AN OFFPRINT FROM

ANCIENT TEXTILES SERIES 36

THE COMPETITION OF FIBRES

EARLY TEXTILE PRODUCTION IN WESTERN ASIA, SOUTH-EAST AND CENTRAL EUROPE (10,000–500 BC)

International workshop Berlin, 8–10 March 2017

Edited by

WOLFRAM SCHIER AND SUSAN POLLOCK

Paperback Edition: ISBN 978-1-78925-429-7
Digital Edition: ISBN 978-1-78925-430-3 (epub)

OXBOW | books
Oxford & Philadelphia

9

Finding the woolly sheep: meta-analyses of archaeozoological data from south-western Asia and south-eastern Europe

Cornelia Becker, Norbert Benecke, Hans Christian Küchelmann and Stefan Suhrbier

Archaeozoological data from 401 sites in south-western Asia and south-eastern Europe dating to the time span 7000–1500 BC were analysed to address the question of when and where the economic shift occurred from a milk- and meat-oriented sheep husbandry to one with a focus on wool production. This article offers some preliminary results from meta-analyses of an associated database. Among the parameters studied fluctuations in the demographic composition of herds as well as osteometric data indicating changes in animal size and body shape have yielded some indirect evidence for incipient and/or increasing importance of wool exploitation in sheep. In south-western Asia this development started around 4000 BC, while in south-eastern Europe it began a thousand years later.

Keywords: south-western Asia, south-eastern Europe, Neolithic–Bronze Age, sheep husbandry, wool production, archaeozoology

Introduction

Today, hundreds of different breeds of sheep are known that are kept for mutton, milk or wool, and sheep husbandry still occupies an important place in the culture of many peoples around the globe. The wild sheep (*Ovis orientalis*) was one of the earliest ungulate species to be domesticated for agricultural purposes. Its domestication took place in the Fertile Crescent, most probably in multiple areas, during the 9th millennium BC.[1] The coat of the early domestic sheep (*Ovis aries*) was hairy, resembling that of its wild ancestor. This type of coat can be observed in mouflons from Sardinia and Corsica, which are regarded as early feral domestic sheep.[2] The agents and events that subsequently led to the development of the woolly sheep are still only rudimentarily understood. A series of genetic mutations probably occurred, resulting in different coat qualities and finally in real wool.[3] Once the usefulness of wool was recognised, stockbreeders might have fostered and accelerated the development by selective breeding. The substitution of the woolly sheep for the archaic hairy form may be considered one of the major innovations in prehistory, providing people with the raw material for a greater variety of textile products.[4]

Given the fact that wool from the Neolithic, Chalcolithic or Bronze Age, like any other animal fibre, is preserved only in rare occasions under special archaeological conditions, and even the genetics of the coat qualities are not yet known, research on the origin of the woolly sheep needs to rely primarily on indirect evidence. Only in this way is it actually conceivable to narrow down the beginning of wool production geographically and chronologically. The research group Textile Revolution chose a multi-proxy approach that draws on archaeological artefacts linked to textile production, written sources, archaeozoological data and geoarchaeological evidence to tackle the question of early wool exploitation.[5] In this paper, selected archaeozoological data from south-western Asia and south-eastern Europe are presented, with the aim of pursuing two basic questions: (1) when and where did the economic shift from

a milk- and meat-oriented sheep husbandry to one with a pronounced focus on wool production occur, and (2) when and how did these changes arrive in south-eastern Europe? Over 30 years ago, in a discussion of the beginning of wool production, Andrew Sherratt stated, 'The answer can only come from a large number of faunal studies using age- and sex-specific mortality estimates'.[6]

The archaeozoological database

In recent years the number of sites with faunal remains relevant to the emergence of sheep with woolly fleece or wool production has grown immensely. The quantity of osteological collections actually available in south-western Asia and south-eastern Europe amounts to several hundreds; however, they are of different degrees of quality. For the present study, only data from those settlements that provide a faunal assemblage with more than 500 identified mammal remains were considered (Fig. 9.1a and b). Materials from religious and/or cultic contexts were excluded. The underlying database was developed by one of the authors (H.C. Küchelmann) who also documented the data over the last four years. To keep on project schedule, we gave priority to sites in south-eastern Europe, while for south-western Asia a smaller number of assemblages (with more than 1000 identified mammal remains) were included. During data acquisition no selection was made with regard to representativeness of the faunal samples (small- versus large-scale excavation, hand-collected versus sieved materials) and quality of publication (single table versus monograph, reliability of the species identification). The collecting and recording of data was focused on those sites that date to the time span between 7000 and 1500 BC, putting most emphasis on the 5th to the 3rd millennium BC when wholly sheep most probably made its appearance. To allow diachronic studies, each site or phase of a site (sub-unit) was assigned, whenever possible, to a time slice of 500 years.

A defined set of data was recorded that consists of three interrelated levels. Level 1 ('site core data') includes the general identification data of each site, comprising site name, location (latitude and longitude), site category, country, year(s) of excavation, chronological information and references. Level 2 ('site bone data') consists of data related to the specific faunal assemblage. These are frequencies (NISP – number of identified specimens) of the major livestock species, frequency of artiodactyl game, age data for sheep/goat (on mandibles and epiphyses of postcranial elements), sex data for sheep (on horn cores and pelvic bones) and pathologies. Level 3 ('*Ovis* bone metrics') consists of selected measurements of single sheep bones.

A total of 401 sites respectively 565 subunits were entered into the database by H.C. Küchelmann. These sites produced more than two million identified mammal bones, among

