | 41.2 | 5 |
| 24–30 | 6 | 0 | 0.0 | 3 |
| 36–42 | 8 | 2 | 20.0 | 8 |

[1] Following Silver (1969):
12 months: fusion of scapula, distal humerus, proximal radius, pelvis, proximal phalanx 2;
24–30 months: fusion of distal metacarpal, distal tibia, distal metatarsal, calcaneum, proximal phalanx 1;
36–42 months: fusion of proximal humerus, distal radius, proximal ulna, proximal femur, distal femur, proximal tibia.

[2] Including unfused diaphyses, unfused epiphyses, fusing specimens, and those of unambiguously immature size and/or texture.

years) and 19% full adults (fourth to eighth year), but 53% young adults (third and fourth years). Unfortunately, these data were recorded before the development of criteria for distinguishing between sheep and goat in *adult* mandibles and teeth, but application of Payne's criteria for *juveniles*[27] identified all four first-year (stage C) mandibles as sheep, potentially indicating a significant difference between the two species in management goals. Thanks to the overrepresentation of pelves, evidence for adult sex ratio in sheep and goats is relatively plentiful (Table 15): counting only specimens with fused acetabulum, the ratio of females to males is 10:4 in sheep and 1:2 in goats. If specimens of indeterminate fusion (*probably* fused, as they have developed morphology characteristic of an adult female or male) are also included, the ratios are 12:7 and 5:4, respectively. Measurable bones are far too few to shed any biometric light on adult sex ratios.

[27] Payne 1985.

## TABLE 13. EPIPHYSEAL FUSION EVIDENCE FOR POST-NEONATAL MORTALITY IN SHEEP AND GOATS

| *Fusion Stage (mos.)*[1] | *Unfused MinAU*[2] | *Fused MinAU* | *Fused %* | *Indeterminate MinAU* |
|---|---|---|---|---|
| SHEEP | | | | |
| 6–10 | 2 | 22 | – | 6 |
| 13–16 | 0 | 4 | | 0 |
| 18–28 | 1 | 3 | | 0 |
| 30–42 | 3 | 1 | | 4 |
| GOAT | | | | |
| 6–10 | 0 | 11 | – | 7 |
| 13–16 | 0 | 1 | | 0 |
| 18–28 | 0 | 3 | | 1 |
| 30–42 | 3 | 1 | | 0 |
| SHEEP/GOAT INDETERMINATE | | | | |
| 6–10 | 6 | 3 | – | 14 |
| 13–16 | 2 | 4 | | 1 |
| 18–28 | 1 | 3 | | 6 |
| 30–42 | 8 | 8 | | 12 |
| ALL (SHEEP + GOAT + SHEEP/GOAT) | | | | |
| 6–10 | 8 | 36 | 81.8 | 27 |
| 13–16 | 2 | 9 | 81.8 | 1 |
| 18–28 | 2 | 9 | 81.8 | 7 |
| 30–42 | 14 | 10 | 41.7 | 16 |

[1] Following Silver (1969):
6–10 months: fusion of scapula, distal humerus, proximal radius, pelvis;
13–16 months: fusion of proximal phalanx 1, proximal phalanx 2;
18–28 months: fusion of distal metacarpal, distal tibia, distal metatarsal;
30–42 months: fusion of proximal humerus, distal radius, proximal ulna, proximal femur, distal femur, proximal tibia, calcaneum.

[2] Including unfused diaphyses, unfused epiphyses, fusing specimens, and those of unambiguously immature size and/or texture.

Anatomically selective bone deposition in the excavated areas of earlier Neolithic Tsoungiza raises the question of whether deposition was also spatially differentiated in terms of the age and sex of animals. The good correspondence, however, between postcranial and mandibular age data, based on different anatomical areas, offers some grounds for optimism that the demographic data summarized here may be broadly representative of the deadstock deposited at earlier Neolithic Tsoungiza. The young mortality profile for pigs, not unusual for the Neolithic period in Greece,[28] is unremarkable, given their high reproductive rate and lack of secondary products other than manure. Mortality among sheep/goats is also more compatible with husbandry geared to meat than to milk or fiber production,[29] again as is usual for Neolithic Greece,[30] but the peak in mortality among young adults is unusual. When the dental and epiphyseal mortality data are combined with the pelvic evidence for sex ratio, it seems that, in

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28. See Cantuel, Gardeisen, and Renard 2008, p. 291, fig. 6.

