



Signals of sedentism: Faunal exploitation as evidence of a delayed-return economy at Norje Sunnansund, an Early Mesolithic site in south-eastern Sweden

Adam Boethius

Department of Archaeology and Ancient History, Lund University, 223 63, Lund, Sweden



ARTICLE INFO

Article history:

Received 2 October 2016
Received in revised form
10 February 2017
Accepted 25 February 2017
Available online 7 March 2017

Keywords:

Sedentism
Delayed-return
Mesolithic
Foraging
Selective hunt
Commensalism
Subsistence strategies
Holocene
Scandinavia
Zooarchaeology

ABSTRACT

Delayed-return foraging strategies connected with a sedentary lifestyle are known from Late Mesolithic Scandinavian settlements. However, recent evidence from the archaeological site of Norje Sunnansund, in south-eastern Sweden, indicates the presence of sedentism from the Early Mesolithic. By analyzing the faunal assemblage from Norje Sunnansund, patterns of delayed-return strategies were examined for five categories of faunal exploitation/interaction: seal hunting, fishing, ungulate hunting, opportunistic hunting and rodent intrusions. The evidence suggests selective hunting strategies, large catches of fish and all year round seasonality indicators as well as evidence of commensal behavior in non-typical commensal species. The data were related to ethnographic accounts and sedentary foraging societies' modes of subsistence. The evidence suggests an expanding, sedentary, aquatically dependent Early Mesolithic foraging lifestyle in southern Scandinavia, which, it is argued, came to dominate the mode of subsistence, implying larger settlements and a larger prevalent population. This process may have been going on for millennia prior to the rise of the Late Mesolithic Ertebølle culture, implying much larger Late Mesolithic populations than previously realized, perhaps comparable with the native cultures of the north-west coast of America.

© 2017 Elsevier Ltd. All rights reserved.

1. Introduction

A delayed-return subsistence strategy has often been connected with complex societies (Arnold, 1996; Bender, 1978; Price and Brown, 1985) and sedentary lifestyles¹ and was originally considered to be one of the traits associated with agriculture and the Neolithic revolution (Meillassoux, 1973). This led to its emphasis in discussions of the basic subsistence strategies of Late Pleistocene and Early Holocene foraging societies and what separates them from the agricultural societies of the Neolithic period (Hole, 1984). In Early Mesolithic Europe, humans have often been seen as mobile groups of people living directly off the land, optimally exploiting their environment (Jochim, 2011) and, in doing so, not creating the

large surpluses that would facilitate a delayed-return lifestyle (Sahlins, 1972). While this might be true in some areas and for some societies, the Early Mesolithic period displays great cultural diversity (Jordan and Zvelebil, 2009; Warren, 2014) and is often defined as a period of great environmental change (Cummings, 2014). Increasing global temperatures (Lowe and Walker, 2015), reforestation of vast land areas previously covered by large grass steppes (Tarasov et al., 2012) and a series of megafaunal extinctions in the Late Pleistocene (Elias and Schreve, 2007) led to a diversification of human subsistence strategies and a broad spectrum revolution (Flannery, 1969; Zeder, 2012).

Although there are many difficulties in identifying sedentism and delayed-return economies in prehistoric foraging societies, because of problems in interpreting the archaeological record (Rowley-Conwy, 2001), diverse evidence from Paleolithic and Early Mesolithic Europe and northern Asia has provided many sources of data that can be used to establish a baseline for interpreting Early Mesolithic Scandinavia. For example, (semi-)sedentary settlements are suggested at exceptional Upper Paleolithic sites such as Dolní Věstonice (Klima, 1962), Kostenki-Borshevo (Klein, 1969) and several other Russian sites (Soffer, 1985), where numerous storage

E-mail address: adam.boethius@ark.lu.se.

¹ The use of the term sedentism follows the definition given by Susan Kent, when she argues that sedentism should be viewed as a group of people spending most of the year at one locus even if 'at other times during the year the group leaves, returning to the community after short, often seasonal, absences' (Kent, 1989). Thereby, and even though the term implies a stationary lifestyle; sedentism, as defined, includes a wide number of mobility strategies, which can vary throughout the years and include different constellations within a group of people (Kelly, 1992).

pits have been found (Soffer, 1985). There are also Upper Paleolithic examples of social stratification, with some individuals displaying extraordinary riches, implying the presence of an elite, such as the three burials from Sungir in Russia (Hayden, 2014). However, even though rich burials are known from the Paleolithic, it is not until well into the Mesolithic period that evidence of large cemeteries, such as at Olenii Ostrov, Zvejnieki, Vedbæk-Bøgebakken and Skateholm, starts to emerge (Albrethsen and Brinch Petersen, 1976; Larsson, 1988; Nilsson Stutz, 2014), providing good examples of social complexity. Because of the complexity and size of the cemeteries and the many large settlements known from the Scandinavian Ertebølle culture, which display a wide array of traits related to complex societies, social stratification, high aquatic dependency and a sedentary lifestyle (Nilsson Stutz, 2003; Rowley-Conwy, 1983; Warren, 2014), the Late Mesolithic Ertebølle culture of southern Scandinavia has been compared with the complex foragers of the American north-west coast (Tilley, 1996), although others have disputed these claims (Cummings, 2013). However, what if there was a delayed-return economy in the Scandinavian Early Mesolithic period, thousands of years prior to the emergence of the Ertebølle culture? Would this require a redefinition of the period prior to the transition to farming in the area, and can a long (and strong) tradition of complex, sedentary, aquatically reliant societies explain why the transition to agriculture was delayed for more than a thousand years before it was fully adopted in Scandinavia?