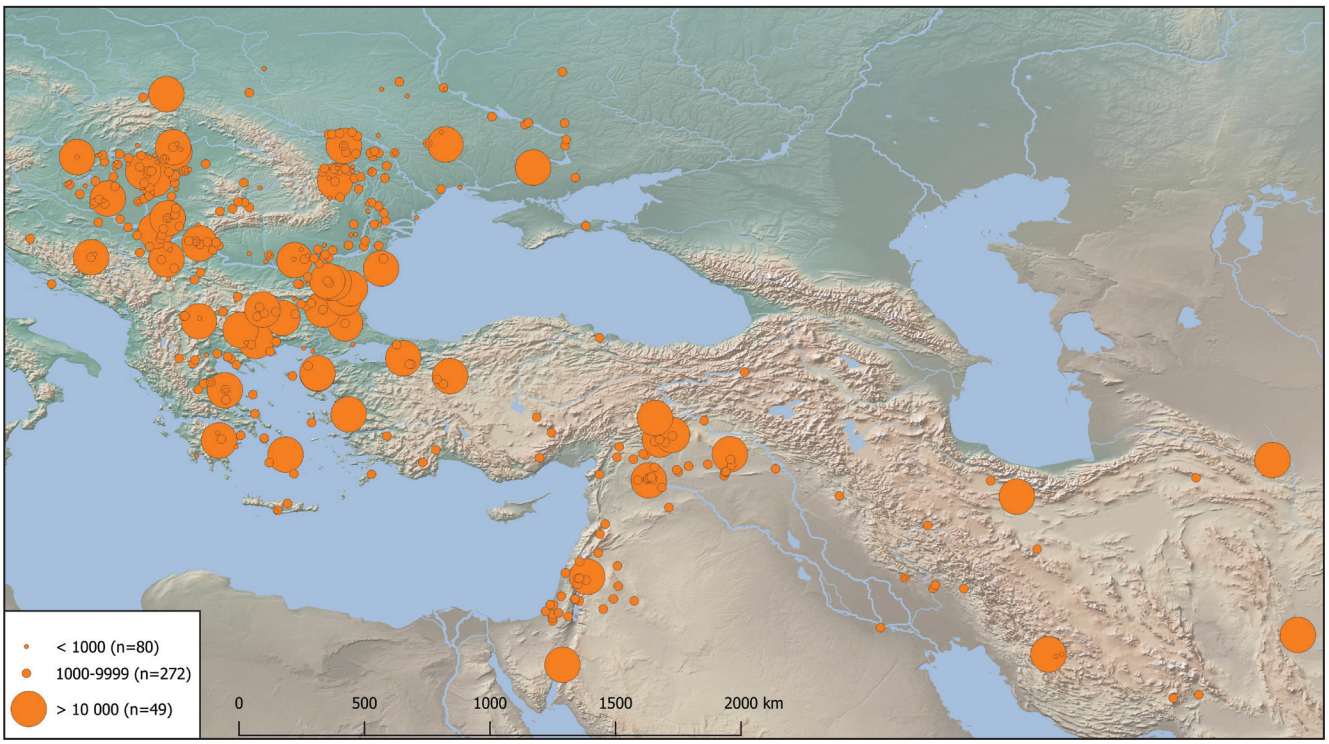


Figure 9.1 a: Geographical distribution of recorded sites combined with data on sample size (quantification: number of identified mammal bones)

them *c*. 67,000 identified sheep remains (Fig. 9.1c). The osteometrical data record consists of 1,152 values (greatest length of complete long bones) for withers height calculations and 13,771 values for the calculation of Logarithmic Size Indices (LSI). An online version of the complete database has recently been published.[7] First results of the analysis of archaeozoological data available in this database are presented and discussed here.

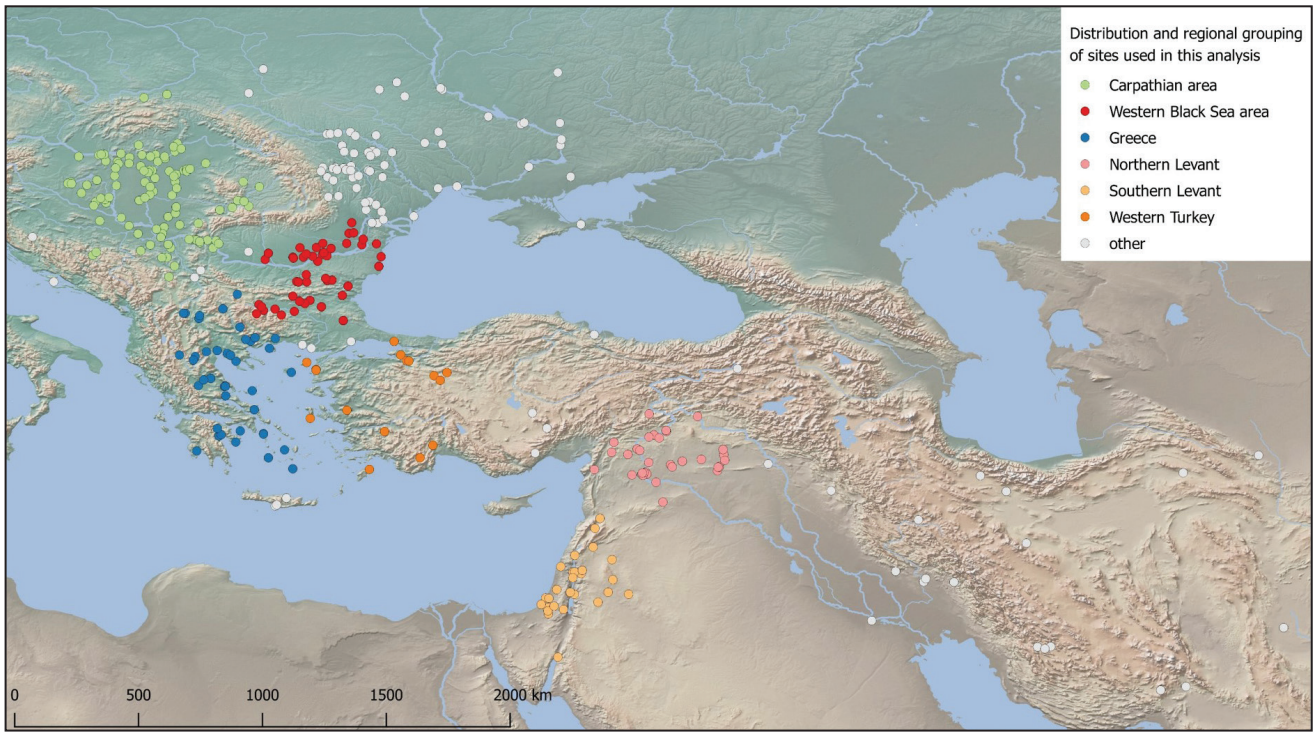


Figure 9.1 b: Distribution and regional grouping of sites considered in this study