29. See Payne 1973, pp. 282–284, figs. 1–3.

30. See, e.g., Halstead 1987, p. 79, fig. 3; Isaakidou 2006, pp. 101–102, figs. 8.2, 8.3; Tzevelekidi, Halstead, and Isaakidou 2014, pp. 432–433, figs. 8, 9.

### TABLE 14. MANDIBULAR EVIDENCE FOR SUGGESTED AGE AT DEATH OF PIGS AND SHEEP/GOATS

| *Pigs* | | | *Sheep/Goats* | | | |
|---|---|---|---|---|---|---|
| *Stage (definition)* | *Age (mos.)*[1] | *MinAU* | *Stage (definition)*[2] | *Age (mos.)*[3] | *MinAU*[4] | *%* |
| A (d4U) | 0–2 | 2 | A (d4U) | 0–2 | – | 0.0 |
| B (d4W, M1U) | 2–6 | 4 | B (d4W, M1U) | 2–6 | – | 0.0 |
| C (M1W, M2U) | 6–12 | 1 | C (M1W, M2U) | 6–12 | 4.0 (4)[5] | 18.3 |
| D (M2W, M3U) | 12–24 | 2 | D (M2W, M3U) | 12–24 | 2.1 (2) | 9.6 |
| E (M3W, M3.3U) | 24–30 | – | E (M3W, M3.3U) | 24–36 | 8.1 (7) | 37.0 |
| F (M3.3W) | >30 | 1 | F (M3.3W, M3<11G) | 36–48 | 3.5 (3) | 16.0 |
| – | – | – | G (M3 = 11G, M2 = 9A) | 48–72 | 1.7 (1) | 7.7 |
| – | – | – | H (M3 = 11G, M2>9A) | 72–96 | 2.5 (1) | 11.4 |
| – | – | – | I (M3>11G) | 96–120 | – | – |
| *Total* | – | 10 | – | – | 22 | 100 |

*Note:* d4 = fourth deciduous premolar; M1/M2/M3 = first/second/third molar; U = unworn; W = worn

[1] After Bull and Payne 1982.

[2] After Payne 1973; tooth-wear stages 9A and 11G follow Payne 1987.

[3] After Payne 1973.

[4] Including proportional reassignment of mandibles ageable only to two or more stages; figures in parentheses = numbers of mandibles assigned to a single stage (following Payne 1973).

[5] All four stage C deaths are of sheep.

### TABLE 15. EVIDENCE FOR ADULT SEX RATIO OF SHEEP AND GOATS (MINAU)

| | *Sheep* | | *Goats* | |
|---|---|---|---|---|
| | *Fused* | *Fusion Indet.* | *Fused* | *Fusion Indet.* |
| Female | 10 | 2 | 1 | 4 |
| Male | 4 | 3 | 2 | 2 |

*Note:* Based on pelvis, following Boessneck 1969. Indet. = indeterminate.

addition to adult females retained for breeding, a significant proportion of males was retained until early adulthood, perhaps to secure large carcasses for collective consumption or large-scale hospitality.[31] In a similar vein, the concentration of first-year deaths among sheep, if not an artifact of small sample size, may be related to the tendency of young grazing sheep to accumulate fat more rapidly than young browsing goats—a contrast that largely determined the divergent prices of lamb and kid in 20th-century A.D. Greece.

## DEADSTOCK, LIVESTOCK, AND GAME

The scarce biometric data from earlier Neolithic Tsoungiza are listed in Table 16, where they are compared with the range of values from EN Knossos (including the Aceramic or Initial Neolithic) on Crete,[32] the largest available contemporary dataset from Greece, and from nearby Bronze Age Tiryns,[33] the largest (albeit later) prehistoric assemblage from the same

[31] Large adult males (usually castrated) are still selected for slaughter at rural weddings in Greece today.

[32] Isaakidou 2004, pp. 253–254, 265–266, 274–275, figs. 7.7, 7.8, 7.14, 7.15, 7.19, 7.20; pers. comm.

[33] Von den Driesch and Boessneck 1990, pp. 135–137, 139, 150, tables 34, 35, 42.