It is generally considered that sedentism can emerge where the energy costs of moving are higher than when staying put (Kelly, 2013:113) and can be narrowed down to situations 'pushing' foragers away from mobility or 'pulling' them towards a sedentary life (Brown, 1985). This can occur when increasing population pressures lead to a shortage of available land and, as a result, higher energy costs for moving around or 'removing' a competitive neighboring group of people (Binford, 2001), when it is more energy efficient to control and use abundant resource extraction points (Binford, 1968; Harris, 1977), or because moving costs exceed the costs of staying (Kelly, 1983:292). Regardless of the reason, in order to live in a sedentary manner over an extended time period, it is vital that the area can support occupation in terms of fulfilling the populations' dietary requirements throughout the year, which is why sedentary societies are located in ecotone environments (Sutton, 2016) where diverse resources can be used as a risk-reducing strategy (Rowley-Conwy and Zvelebil, 1989). Sedentary societies are also associated with delayed-return subsistence strategies and practice storing to cope with seasonal fluctuations (Kelly, 2013:20, 103), and are often primarily dependent on reliable aquatic resources (Binford, 2001:398). Furthermore, as the pressure on the surrounding landscape increases when people are stationary and not actively moving out of an area, as resources start to become depleted (Kelly, 2013:253) it is reasonable to suggest that steps will be taken to ensure that key resources are sustained. Indeed, there is evidence of foraging behavior remodeling and modifying the natural environment from the Mesolithic period, with the control and management of essential plants (such as fruit trees, hazel and oak) enabling a harvest at a later point in time (Bos and Urz, 2003; Holst, 2010; Huntley, 1993; Mason, 2000). Technological innovations are also important for sedentary lifestyles, and the creation of mass-harvesting technologies can increase the nutritional input from a given area and, therefore, reduce the risk caused by low mobility, especially if applied to reliable aquatic resources (Binford, 2001:391–99; Kelly, 2013:127–30). For example, the creation of large fish traps allows the environment to be exploited further and can be considered a delayed-return practice (Rowley-Conwy, 2001; Woodburn, 1980). This type of mass-harvesting technology has been found in southern Scandinavia from the Early Mesolithic onwards (Hædevik et al., 2008; Hansson et al., 2016; Karsten et al.,

2003; Pedersen, 1995) and it stands to reason that if a society is sedentary it should be possible to identify different types of activity taken to ensure continued occupation in the area. Consequently, the aim of this study was to examine the evidence for a delayed-return economy during the Scandinavian Early Mesolithic period and investigate how any environmental adaptations and subsistence strategies related to the prerequisites for a sedentary lifestyle. The faunal assemblage from Norje Sunnansund, the only known Early Mesolithic Scandinavian east-coast site, was used to facilitate the study, in combination with archaeological, paleoenvironmental, ethnographic and ecological approaches. The questions addressed were: can we identify the presumably many active strategies adopted to ensure survival with a sedentary lifestyle, and can circumstantial evidence provide information about sedentism?

2. Materials and methods

The archaeological settlement site of Norje Sunnansund is located in south-eastern Sweden (Fig. 1, left) and has been dated to about 9600–8600 cal. BP (Kjällquist et al., 2016), although the actual use of the settlement should be considered shorter, due to a combination of poorly preserved carbon in the dated bones, especially during the younger phase, and a contemporary radiocarbon calibration plateau, which both increased the dating spans. At the time of occupation, the site was located on the shores of a shallow lake (Vesan), next to a stream leading out to the Baltic basin, which was located 2 km away (Fig. 1, right). The settlement was surrounded by a forest dominated by hazel and pine trees, and in the distance across Vesan the low mountain ridge of Ryssberget stretched for about 20 km. The site mainly contained three cultural layers, representing two separate phases and one significant land feature, a fish fermentation pit surrounded by postholes and stakeholes (Boethius, 2016). Because of significantly poorer preservation in the more recent phase compared with the older phase, it was difficult to date the younger phase properly and the more fragile organic material had degenerated and disintegrated. Even though the settlement was clearly occupied during two separate phases, demarcated by a flooding event, it was impossible to establish how long the site had been flooded for. Furthermore, the content of the different layers appeared on occasions to have been mixed during the occupation of the site. Furthermore, a third layer of water-deposited bones and artifacts derived from both phases could not be temporally separated, which also applies to the bones from the preliminary excavation. However, because the site was completely abandoned at around 8600 cal. BP and covered by the Littorina transgression (Andrén et al., 2011), there were no later intrusions into the cultural layers. Therefore, this study treats the whole Norje Sunnansund site as a single entity and all quantifications and interpretations are based on the entire assemblage. For specific information regarding the separate phases of the site see appendix (Tables A1–A3), for discussions regarding the different phases see Kjällquist et al. (2016), and for further discussions regarding the fish bone material during the oldest phase see Boethius (2016, 2017b). The interpretations presented here are based mainly on the osteological analysis of the site's faunal assemblage. All the mammal and bird bones found at the excavation were analyzed, but only about 13% of the recovered fish bones. Combining all the phases and layers resulted in an assemblage of 1940 mammal bones, 106 bird bones and 16,180 fish bones (Tables A1–A3), which were identified to species level or, where this was not possible, to family level.

The bone material was analyzed with the aid of the reference collections at the National Historical Museums in Lund, at the Department of Historical Osteology, Lund University, Sweden, and the Zoological Museum, Copenhagen University, Denmark. The quantifications were based on number of identified specimens