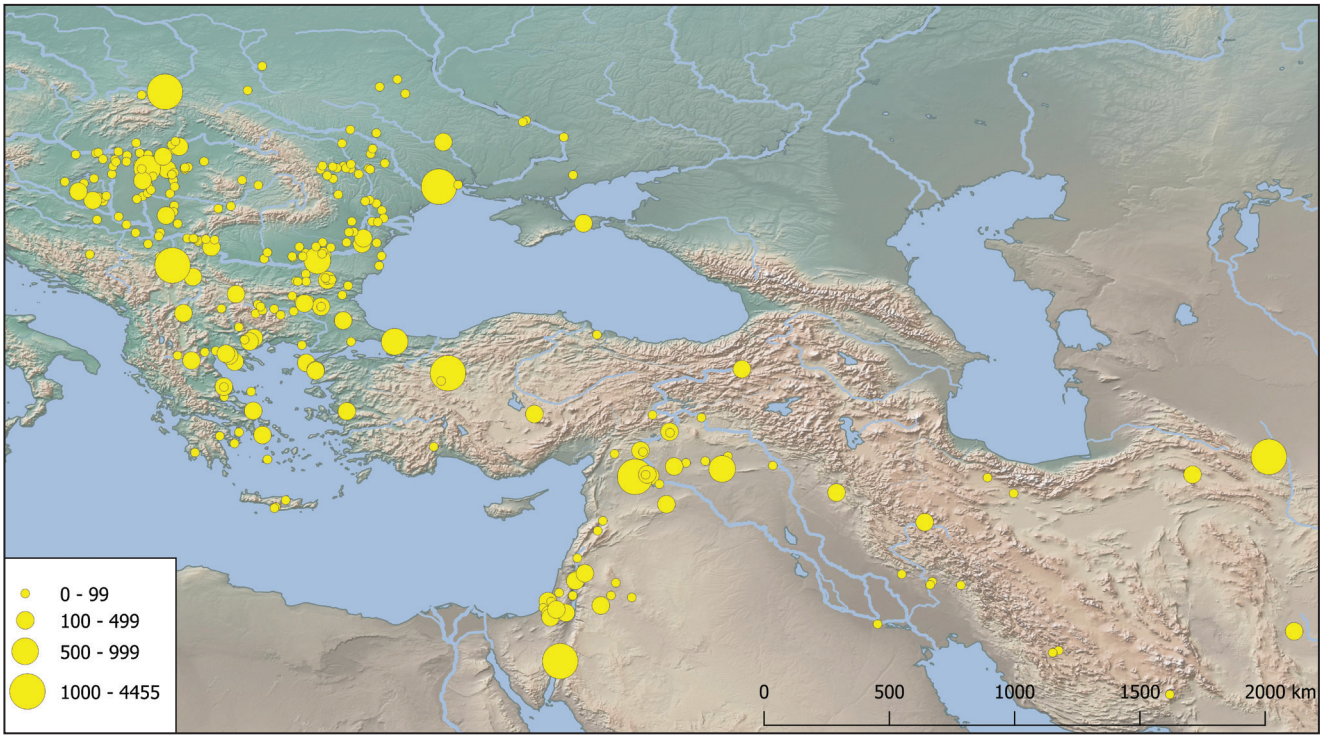


Figure 9.1 c: Abundance of sheep remains (NISP) at sites considered in this study

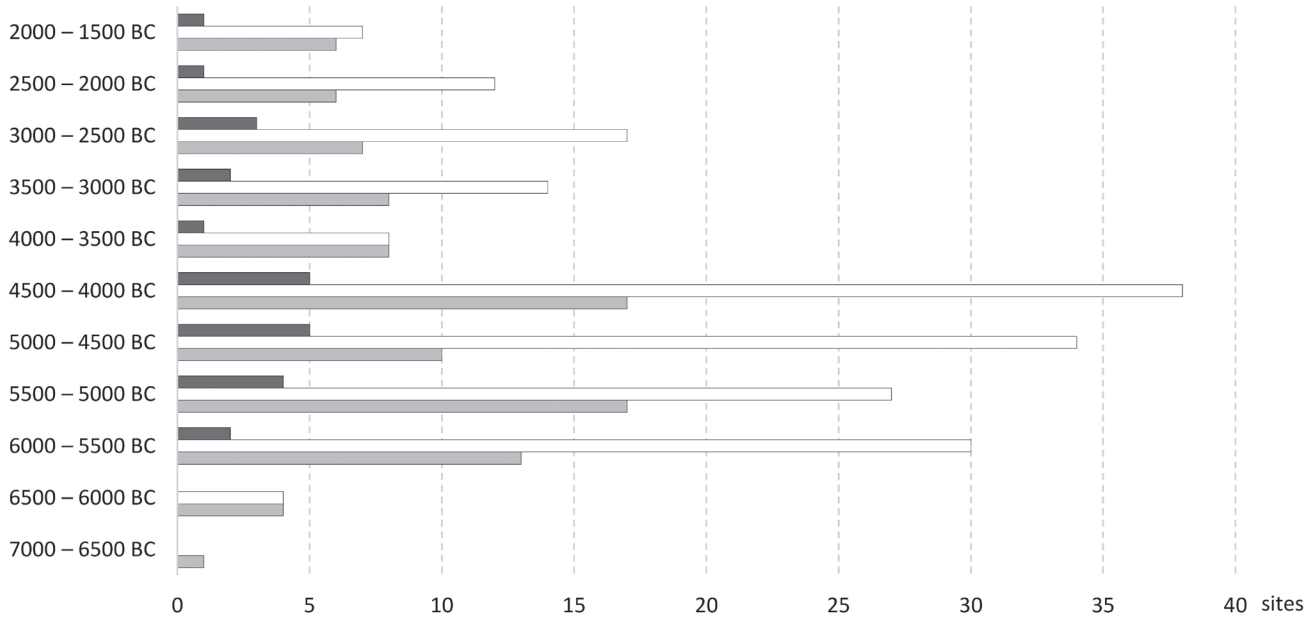
Results and discussion

The 401 sites considered here are distributed over a huge area stretching from the Carpathian Basin in the west to the Iranian highlands in the east (Fig. 9.1a). The geographical distribution of the sites is quite uneven, mainly reflecting the state of archaeological research in the two regions plus certain restrictions within our project (see above). Concerning sample size, there are 49 sites with more than 10,000, 272 sites with 1000 to 10,000 and 80 sites with less than 1000 identified mammal remains. For comparative purposes the sites were grouped into six sub-regions: the Carpathian area, western Black Sea area, Greece, western Turkey, northern Levant and southern Levant (Fig. 9.1b).

The chronological resolution of the available data is illustrated in Figure 9.2. Numerous faunal assemblages have been analysed and presented only as bulk samples without further precise dating according to contexts or intra-site phases. However, there are still 312 sites or sub-units left that could be assigned to time slices of 500 years. They show an uneven distribution over the time period from 7000 to 1500 BC. A large amount of data is available for the 6th and 5th millennium BC, whereas for the 4th and 3rd millennium BC the quantity of data decreases dramatically. This is an unfavourable situation, because these two millennia in particular were most important for the questions raised here. Also, taking into account the uneven distribution of sites, it turns out that there is no region in south-eastern Europe or south-western Asia for which we might pursue very detailed questions over a long time sequence on a broad basis of bone material.

Since the beginnings of animal husbandry, sheep along with goat, cattle and pig formed the basis of stockbreeding in south-western Asia and south-eastern Europe. Figure 9.3 presents the diachronic development in the ratio of these species within the faunal assemblages for three sub-regions of south-eastern Europe based on NISP counts to illustrate the extent and importance of sheep husbandry through time. Due to the known difficulties in distinguishing bones of sheep and goat, both species are considered together in this figure.

In Greece, sheep/goat shows a percentage of *c*. 80% in the oldest period (6500–6000 BC). Subsequently, their proportion steadily decreases to *c*. 40% in the period 3500–3000 BC. After this, there is a slight increase in the percentage of sheep/goat (*c*. 50%). The western Black Sea area shows a similar trend with steadily decreasing percentages of the small ruminants from the oldest periods (*c*. 50%) to the period 3000–2500 BC (*c*. 25%) and a significant increase in the proportion of sheep/goat in the youngest periods. In the Carpathian basin the composition of the domestic fauna is very variable, exhibiting no clear trend. We see high percentages of sheep/goat in the two oldest phases (*c*. 50–70%) followed by a sharp decrease in the periods 5500–4500 BC (<20%). The subsequent periods are



	7000 – 6500 BC	6500 – 6000 BC	6000 – 5500 BC	5500 – 5000 BC	5000 – 4500 BC	4500 – 4000 BC	4000 – 3500 BC	3500 – 3000 BC	3000 – 2500 BC	2500 – 2000 BC	2000 – 1500 BC
> 10,000			2	4	5	5	1	2	3	1	1
1,000 – 10,000		4	30	27	34	38	8	14	17	12	7
< 1,000	1	4	13	17	10	17	8	8	7	6	6