## TABLE 16. BIOMETRIC DATA FOR DOMESTIC PIGS, SHEEP, AND GOATS AND FOR FOX, COMPARED WITH RANGES FROM EN KNOSSOS AND EH–LH TIRYNS (MM)

| | *Measurement*[1] | *Earlier Neolithic Tsoungiza* | *EN Knossos*[2] *(Range)* | *EH–LH Tiryns*[3] *(Range)* |
|---|---|---|---|---|
| **PIG** | | | | |
| Scapula | BG | 21.9 | 25 | 18–25 |
| Humerus | Bd | 36.6 | 39–47 | 29–42 |
| Pelvis | LAR | 34.1 | – | 25–34 |
| Tibia | Bd | 27.4 | 27 | 24–31 |
| Astragalus | GLl | 36.2, 45.1 | 37–45 | 28–44 |
| | GLm | 32.5, 39.2 | – | 30–40 |
| **SHEEP** | | | | |
| Scapula | BG | 18.4, 19.5 | 17–23 | 16–27 |
| | GLp | 27.5, 29.0, 31.0 | 27–38 | 27–41 |
| Humerus | Bd | 27.8, 28.7 | 24–34 | – |
| Radius | Bp | 27.6, 27.6 | 28–32 | 26–42 |
| Pelvis | LA, male | 27.0, 29.0, 29.5, 31.1 | – | 26–32 |
| | LA, female | 23.7, 24.8, 25.4, 25.8, 28.2, 28.3 | – | 25–31 |
| Tibia | Bd | 24.3 | 22–25 | 22–30 |
| **GOAT** | | | | |
| Scapula | BG | 20.3, 25.5 | 18–25 | 19–29 |
| | GLp | 39.5 | 26–34 | 27–37 |
| Humerus | Bd | 33.5, 35.0 | 30–40 | – |
| Radius | Bp | 28.6, 30.8 | 31–35 | 25–38 |
| Metacarpal | Bd | 32.9 | 35 | 25–34 |
| Pelvis | LA, male | 32.0 | – | 32.5 |
| Tibia | Bd | 23.8 | 25–28 | 22–30 |
| Calcaneum | GL | 59.1 | – | 51–60 |
| **FOX** | | | | |
| Tibia | Bd | 15.5, 15.5 | – | 15–17 |

[1] After von den Driesch (1976). Bd = greatest breadth of distal end; BG = breadth of glenoid cavity; Bp = greatest breadth of proximal end; GL = greatest length; GLl = greatest length of lateral half; GLm = greatest length of medial half; GLp = greatest length of glenoid process; LA = length of acetabulum; LAR = length of acetabulum on rim.

[2] Data (including Aceramic or Initial Neolithic) after Isaakidou 2004; pers. comm.

[3] Data after von den Driesch and Boessneck 1990.

region as Tsoungiza. The earlier Neolithic measurements from Tsoungiza fall within the Knossian range in the case of sheep, for which the Knossos sample is quite large, and generally in the case of goats and pigs, for which the comparative samples are much smaller. The earlier Neolithic sheep, goats, and pigs at Tsoungiza are thus of broadly similar size to those at contemporary Knossos, compatible with possible derivation from a common Anatolian or eastern Mediterranean source.[34] Tsoungiza sheep fall at the lower end of the Bronze Age Tiryns range, and pigs at the upper end, while goats occupy an intermediate position. The general correspondence of the Tsoungiza biometric data with those from EN Knossos, and the more variable fit with EH–LH Tiryns, offer further support for the view that the faunal assemblage analyzed here is indeed mainly of earlier Neolithic date, with, at worst, limited contamination by overlying Bronze Age material.