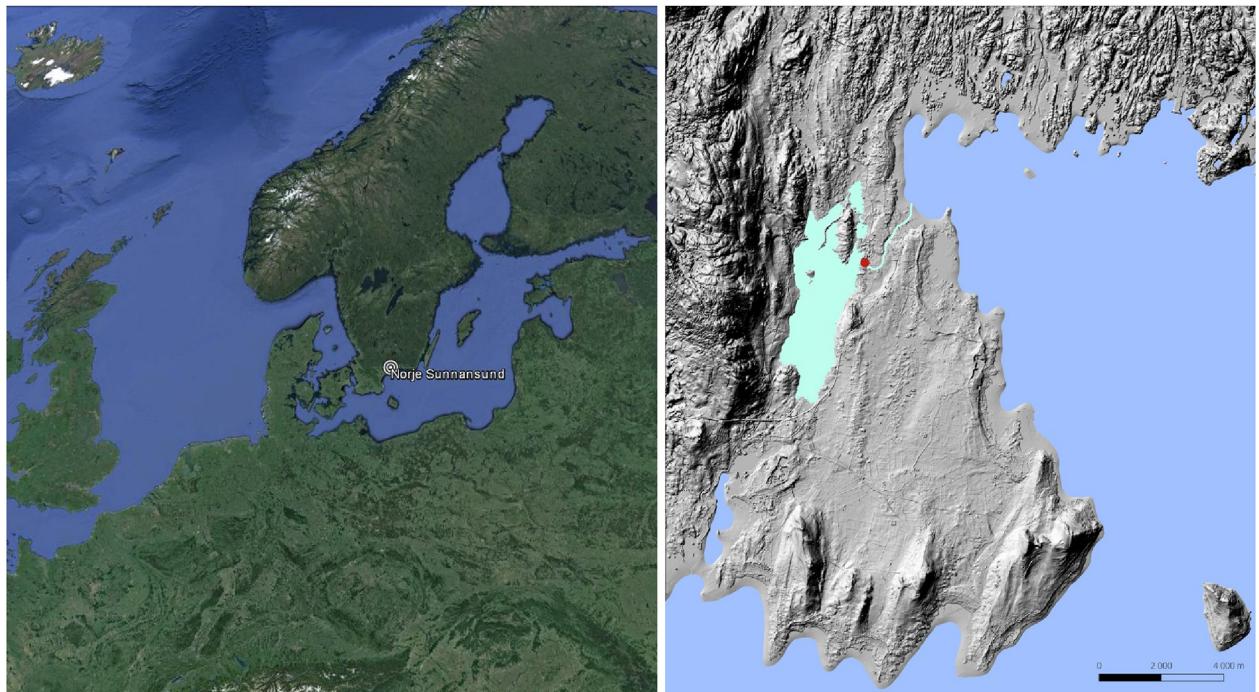


Fig. 1. A map of the area surrounding Norje Sunnansund around 9200 cal. BP. The map is based on a terrain model with 5-m resolution and LIDAR data; topographic information came from the Swedish Land Survey road map [[©] Lantmäteriet i2012/892] and Swedish Geological Survey marine geological map lowtopo2 (Seifert et al., 2001). Map by N.-O. Svensson, Kristianstad University. Picture on the left from Google Earth.

(NISP). The minimum number of individuals (MNI) have also been derived, by calculating overlapping parts of the most frequently occurring skeletal element and without considerations to age differences, although MNI has not been used beyond being reported (Tables A1–A3).

The element distribution pattern has been examined on animals hunted for fur by dividing the skeletal elements of the body into four regions based on ethnographic dismembering and butchering patterns (Binford, 1981). These are: *cranium*—skull, mandible, and loose teeth; *limb bones*—scapula, humerus, radius, ulna, femur, tibia, and fibula; *body core*—ribs, vertebrae, and pelvis; and *distal extremities*—carpals, tarsals, metapodials, and phalanges.

Age determinations were based on epiphyseal fusion, where the bones represented in each epiphyseal closing stage is illustrated as the percentage of fused/unfused bones in order to derive a kill-off pattern, and osteometrics together with bone texture to identify juveniles (Table 1). Kill-off patterns based on the epiphyseal fusion of different age groups are commonly applied in zooarchaeological studies (O'Connor, 1982), where the frequency of fused epiphyses in each age category represents animals killed at older ages and can be used to construct survivorship curves. Thereby, the age profiles consist of a *Younger than:* category, which is based on the percentage of unfused epiphysis in each age category, and in the youngest age category the addition of bones where size and texture on an individual bone indicates a newly born. The *Older than:* age category is based on the number of fused epiphyses from bones in each age category. Thereby, *Younger than:* equals the percentage of animals not surviving the age group and *Older than:* equals the percentage of animals that survives the age group. Tooth wear and development have not been used because of a limited number of age-determinable teeth. For wild boar, age determination was carried out according to Zeder et al. (2015), with the addition that some of their original detailed categories were combined into larger categories for a more comprehensive illustration due to the limited sample. For roe deer, epiphyseal fusion was analyzed

according to Tome and Vinge (2003). Red deer epiphyseal fusion was analyzed using three different sources, because of the lack of a comprehensive study. Bosold (1966) was used for phalanges and metapodials, Lyman (1991) for the humerus, femur, radius and tibia, and Heinrich (1991) for the remaining skeletal elements. Seal age determination was based on epiphyseal fusion and measurement comparisons with modern seals according to Storå (2001). Measurements were taken according to Von Den Driesch (1976) and on seals according to Ericson and Storå (1999).

3. Results and discussions

3.1. The exploitation of animals

The emergence of sedentism is a heavily discussed subject and has been examined from many different angles. Scandinavia can in no way be considered an isolated area during the Early Mesolithic period, and evidence of outside influences and interaction is apparent in the archaeological material in the spread of lithic blade technologies from the east (Sørensen et al., 2013). The interaction between groups of people is of interest regarding the emergence of sedentism, particularly because ethnographic evidence suggests that once sedentism is adopted by one group of people, neighboring groups often follow the same sedentary lifestyle, because sedentary groups tend to evolve into larger societies that make territorial claims, effectively denying smaller, mobile populations access to key areas (Kelly, 2013:107). Therefore, the emergence of sedentism in one area by one particular group of people signifies that it could be found elsewhere, or that evidence of other sedentary societies should emerge soon after in other areas, between which human interaction can be perceived.

The bone material from Norje Sunnansund reflected the location of the settlement: the inhabitants had exploited the whole of the surrounding environment. This pattern is visible at most Mesolithic sites, but is even more apparent at Norje Sunnansund because more

Table 1

The criteria's (epiphyseal fusion data and size and texture interpretations) used to divide the elements into different age categories. In some cases it has not been possible to determine if the seal phalanges were from the hind- or foreleg, in these cases the younger age category has systematically been assigned. px = proximal, di = distal.