Figure 9.2: Chronological distribution of sites and subunits that could be assigned to time slices of 500 years

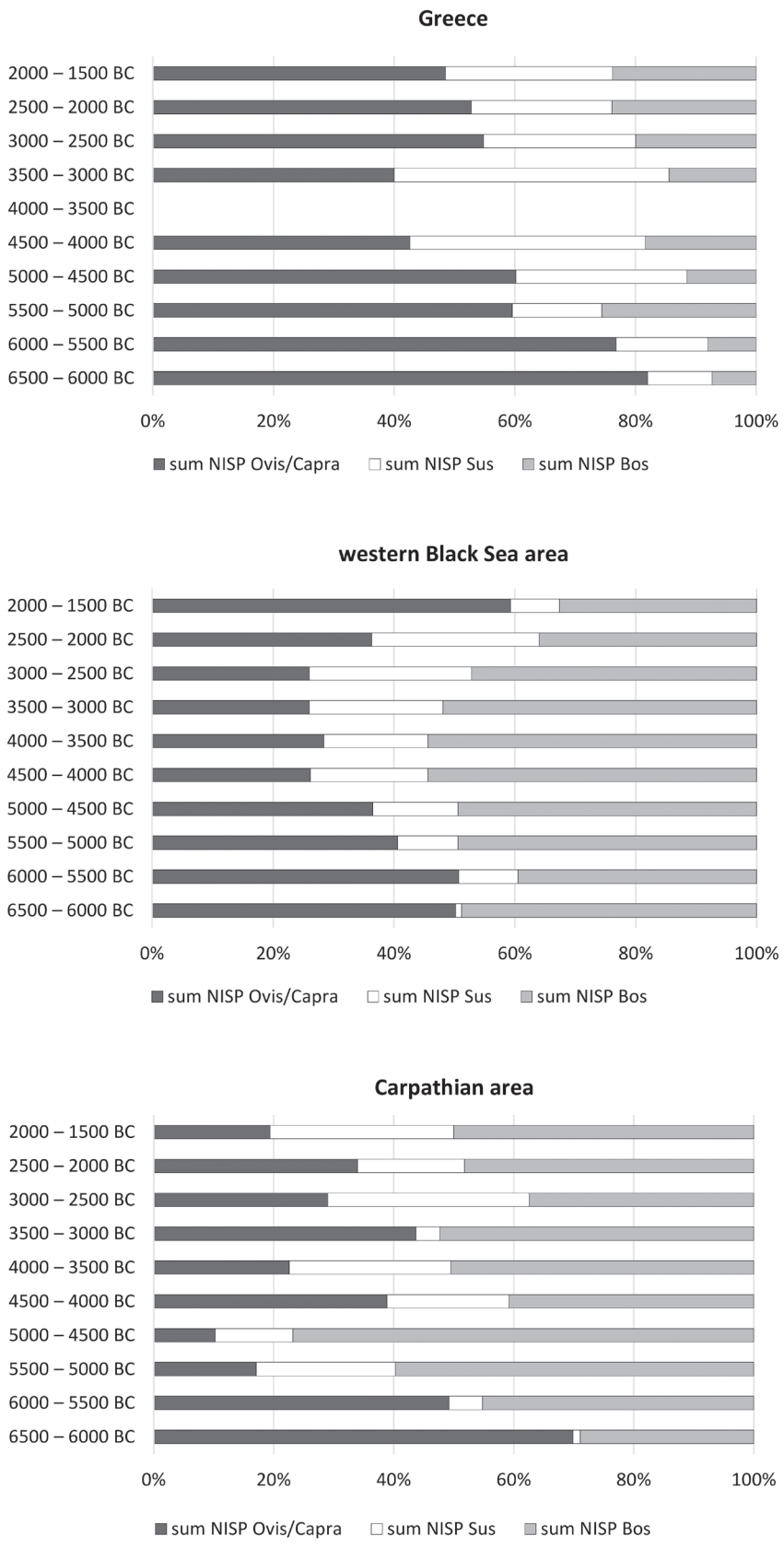


Figure 9.3: Diachronic development in the ratio of sheep/goat, pig and cattle in three sub-regions of south-eastern Europe

characterised by an up and down in the amount of the small ruminants varying between *c*. 20% and 40%.

These results sharply contrast to those of south-west Asia, which will be mentioned only briefly. In the northern and southern Levant, the small ruminants (sheep and goat) are by far the most frequent domestic mammal species in all periods for which the ratio could be evaluated. The percentage of sheep/goat mostly exceeds 75%. There are two significant outliers with high proportions of pig (>30%), *i.e.* in the periods 5000–4500 BC in the southern and 3000–2500 BC in the northern Levant. In the sub-region of western Turkey, we see a high percentage of sheep/goat (*c*. 70%) in the oldest period (6500–6000 BC). In the subsequent periods, sheep and goats are still the most frequent species among the domestic mammals, but their proportion is significantly lower, varying between *c*. 40% (periods 6000–5500 and 4000–3500 BC) and *c*. 60% (from 3500 BC onwards).

Among the bone finds of the small ruminants, a distinction between sheep and goat can usually be made for at least a part of the material, thus allowing a rough estimation of the ratio between sheep and goat in the faunal assemblages. Figure 9.4 illustrates the development of this ratio in the two regions under study. In south-western Asia, the ratio between sheep and goat varies between 1:1 and 3:1. No clear trends in the development of this ratio are visible. The oldest periods and those between 3000 and 2000 BC exhibit the highest percentages of sheep in the collections of the small ruminants. As might be expected, the sites of south-eastern Europe generally show a higher proportion of sheep. The ratio between sheep and goat varies between 3:2 and 5:1. It appears that the share of sheep among the small ruminants declines slightly from the oldest to the youngest period, interrupted by an increase of this species in the period 3500–3000 BC.

The way sheep and other domestic animals were primarily exploited in the past is reflected in the age structure and sex ratio of the corresponding bone collections. Sebastian Payne has outlined models for the types of kill-patterns one might expect from meat-, milk-, and wool-/hair-producing flocks of sheep and goats.[8] When these species are kept primarily for meat, most of the animals will be killed by approximately 2–3 years of age. It is at this age that the sheep and goats approach bodily maturity and continuing to feed them beyond this will not substantially increase meat output. A relatively small number of adults will be kept for breeding purposes. Shepherds emphasising milk production will eliminate excess lambs and kids, especially males, early in the first year of life. Wool-production strategies in sheep lead to very different age distributions, since adult animals, and especially castrates, are primary wool-producers. One might therefore expect to find a high proportion of adult animals in the kill-off from a wool-producing flock.

In Figures 9.5 and 9.6 the kill-off pattern of sheep is evaluated on dental eruption and wear in mandibles, a widely used method. Although nowadays a distinction between sheep and goat is partly possible on the basis of mandibles, the relevant finds were pooled (sheep/goat). This is because most of the older publications present age data on mandibles for both species as one group. The sex ratio of sheep, however, was evaluated on pelvic bone finds.