Tsoungiza is fairly typical of earlier Neolithic mammalian faunal assemblages from Greece in the rarity of game and, among the domesticates, in the predominance of sheep over goats, pigs, and cattle.[35] The dominance of sheep may be attributable to their particular suitability for grazing cultivated land in the form of fallow fields, crop stubble, and sprouting cereals.[36] This was the practice around Tsoungiza in the middle decades of the 20th century, when much of the valley floor and some of the surrounding slopes were devoted to cereals and pulses and were grazed between harvest and sowing by sheep, while the steeper or rockier slopes supported evergreen bushes browsed by goats.[37] The proportion of sheep at Tsoungiza (45%) is at the lower end of the range for published EN and MN assemblages (43%–85%) from Greece.[38] Given the contrasting mortality profiles of pig and sheep/goat, however, the proportion of sheep among *live*stock (the crucial variable if the posited close link between sheep and cultivated land is correct) might have been much higher than among *dead*stock (as reflected in the faunal remains from animal consumption). Age-at-death data are too sparse and coarse to shed light on whether earlier Neolithic livestock from Tsoungiza (300–350 masl) moved up to the Lake Stymphalia basin (600 masl) in summer or down to the edge of the plain of Argos (200 masl), as was the case with some recent herds. The dominance of sheep over goats, however, in a landscape with abundant perennial browse, is compatible with the concentration of earlier Neolithic livestock on land under cultivation, and thus with herding on a modest scale.

The rarity of bones of wild mammals in an assemblage that is anyway rather small limits the scope for investigating hunting in any detail, but it may be significant that game is represented at earlier Neolithic Tsoungiza by only hare and fox. Such small game is heavily outnumbered by large game (especially wild boar and red or fallow deer) at Bronze Age and some LN sites on the Greek mainland, whereas large game is relatively scarce at earlier Neolithic sites.[39] The Tsoungiza assemblage tentatively reinforces this pattern, without helping to resolve the question of whether the scarcity of large game reflects their lack of availability, their avoidance by early farmers, or their pursuit but consumption away from residential sites.[40]

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[34] See Zeder 2008, pp. 11599–11601; Halstead and Isaakidou 2013, pp. 130, 138; Munro and Stiner 2015.

[35] See Cantuel, Gardeisen, and Renard 2008; Halstead and Isaakidou 2013.

[36] See Halstead 2006.

[37] This is based upon the author's 2002 interview with an octogenarian retired herding couple in the adjacent modern village of Archaia Nemea.

[38] See Halstead and Isaakidou 2013, p. 132, table 7.2.

[39] See Cantuel, Gardeisen, and Renard 2008, p. 283, table 2; Halstead and Isaakidou 2013, p. 137, table 7.4; Munro and Stiner 2015, p. 598, fig. 2.

[40] Halstead and Isaakidou 2013, p. 136.

## DISCUSSION AND CONCLUSIONS

Despite its small size and, for the most part, less than ideal circumstances of recovery, the faunal assemblage from earlier Neolithic Tsoungiza provides some valuable insights into animal exploitation at this site and in this period. Taxonomically, the assemblage is not dissimilar to those from other contemporary sites in Greece, including Lerna, Kouphovouno, and Franchthi Cave in the southern mainland:[41] wild taxa are very scarce and restricted to small game (hare and fox); and, among the domesticates, ovicaprids are overwhelmingly predominant over pigs and cattle, while sheep clearly outnumber goats (at Tsoungiza, perhaps by 2:1), wherever such information is available. Dog was not identified directly, but is likely to have been responsible for at least some of the traces of gnawing on bones of other taxa.

Pigs were overwhelmingly slaughtered young (mostly before the end of their second year), and some sheep were killed in the latter part of their first year, but most ovicaprids, perhaps including several males, were killed as young adults. While this still suggests a focus on production of meat rather than secondary products, the peak of slaughter is rather later than usual for the Neolithic period of Greece and perhaps reflects a desire for large carcasses. An even sex ratio, albeit without an overall delay in peak slaughter to early adulthood, is also documented for sheep at EN Knossos, and, at both sites, marked scarcity of cattle (roughly 5% at Tsoungiza and 8% at Knossos) perhaps enhanced the value of large (adult male) ovicaprids offering large quantities of meat.[42]