Red deer	
1 year	Radius px, Coxae acetabulum, Scapula, Juveniles based on texture and size
1–2.5 years	Phalanx 1 + 2, Tibia di, Humerus di
2.5–4 years	Femur, Radius di, Ulna di, Metapodia di, Humerus px, Tibia px
>4	Vertebrae
Wild boar	
0–1.5 years	Atlas, Axis, Coxae, Scapula, Radius px, Phalanx 2, Humerus di, Juveniles based on bone texture and size
1.5–3 years	Phalanx 1, Tibia di, Metapodia, Fibula di
3–4 years	Calcaneus, Femur px
>4–5 years	Radius di, Femur di, Tibia px, Ulna, Fibula px, Humerus px
Roe deer	
0.5 year	Scapula, Acetabulum, Humerus di, Radius px, Phalanx 1 px, Atlas, Juveniles based on bone texture and size
1–2 years	Vertebrae, Humerus px, Radius di, Ulna, Metapodia, Femur, Tibia, Phalanges 2 px, Calcaneus
Seal	
Yearling	Posterior Phalanx 1 + 2 di, Metapodia 1 di, Acetabulum, Scapula, Anterior Phalanx 3 px, Humerus px, Yearlings based on texture and size
Juvenile	Tibia + Fibula px, Femur px, Humerus di, Radius px, Sacrum, Calcaneus px, posterior Phalanx 3 px, Juvenile based on size
Young adult	Humerus px, Femur di, Ulna px, Crural px, Anterior Phalanx 1 + 2 px
Old adult	Metapodia 1 px, Metapodia I–V di, Ulna di, Radius di, Crural di, posterior Phalanx 1 + 2 px, Vertebrae

species have been found there than at any other southern Scandinavian Early or Middle Mesolithic site (Boethius, 2017b). The high species diversity made it important to condense the information relevant to foraging strategies and interpretative signals into manageable entities, which was done by considering five different categories: seal hunting, fishing, ungulate hunting, opportunistic hunting and rodent intrusions. By means of this division; the central question of this study addresses the evidence of a delayed-return economy in the Scandinavian Early Mesolithic period and how subsistence strategies can provide evidence of a sedentary lifestyle.

3.1.1. Seal hunting

3.1.1.1. Seal hunting results. Traditional seal hunting has the potential to provide large quantities of food in a relatively short period of time. Furthermore, seal hunting may not be carried out solely for dietary needs (Storå, 2001:4), they can also be hunted for fur and blubber, adding to the importance of the animal. This significance is often observed in archaeological contexts, as seal hunting locations can generate large quantities of seal bone that dominate the bone assemblage (Aaris-Sørensen, 1978; Lindqvist and Possnert, 1997; Storå, 2001). At Norje Sunnansund both ringed seals and grey seals were present, although predominantly grey seals (Fig. 2). As the grey seal is the larger of the two species it was probably the most important as a source of meat and blubber; although considering that the majority of the seal bones have not been determined to species level a higher seal identification rate might prove this assumption wrong.

The seals found at the site displayed a seemingly even age distribution; around 60% of the bones from each age category have fused epiphyses and around 40% have unfused (Fig. 3). However, in this seemingly even fusion stage lays a highly uneven hunting pattern. Because the percentage of fused epiphyses is fairly constant in all categories, what is actually means is that only yearlings and old adults have been selected for hunt, if juveniles and young adults had been hunted the kill-off pattern would show an increasing prevalence of unfused bones with increasing age group. Thereby, almost half of the hunted seals were yearlings and the other half were old adults; with no, or very limited, amounts of hunted seals from the juvenile or young adult age group represented in the material (Fig. 3, lower). Furthermore, the presence of newly born seals (Fig. 4) and fetal bones in the area surrounding the fermentation facility, from both grey and ringed seals, indicated that seals in-calf might have been specifically targeted (Boethius, 2016).

3.1.1.2. Seal hunting discussion. The finding of newly born seals and

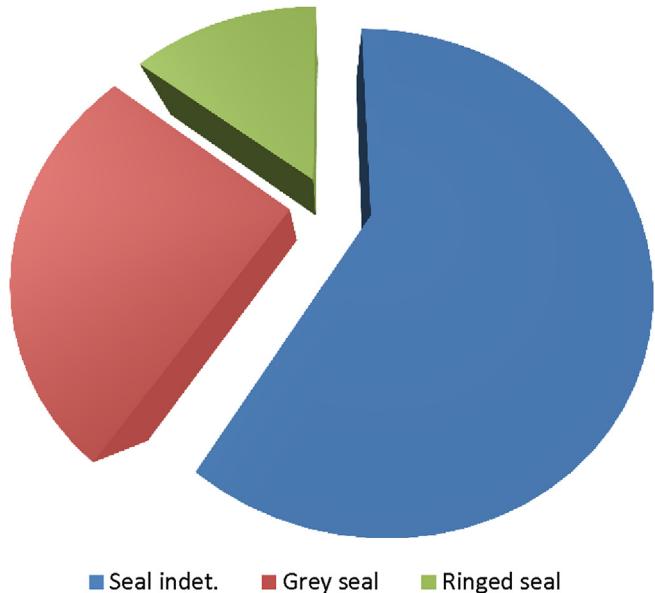


Fig. 2. Relative abundance of seal species based on NISP. N: grey seal (*Halichoerus grypus*) = 77, ringed seal (*Pusa hispida*) = 42, indeterminable (indet.) seal (Phocidae) = 172.