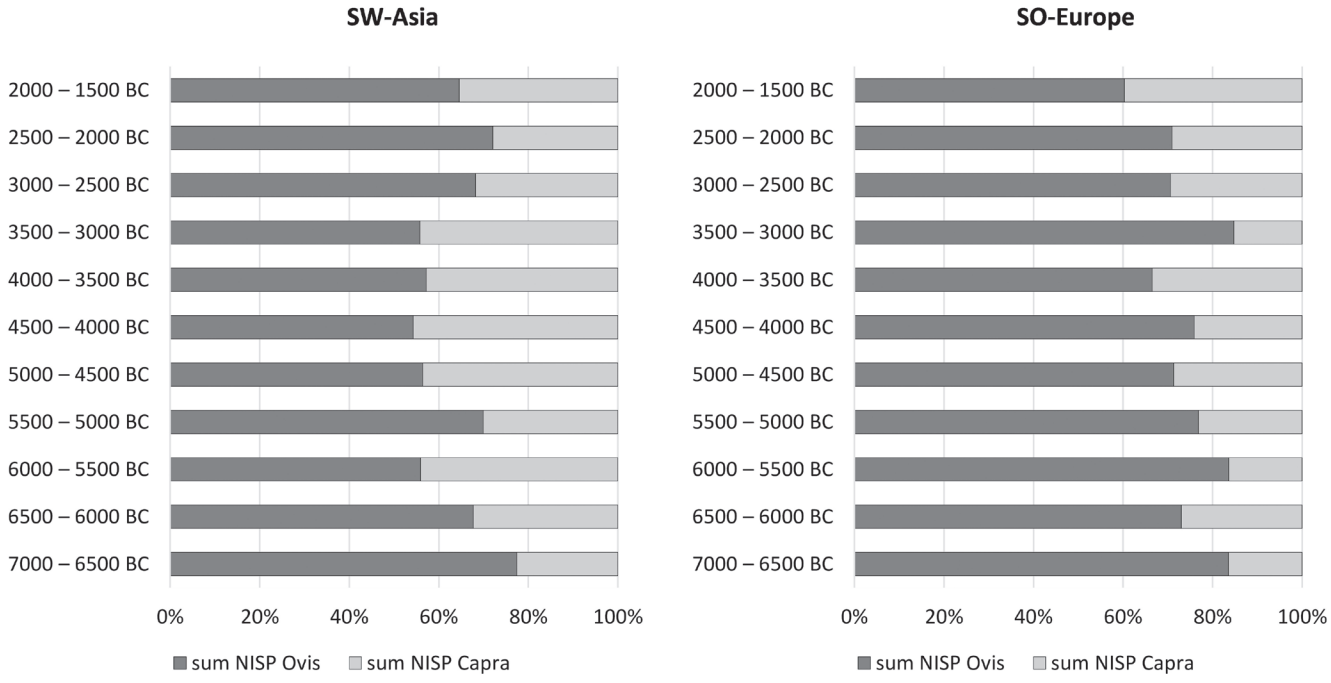


Figure 9.4: Diachronic development in the ratio of sheep and goat in south-western Asia and south-eastern Europe

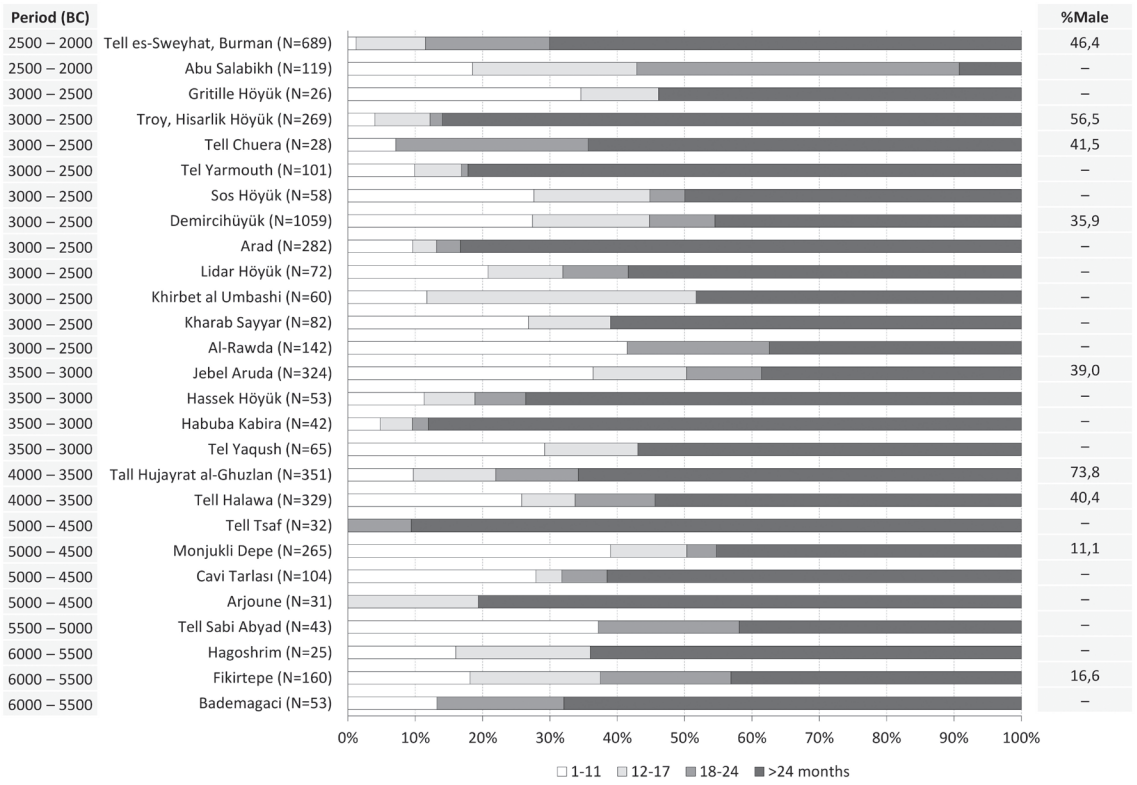


Figure 9.5: Age structure of sheep/goat and sex ratio in sheep (% of males) for selected sites in south-western Asia