As observed for other (especially earlier) Neolithic sites in Greece, traces of butchery were very sparse. Given that cutting of raw meat requires more force, and so is more likely to mark the bone than is the case with cooked meat, this suggests that carcasses were subdivided into large units for cooking in ovens or pits or on open fires, but not in ceramic vessels (which bear no trace of such use). The "long" limb bones were then broken open, arguably after removal of the cooked meat, to extract marrow. At earlier Neolithic Knossos, Paliambela-Kolindrou, and Revenia-Korinou (the only sites with data of the necessary resolution), fragmentation was very intensive, including splintering of the small first and second phalanges of sheep and goats, and was perhaps intended to extract bone grease as well as marrow. There is no evidence of this at Tsoungiza, but this might be an artifact of partial retrieval and/or of the apparent discard of most long bones away from the excavated areas of the site. Pelves of sheep and goats were strikingly overrepresented in the recovered assemblage, and scapulae perhaps also (to a much lesser extent). Of suggested practical explanations, a lack of filleting traces perhaps argues against the drying or smoking of meat with these flat and relatively fat-free bones attached, by default tentatively favoring the retention of these bones when the fat-rich long bones were removed to be processed for marrow and perhaps grease. In either case, however, the abundance of pelves, equally characteristic of both context 3 and context 5 and recurring through all the layers of these deposits, is of considerable interest. First, since sheep/goat pelves were also distinguished by a high frequency of burning and because no similar faunal anomaly was

[41] For Lerna, see Gejvall 1969; for Kouphovouno, see Cantuel 2010; for Franchthi Cave, see Munro and Stiner 2015.

[42] For Knossos, see Isaakidou 2006, p. 102, table 8.2 (sex ratio); 2008, p. 94, fig. 6.1 (% cattle).

found in the Bronze Age assemblages from the site, it seems clear that the faunal contents of the deposits discussed here, despite occasional later ceramic admixtures, represent mainly earlier Neolithic material. Secondly, the scale of overrepresentation of pelves, both in numbers of specimens and in horizontal and vertical distribution, implies some collective organization of bone discard, and hence perhaps also of carcass consumption. Moreover, the unusual concentration on slaughter of young adults suggests that management of sheep/goats at least was in part geared to supplying large carcasses for such collective commensality.

These hints of carnivorous commensality must be considered in their wider context.[43] Most, if not all, known earlier Neolithic communities in Greece seem to have been too large (at least a few dozen members) for subsistence on anything other than cultivated grains to be viable,[44] and there is no reason to imagine that Tsoungiza, with occupation spread over more than 2 ha, was atypically small. Such a subsistence base would have involved year-round storage, probably by small residential groups rather than communally,[45] and favored relatively sedentary residence. Both "private" storage and long-term residence would have promoted tendencies to social fission, while collective commensality or interhousehold hospitality, in which ceramic tableware probably played a major role, seems to have been a central countermeasure for maintaining community solidarity.[46] Faunal evidence from other Neolithic sites indicates that many domestic animals were slaughtered at an age when the resulting carcass was too large for immediate consumption by individual households, while sparse signs of butchery also imply cooking of carcass segments too large for household consumption. In addition, contextual analysis of patterns of joins or articulations between bone fragments at EN Revenia-Korinou and EN Paliambela-Kolindrou in northern Greece and at EN–FN Knossos on Crete suggests that carcasses were dispersed across these sites *before* discard of consumption refuse.[47] On this basis, it has been argued that meat, and probably likewise "special" beverages,[48] but perhaps not grain staples, played a central role in the commensal events that maintained community solidarity during the Neolithic period. To what extent the divisive pressures of sedentism and household economies were in play in the earlier Neolithic are matters of dispute,[49] which the small-scale exposures at Tsoungiza cannot resolve, but the faunal assemblage implies a collective dimension to the consumption of domestic animals. If we accept the argument that the hallmark of a domestic animal is that it belongs to someone,[50] then private provision of carcasses for collective consumption or large-scale hospitality will also have offered opportunities to compete for prestige or political capital, with the potential to sow seeds of inequality while at the same time promoting collective solidarity.

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[43] See, e.g., Halstead 2011a.

[44] See, e.g., Bogaard and Halstead 2015.

[45] See Flannery 1972; Urem-Kotsou 2017; Halstead 2019.

[46] See, e.g., Tomkins 2007; Urem-Kotsou and Kotsakis 2007.

[47] For EN Revenia-Korinou, see Isaakidou, Halstead, and Adaktylou 2018, p. 123; for EN–FN Knossos, see Halstead and Isaakidou 2013, p. 134. The material from EN Paliambela-Kolindrou is currently under study by P. Halstead.

[48] For beverages, see Urem-Kotsou et al. 2002; Valamoti et al. 2007.

[49] See, e.g., Whittle 1996; Tomkins 2004; cf. Halstead 2005, 2011a, 2019; Kotsakis 2018.

[50] Ingold 1986, p. 113.

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