seal fetuses is interesting from an environmental perspective, as ringed seals give birth within the ice during late winter to early spring (Almkvist et al., 1980) and modern grey seals in the Baltic give birth on top of the ice during late winter to early spring (Jensen, 2004). Therefore, the age distribution shown in Fig. 3 indicates the hunting of seal mothers and their young pups, which would have been found together on the ice, whereas the location of females that had not given birth and males would have been much less predictable and would probably be out of reach further out to sea. This means that seal hunting was primarily taking place on the ice during late winter to early spring. Seal hunting on the ice is not an uncommon interpretation; it is often assumed to have been carried out by people associated with the Middle Neolithic pitted ware culture on Gotland (Storå, 2001:31, 46), as well as being known from ethnographic accounts of circumpolar societies (Murdoch, 1892). The finding of a very young ringed seal (Fig. 4, left) and a ringed seal fetus is, however, an important environmental indicator, because they need ice thick enough to carry a snow shelter, which the mothers build within the ice (Härkönen, 2011). During the

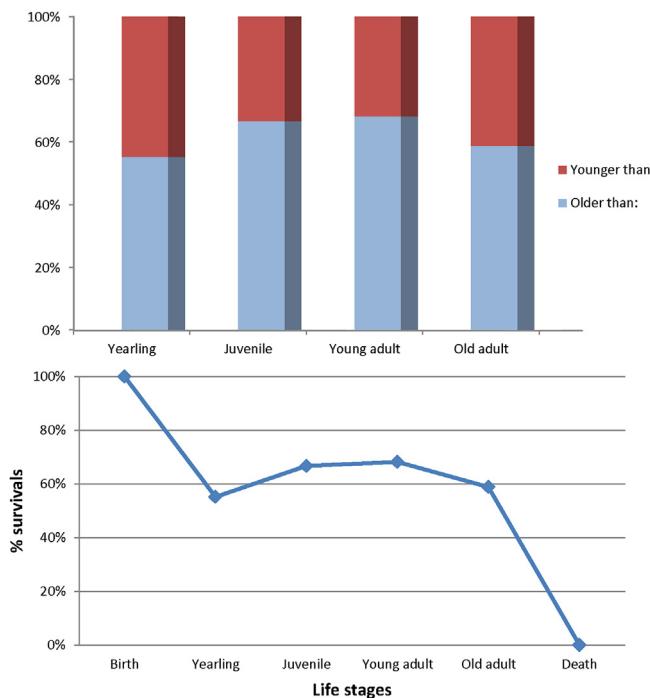


Fig. 3. Upper: Age distribution based on epiphyseal fusion and osteometrics on bones from grey seal, ringed seal and indeterminate seal species. Lower: Seal kill-off pattern derived from upper figure. Survivorship equals frequency of fused epiphysis in each age category, which in turn represents animals killed at an older age. Based on NISP in each category. n: Yearling = 28, Juvenile = 12, Young adult = 22, Old adult = 17.

boreal period, there was a continuous increase in temperature and the climate is considered to have been somewhat warmer than today (Antonsson, 2006), with the winters being about 1.5 °C colder in north-eastern Europe (Davis et al., 2003). The location of Norje Sunnansund suggests that it should have been impossible for ringed seals to breed in this area as the ice sheet would have been too thin. The most southern breeding area for ringed seal populations today is in the Gulf of Riga (Latvia), where the winter temperature is on average about 3.5 °C colder than in Blekinge, which means that if it was not cold enough the seals would have travelled further north and would not be available to hunt during the winter. An explanation for the presence of very young and fetal

ringed seals in the Norje Sunnansund bone assemblage possibly lies with a known cold event. Around 9200 cal. BP, large volumes of freshwater were released into the Atlantic Ocean (Fleitmann et al., 2008), temporarily lowering the effect of the Atlantic thermohaline circulation, leading to a colder climate in the Northern Hemisphere. The effect of this event lasted no more than 150 years (Fleitmann et al., 2008; Rasmussen et al., 2007) but coincides with the older phase of the Norje Sunnansund settlement.

The age distribution pattern (indicating the hunting of mothers and their cubs), the osteometrics (indicating newly born seals and seal yearlings) and the presence of seal fetuses are indications of an unsustainable hunting practice that could not have been carried out for very long without depleting the local seal population. However, if viewed from the perspective of a short but intense cold spell, this type of hunting practice makes more sense, as it indicates a rapid adaptation to new climatic conditions. Given the relatively limited numbers of seal bones, compared with bones from fish and terrestrial mammals, it is possible that the hunting of seals at Norje Sunnansund was first and foremost carried out in order to supply fat and skins and that the toll extracted on the seals would not have been on a scale large enough to seriously harm the seal population.

3.1.2. Fishing

3.1.2.1. Fishing results. Fish bones were abundant at the site: up to 200,000 were found whereof around 13% have been analyzed, which has resulted in 16,180 identified and 4418 unidentified fish bones. The fish represented were all freshwater species, presumably because the adjacent lake, stream and Baltic basin were all freshwater at the time. Estimations based on the bone material analyzed from the oldest phase indicated that at least 48 tons of fish were caught (Boethius, 2017b). Less than 10% of the original site has been excavated so, taking the entire settlement into account, even larger quantities of fish were probably caught (Boethius, 2017b). The fish were dominated by cyprinids, mainly roach, which amounted to 75% of the total NISP, followed by perch, pike, eel and burbot, in declining order of presence (Fig. 5).