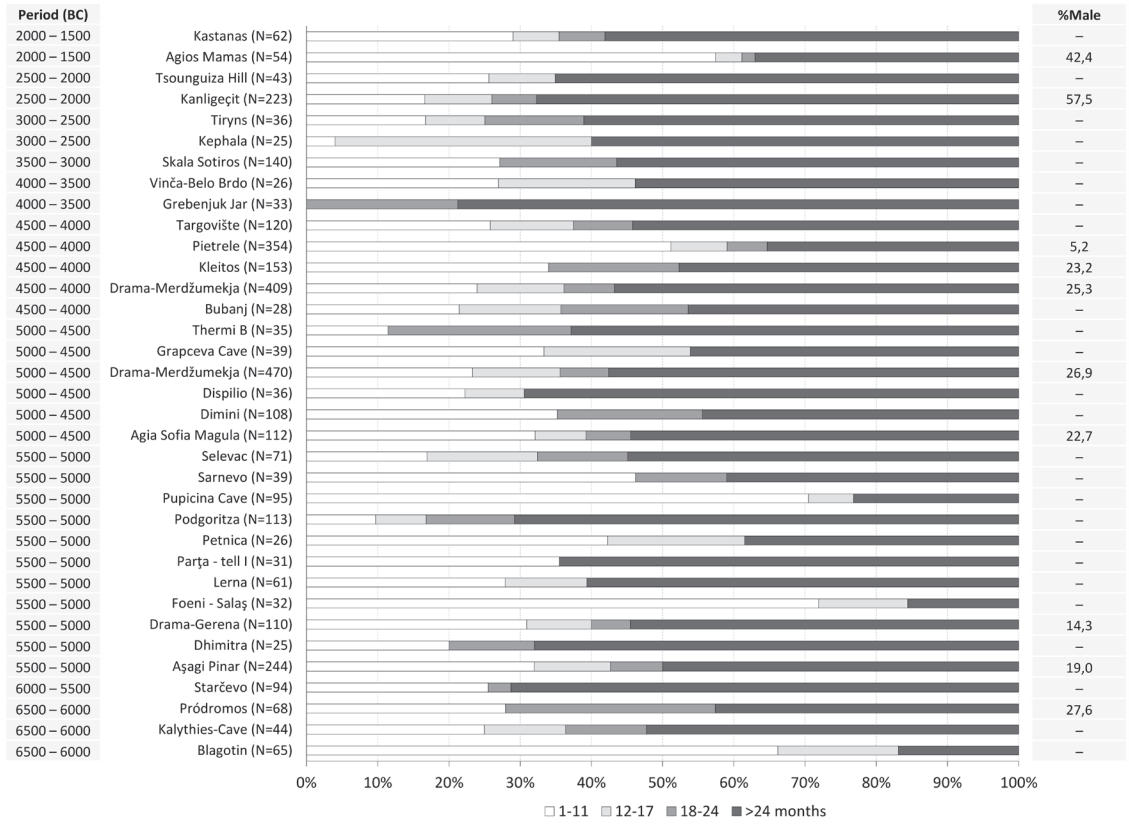


Figure 9.6: Age structure of sheep/goat and sex ratio in sheep (% of males) for selected sites in south-eastern Europe

Due to the fact that most of the female sheep in prehistoric times were hornless, sex determinations on horn cores are generally heavily biased towards males. For this reason sex identifications on horn cores were excluded from the analysis. Figures 9.5 and 9.6 present the kill-off pattern in sheep/goat for sites that have produced more than 20 ageable mandibles and the sex ratio for assemblages with more than 20 sexable pelvic bones. The mandibles were originally assigned to 10 different age classes according to a system used in the Archaeological-Zoological Working Group Schleswig.[9] In the corresponding figures, they are reduced to four to facilitate their readability.

The sites in south-western Asia exhibit a great variability in the age structure of sheep/goat (Fig. 9.5).[10] In most of the assemblages, animals older than two years of age when slaughtered form the largest group. A diachronic view does not show clear trends in the development of the age structure. This also applies if the data set is reduced to sites with more than 100 ageable mandibles. Concerning sex ratio, female sheep clearly prevail among the sub-adult and adult animals in the collections of the oldest periods (6000–5500 and 5000–4500 BC). This pattern points towards a mode of exploitation where meat and milk were the main products. From 4000 BC the proportion of male sheep increases significantly. In general, rams and castrates now represent more than one-third of the animals. Very high percentages of male sheep (>50%) have been observed at Tall Hujayrat al-Ghuzal and Troy. Because male sheep, and in particular castrates, produce more wool and a wool of better quality than females, this change in sex ratio could be an indication of an economic shift from a milk- and meat-oriented sheep husbandry to one with a pronounced focus on wool production.

Similarly to south-western Asia, the sites in south-eastern Europe show a great variability in the age profile of sheep/goat (Fig. 9.6). Most of the assemblages are characterised by a high proportion of animals older than 24 months of age. Again, no trend in the development of the age structure is visible, pointing to the fact that sheep and goats were always kept for a broad spectrum of products with varying importance from site to site. Even within the same culture a high variability of exploitation strategies can be detected. Females dominate among the sub-adult and adult sheep in most of the assemblages of the older periods. In contrast to south-western Asia, higher percentages of males occur only from the second half of the 3rd millennium BC. This is the period (Early Bronze Age) during which the keeping of woolly sheep and the exploitation of wool is generally expected in south-eastern Europe.[11]

The last aspect to be discussed here is the development of size and body shape in sheep using the logarithm size index (LSI) method.[12] In this method, the differences between the logarithmic value of a prehistoric bone and the corresponding logarithmic value of a standard individual for selected dimensions (bone measurements) are calculated. The resulting LSI values can then be treated statistically, *e.g.* for the calculation of parameters such as mean, median and standard deviation for specific groups of bones (subunits, time periods). In this study, for the calculation of LSI values a set of 23 breadth and depth distances has been chosen from post-cranial elements that have a good chance of becoming preserved (bones with early fusing epiphyses plus talus and calcaneus). The standard individual used here is a skeleton of a recent female sheep from the Bavarian State collection.[13] The archaeozoological database contains a total of 13,771 measurements of single sheep bones for which LSI values have been calculated. Two graphs present an overall picture of the development of size and shape in sheep in south-western Asia as well as in south-eastern Europe (Figs 9.7 and 9.8). In these graphs, the LSI values are grouped into periods covering the time span from 6500 to 1500 BC.

In south-western Asia, the sheep of the early periods (6500–4500 BC) are quite uniform in size and body shape, *i.e.* the mean values and ranges (minimum, maximum) are similar (Fig. 9.7). In the following periods (4500–3000 BC), a rising mean value and a shrinking of the variability, in particular for the minima, can be seen. This indicates the presence of larger or more robustly built sheep at that time. From 3000 BC onwards, again a larger variability and a slight decrease of the mean values become apparent. In south-eastern Europe, the development of size and shape in sheep shows a somewhat different picture (Fig. 9.8). For a long period of time, *i.e.* from 6500 to 3500 BC, the osteometric data show a slight but steady decline in the mean values, while the variability remains almost unchanged. After 3500 BC, and especially in the period 3000–2500 BC, a clear increase in the mean values can be seen and at the same time higher lower and upper ranges (minimum, maximum) in the LSI distribution. Similar to south-western Asia, the presence of larger or more robust built sheep can be assumed at that time. In the subsequent periods (2500–2000 BC), size and shape in sheep remain more or less the same, followed by a period (2000–1500 BC) where we see again a larger variability and a marked decline of the mean value.

Both in south-western Asia and south-eastern Europe, small-sized sheep were typical for the Neolithic period. From 4500 BC onwards sheep of larger size and more robust body shape occur at first at sites in south-western Asia. Whether they represent a completely new breed of sheep introduced from an unknown region or sheep that resulted from selective breeding of local sheep remains an open question. Possibly this new type of sheep is characterised by a woolly fleece. In south-eastern Europe, especially on the Balkan Peninsula, a similar development is visible, but with a considerable delay of time. Here, sheep of larger size and more robust body shape occur from 3000 BC onwards. It has still to be demonstrated, probably via genetic studies, whether these larger sheep represent imported animals from

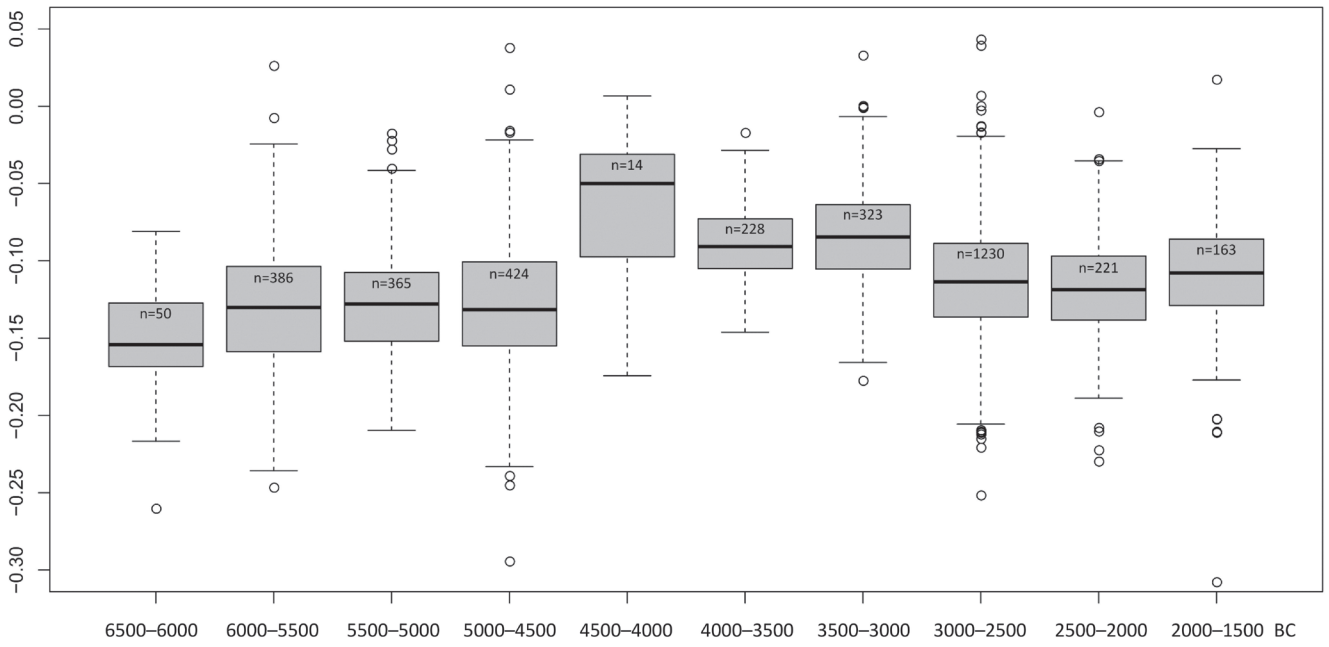


Figure 9.7: Development of size and shape in sheep in south-western Asia presented as boxplots of LSI values. Box = distance 25th–75th quartile with mean, whiskers = distance 10th–90th percentile, small circles = outliers

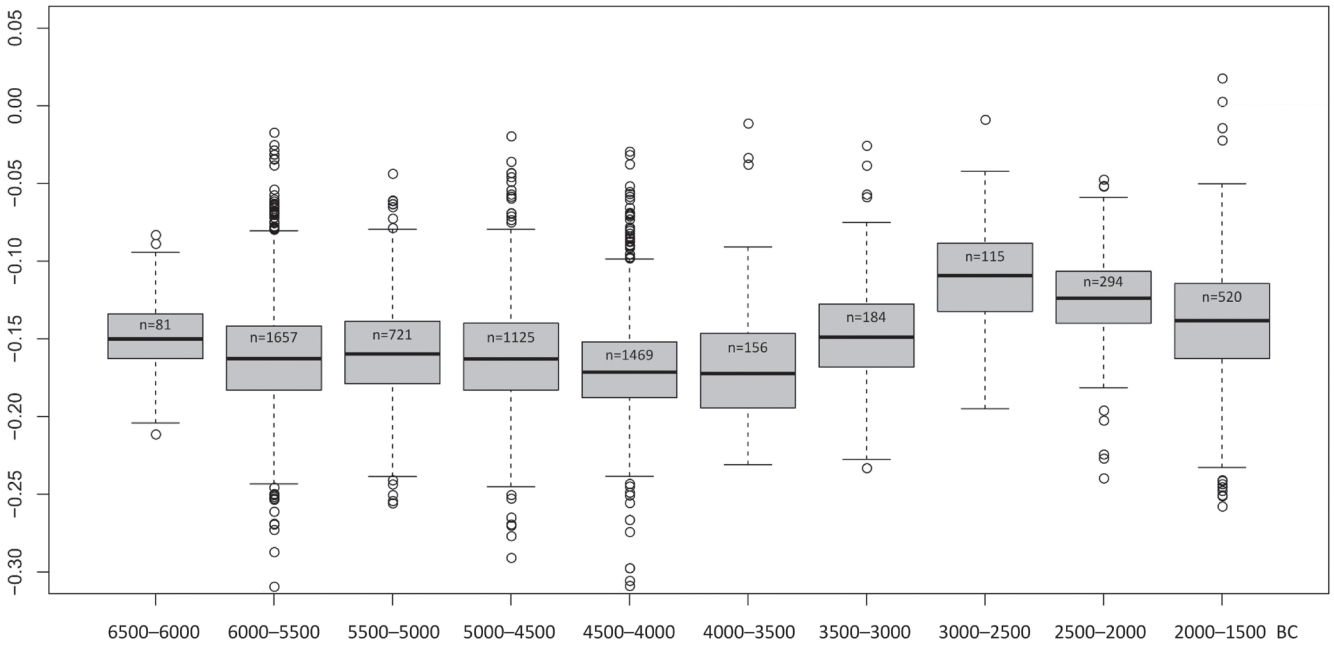


Figure 9.8: Development of size and shape in sheep in south-eastern Europe presented as box-plots of LSI values. Box = distance 25th–75th quartile with mean, whiskers = distance 10th–90th percentile, small circles = outliers

the Near East or the outcome of local breeding. Possibly, the new type of sheep was imported to the Balkan Peninsula along with the domestic horse, which appears here for the first time at about the same period of time, originating from Anatolia.[14]

Conclusions

The archaeozoological data available from south-western Asia and south-eastern Europe provide some insight into the practice of sheep husbandry and its changes through time. Although a large body of information could be collected

and recorded, a more detailed analysis is still hampered by an uneven distribution of sites and unsatisfactory chronological resolution of many faunal assemblages. This is especially true for the most interesting period of this study, the 4th and 3rd millennia BC. Further archaeozoological work on the development of sheep husbandry should focus on these periods.