In addition to the large number of fish bones found at the site, a facility for fermenting fish was discovered. The fish fermentation facility (Fig. 6) consisted of an oblong pit filled with fish bones, surrounded by post holes, for roof bearing poles, and smaller stake holes, which once held stakes used for tightening wild boar and seal skins containing the fermenting fish (Boethius, 2016). This has

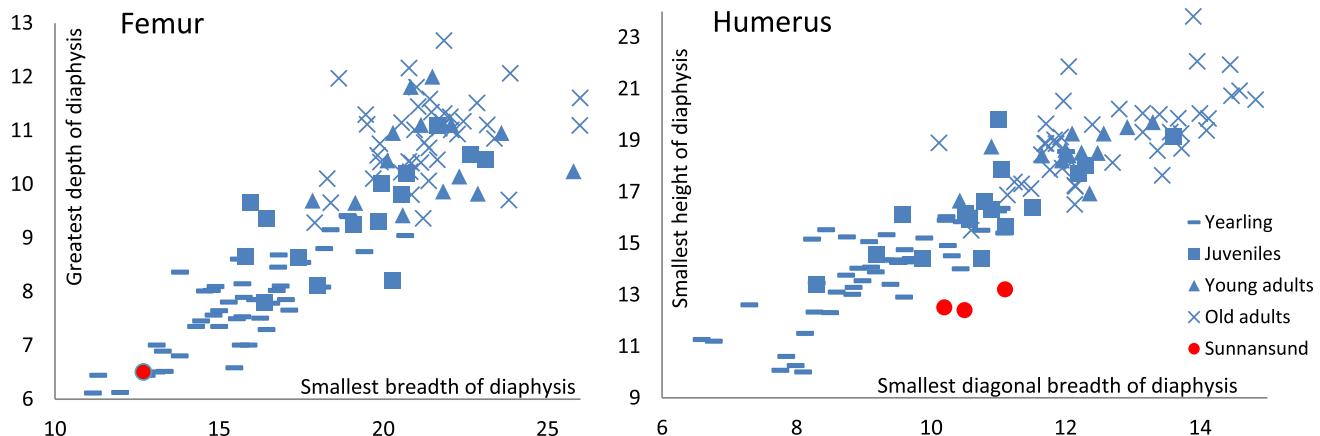


Fig. 4. Size of ringed seal femur and humeri from Norje Sunnansund compared with modern ringed seals. Measurements of modern seals and age group division courtesy of J. Storå (Storå, 2001:paper II). Measurements in millimeters according to Ericson and Storå (1999). Two of the humeral fragments and the femoral fragment from Norje Sunnansund were assigned to the younger than yearling category and one of the humeral fragments to the younger than juvenile category in Fig. 3 above.

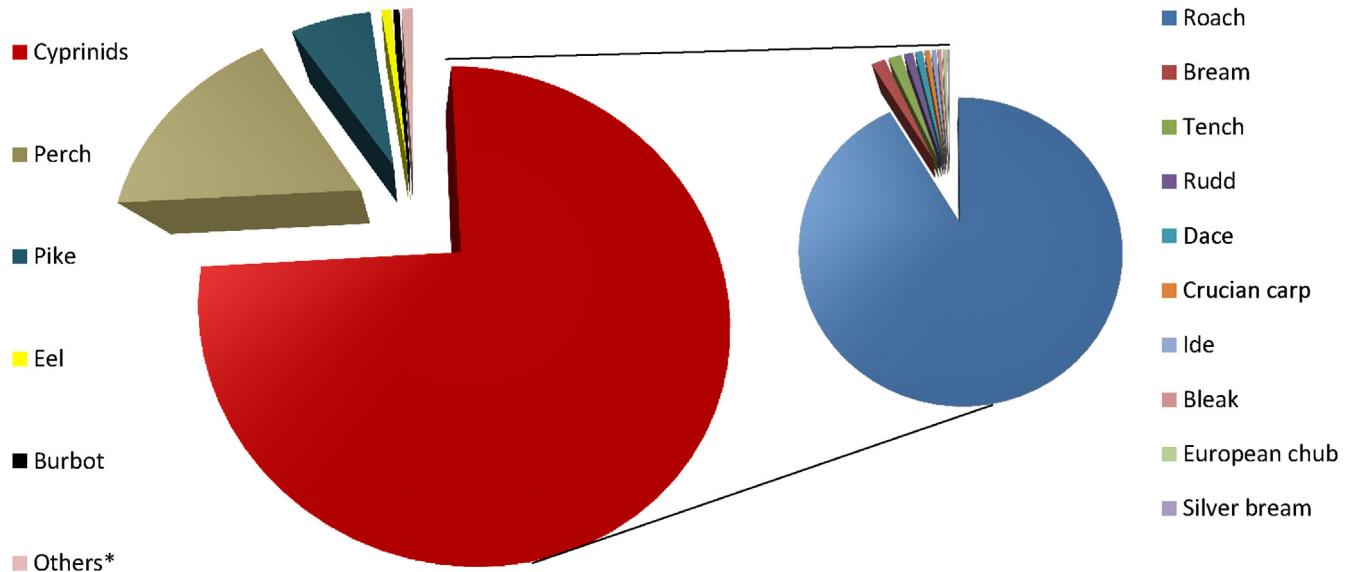


Fig. 5. Relative abundance of fish species based on NISP. Left: cyprinids (cyprinidae) = 11,978, perch (*Perca fluviatilis*) = 2728, pike (*Esox lucius*) = 1098, eel (*Anguilla anguilla*) = 138, burbot (*Lota lota*) = 83, others = 155. *: pike-perch (*Sander lucioperca*) = 53, ruffe (*Gymnocephalus cernua*) = 35, whitefish (*Coregonus sp.*) = 32, smelt (*Osmerus eperlanus*) = 10, salmon/trout (*Salmo salar/trutta*) = 9, perciniids (percidae indet.) = 13, Arctic char (*Salvelinus alpinus*) = 3. Right: Cyprinid bones determined to species. Roach (*Rutilus rutilus*) = 1016, Bream (*Abramis brama*) = 20, Tench (*Tinca tinca*) = 19, Rudd (*Scardinius erythrophthalmus*) = 13, Dace (*Leuciscus leuciscus*) = 11, Crucian carp (*Carassius carassius*) = 8, Ide (*Leuciscus idus*) = 7, Bleak (*Alburnus alburnus*) = 6, European chub (*Squalius cephalus*) = 6, Silver bream (*Blicca bjoerkna*) = 3.

been linked directly with the conservation and storage of food products and is therefore associated with a delayed-return subsistence practice.

3.1.2.2. Fishing discussion. The amount of fish bone found at Norje Sunnansund is itself a good indicator of a sedentary lifestyle (Boethius, 2017b). These volumes of fish would have been enough to support a large number of people during many years of site occupation. Large volumes of caught fish are most probably associated with a sedentary society applying mass-harvesting technologies, such as stationary fish traps and nets, to catch the fish during predictable events when the fish are especially abundant in the area (Kelly, 2013:127); at Norje Sunnansund this would have been during the autumn, when roach aggregate to fake-spawn, and during the spring, when roach do spawn (Curry-Lindahl, 1969). Furthermore, mass catches imply the creation of storage facilities and the preservation of fish. The fermentation facility found at the site provides evidence of this, and offers an insight into complex methods of food storage (Boethius, 2016). The preservation and storage of fish are good indications of a delayed-return economy, where investment in both the method of catching the fish and the time needed for the fish to ferment properly provides edible food months after the catch was landed. Large amounts of caught fish would have generated enough food to sustain a large number of people throughout most of the year, and therefore meet the subsistence requirements of a sedentary settlement. In ethnographic reports of foraging societies, an increase in reliance on aquatic resources is generally combined with a lower rate of movement (Marlowe, 2005:Fig. 6), and a high reliance on aquatic resources is, in itself, an argument for a higher degree of sedentism. Furthermore, sedentary foraging societies are generally much larger than mobile terrestrial hunter societies, especially if aggregated during the winter (Kelly, 2013:167,172). In addition, in areas with abundant resources, demographic modelling suggests rapid human population growth (Kelly, 2013:185) that, if considered in a sedentary aquatic-dependent community, implies a large number of residents and subsequent expansion into neighboring areas as the original

area becomes packed (over-crowded). In Binford's opinion a 'heavy use of aquatic resources was itself a density-dependent response' (Binford, 2001:385,423).

3.1.3. Ungulate hunting

3.1.3.1. Ungulate hunting results. The ungulates at Norje Sunnansund were dominated by red deer and wild boar, closely followed by roe deer, which together made up about 95% of the ungulate assemblage (Fig. 7). Aurochs and elk were represented by just a small number of identified fragments. Even though they would only have occurred in small numbers in the landscape, they appeared to have been of lesser dietary importance compared with the smaller ungulates (Fig. 7). The low abundance of both aurochs and elk is interesting, as they are generally more common at Early Mesolithic sites (Magnell, in Print). However, most contemporaneous sites, except Huseby Klev and Balltorp on the Swedish west coast which also have low numbers of elk and aurochs (Boethius, 2017a; Jonsson, 1996, 2014), are from inland locations. Thereby, elk and aurochs abundance could indicate a pronounced divergence between inland and coastal sites.

The age distribution of the smaller ungulates suggested a selective hunting approach. There was a low out-take of juveniles for both roe deer and red deer, and a high kill-off rate between 2.5 and 4 years old for red deer (Fig. 8). A different kill-off pattern was seen with the wild boar, which showed a more equal hunting pressure across all ages; indicated by decreasing prevalence of wild boars with fused epiphyses with increasing age.

3.1.3.1. Ungulate hunting discussion. The dissimilarities in the kill-off patterns between the cervids, especially red deer, and wild boar, have implications for the interpretation of the terrestrial hunting activities. The age distribution of cervids indicates a small out-take of individuals younger than 2 years, suggesting a selective hunting pattern. The red deer show a high kill rate between 2.5 and 4 years old, when individuals would have reached full body size and provided an optimum amount of meat; it would also have been before the males reached reproductive age, which occurs later than