In south-western Asia and south-eastern Europe, sheep along with goat, cattle and pig formed the basis of stock-breeding between 7000 and 1500 BC. Comparing both regions, the extent of sheep husbandry exhibits a great regional variability mainly reflecting different environmental conditions. At sites in south-western Asia, sheep and goats were generally of great economic importance in all periods considered here. In south-eastern Europe, the keeping of sheep and goats gradually declined after an initial phase when animal husbandry became established in the course of Neolithisation. This can be interpreted as an adaption of the stock breeding of Near Eastern origin to new regions with different vegetation and climate. The data concerning species composition do not indicate an expansion of sheep farming at the expense of the other species that could be linked to the beginning of wool production. Obviously, the emergence of wool as a newly exploitable secondary product was not accompanied by greater changes in herd composition.

As might be expected, the age distributions of sheep/goat at the sites in south-western Asia and south-eastern Europe do not match any of Payne's idealised strategies for meat-, milk- and wool-producing flocks. The age profiles rather demonstrate that over the millennia sheep and goats were always kept for a broad spectrum of products. Even within the same culture a high variability of exploitation strategies can be detected. But as far as the sex ratio of sheep is concerned some interesting trends are visible in the data record. From 4000 BC onwards the proportion of male sheep that were kept to an older age increases significantly at sites in south-western Asia. This change in sex ratio could be an indication of an economic shift from a milk- and meat-oriented sheep husbandry to one with a pronounced focus on wool production. In south-eastern Europe, the same trend can be observed, but starting later, *i.e.* from 2500 BC onwards.

As the metrical data show, the changes seen in the exploitation of sheep were accompanied by the emergence of a new type of sheep. Both in south-western Asia and south-eastern Europe, small-sized sheep typical for the Neolithic period were replaced by sheep of larger size and more robust body shape. In south-western Asia, this development started in the period 4500–4000 BC and in south-eastern Europe much later, at about 3000 BC. This new type of sheep was probably characterised by a woolly coat.

Assuming that the striking changes in the sex ratio of sheep towards the occurrence of significantly more male animals in the younger periods and the corresponding changes in phenotype are markers of a sheep husbandry where wool was exploited, the archaeozoological evidence in fact could point to the beginning of wool production in south-western Asia in the centuries around 4000 BC. From here this new form of sheep management probably found its way to south-eastern Europe at the turn from the 4th to the 3rd millennium BC.

In a further step of evaluating the origin and spread of wool production, it will be necessary to combine our results with those from related studies within the Textile Revolution project (artefacts linked to textile production, written sources, geoarchaeological research).

Notes

1 Fuller *et al*. 2011; Peters *et al*. 2013.
2 Ludwig and Benecke 2003.
3 Ryder 1969.
4 Sherratt 1983.
5 Becker *et al*. 2016.
6 Sherratt 1983, 94.
7 Grabundžija *et al.* 2019.
8 Payne 1973.
9 Hüster 1990, table 27.
10 Helmer *et al*. 2007.
11 Greenfield 2005.
12 Meadow 1999, 288.
13 Manhart 1998, table 104.
14 Benecke 2006.

References

Becker, C., Benecke, N., Grabundžija, A., Küchelmann, H.C., Pollock, S., Schier, W., Schoch, C., Schrakamp, I., Schütt, B. and Schumacher, M. (2016) The Textile Revolution: research into the origin and spread of wool production between the Near East and central Europe. *eTopoi. Journal for Ancient Studies*, Special Volume 6, 102–151.

Benecke, N. (2006) On the beginning of horse husbandry in the southern Balkan Peninsula: the horse bones from Kirklareli-Kanlıgeçit (Turkish Thrace). In M. Mashkour (ed.) *Equids in Time and Space: Papers in Honour of Vera Eisenmann*, 92–100. Oxford, Oxbow Books.

Fuller, D.Q., Willcox, G. and Allaby, R. (2011) Cultivation and domestication had multiple origins: arguments against the core area hypothesis for the origins of agriculture in the Near East. *World Archaeology* 43(4), 628–652.

Grabundžija, A., Küchelmann, H.C., Park, M. and Schoch, C. (2019) The Textile Revolution, online database repository, Edition Topoi, Berlin. http://repository.edition-topoi.org/collection/WOLL/object/BONES, accessed 16 December 2019.

Greenfield, H.J. (2005) A reconsideration of the Secondary Products Revolution in south-eastern Europe: on the origins and use of domestic animals for milk, wool, and traction in the central Balkans. In J. Mulville and A.K. Outram (eds) *The Zooarchaeology of Fats, Oils, Milk and Dairying.* Proceedings of the 9th Conference of the International Council of Archaeozoology, Durham, August 2002, 14–31. Oxford, Oxbow Books.

Helmer, D., Gourichon, L. and Vila, E. (2007) The development of the exploitation of products from Capra and Ovis (meat, milk and fleece) from the PPNB to the Early Bronze in the northern Near East (8700 to 2000 BC cal.). *Anthropozoologica* 42(2), 41–69.

Hüster, H. (1990) *Untersuchungen an Skelettresten von Rindern, Schafen, Ziegen und Schweinen aus dem mittelalterlichen Schleswig, Ausgrabung Schild 1971–1975*. Neumünster, Karl Wachholtz Verlag.

Ludwig, A. and Benecke, N. (2003) Zur Systematik und Paläontologie der Gattung Ovis mit besonderer Berücksichtigung der Stellung des Europäischen Mufflons. *Beiträge zur Jagd- und Wildtierforschung* 28, 35–45.

Manhart, H. (1998) *Die vorgeschichtliche Tierwelt von Koprivec und Durankulak und anderen prähistorischen Fundplätzen in Bulgarien aufgrund von Knochenfunden aus archäologischen Ausgrabungen*. München, Documenta naturae 116, 1–353.

Medaow, R.H. (1999) The use of size index scaling techniques for research on archaeozoological collections from the Middle East. In C. Becker, H. Manhart, J. Peters and J. Schibler (eds) *Historia animalium ex ossibus: Beiträge zur Paläoanatomie, Archäologie, Ägyptologie, Ethnologie und Geschichte der Tiermedizin*, 285–300. Rahden/Westfalen, Verlag Marie Leidorf.

Payne, S. (1973) Kill-off patterns in sheep and goats: the mandibles from Aşvan Kale. *Anatolian Studies* 23, 281–303.

Peters, J., Buitenhuis, H., Grupe, G., Schmidt, K. and Pöllath, N. (2013) The long and winding road: ungulate exploitation and domestication in Early Neolithic Anatolia (10000–7000 cal BC). In S. Colledge, J. Conolly, K. Dobney, K. Manning and S. Shennan (eds) *The Origin and Spread of Domestic Animals in Southwest Asia and Europe*, 83–114. Walnut Creek, CA, Left Coast Press.

Ryder, M.L. (1969) Changes in the fleece of sheep following domestication (with a note on the coat of cattle). In P.J. Ucko and G.W. Dimbleby (eds) *The Domestication and Exploitation of Plants and Animals*, 495–521. London, Duckworth.

Sherratt, A.G. (1983) The secondary exploitation of animals in the Old World. *World Archaeology* 15(1), 90–104.