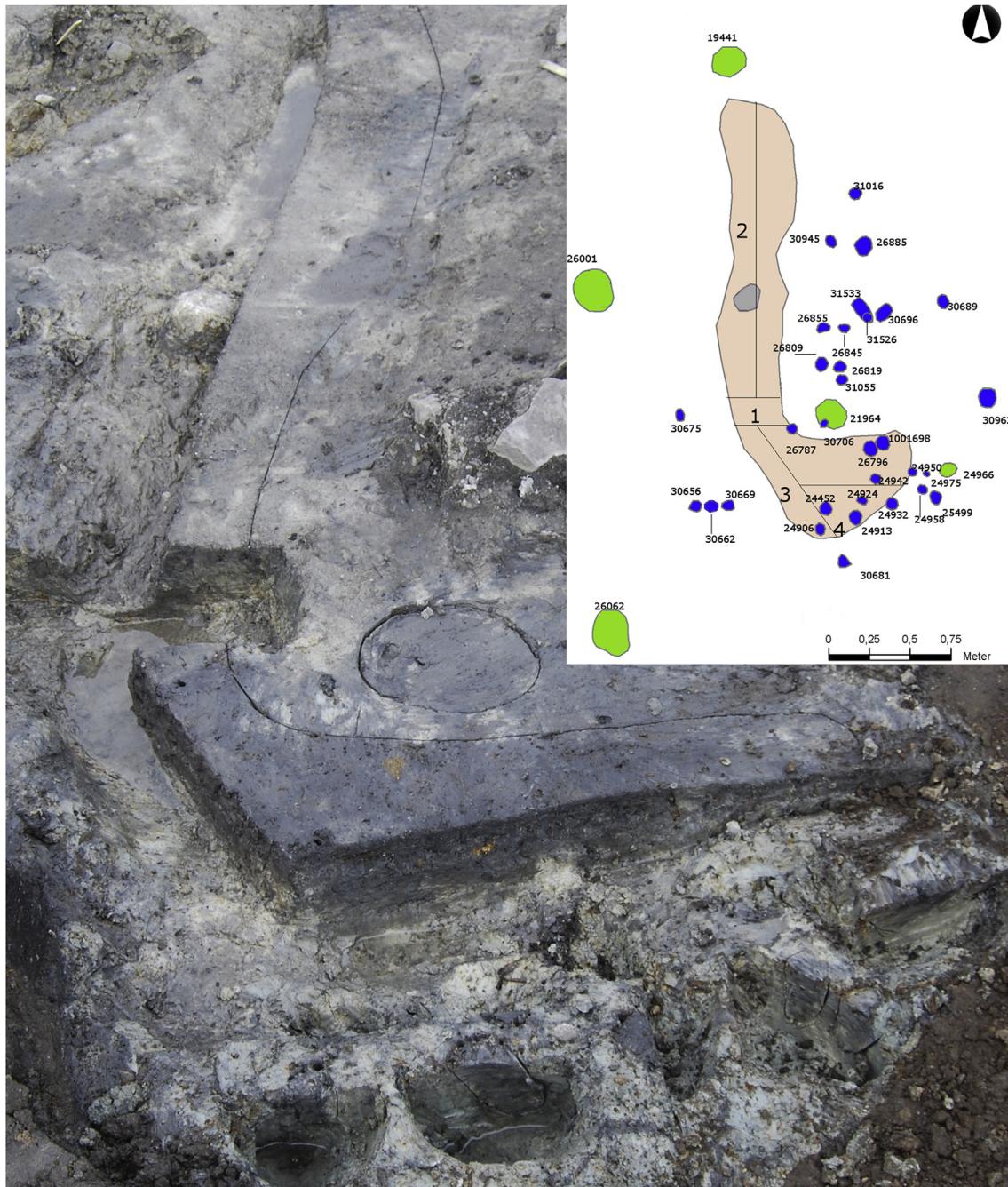


Fig. 6. The fish fermentation facility when half of the feature had been removed (main picture) and a plan of the feature (upper right) including the gutter with its surrounding post- and stakeholes. Picture and further explanation in Boethius (2016). Photo: SHMM.

sexual maturity in a well-functioning red deer hierarchy² (Clutton-Brock et al., 1979; Clutton-Brock and Guinness, 1982). This is a pattern known from many Mesolithic settlements in southern Scandinavia (Bay-Petersen, 1978; Boethius, 2017a; Magnell, 2006). However, the wild boars were hunted from younger ages, which imply that not all species were hunted once they had reached full body size. More intricate hunting strategies appear to have caused the observed kill-off patterns.

Wild boars are highly fecund, giving birth to between four and six, sometimes more, piglets each breeding period, and they can breed successfully twice a year if circumstances are favorable (Briedermann, 1990)³. However, wild boars also have a high natural mortality rate and studies have shown that about 48% of wild boars die within the first year of life (Jezierski, 1977). It is suggested, therefore, that the high mortality among wild boar piglets is of low significance to the future of the population (Jezierski, 1977), so a

² The effective reproduction age of red deer does not normally occur until 5 years old, as males compete and earn their place to hold harems and reproduce and young stags are unable to control and protect hinds.

³ Around 85% of modern Swedish wild boar piglets are born between February–May and there is no reason to suspect that the same does not apply to Mesolithic Scandinavia (Magnell 2006).

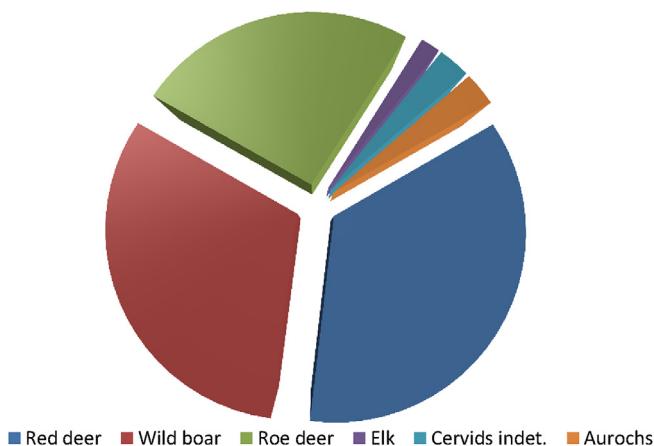


Fig. 7. Relative abundance of ungulate species. NISP: red deer (*Cervus elaphus*) = 373, roe deer (*Capreolus capreolus*) = 271, elk (*Alces alces*) = 19, cervids indet. (Cervidae) = 31, aurochs (*Bos primigenius*) = 32, wild boar (*Sus scrofa*) = 331.

safe higher out-take is possible. Both roe deer and especially red deer have a different reproduction strategy compared with wild boar. In areas with limited predation, studies have shown that red deer hinds give birth to an average of 0.7–0.78 calves a year, resulting in an average of 4.4–6.8 calves that reach 1 year of age

during a hind's lifetime (Clutton-Brock et al., 1986). A high out-take of young red deer will therefore soon deplete a local population. This becomes even more evident when other predators are taken into account, which typically prey on the young (Okarma, 1995). Roe deer can be subjected to a somewhat higher hunting pressure as they reach reproductive age earlier than red deer and often gives birth to two fawns a year (Vincent et al., 1995).

The different kill-off pattern seen between the two cervid species and wild boar indicate different hunting strategies for different species. These hunting strategies could be considered conservative, working to maximize the gain from each killed animal from species with a lower reproduction rate. Environmental conservation practices are known from ethnographic sources, for example Alaskan Inupiat communities commonly open their fishing weirs, releasing half of their catch, to ensure a future fish population (Burch, 2007), and riverine communities in north-western American consciously avoid blocking entire rivers as they know it will have disastrous effects (Erlandson and Rick, 2008). The Huna Tlingit in Alaska are reported to practice conservative glaucous-winged gull (*Larus glaucescens*) egg harvest by only selecting eggs from nests containing one or two eggs, as this will trigger the female to continue laying eggs until there are three eggs in the nest (Hunn et al., 2003). Other accounts of managing the environment have been reported from North America, such as the burning of brush vegetation to increase harvest and produce fresh saplings for grazing ungulates, and pruning

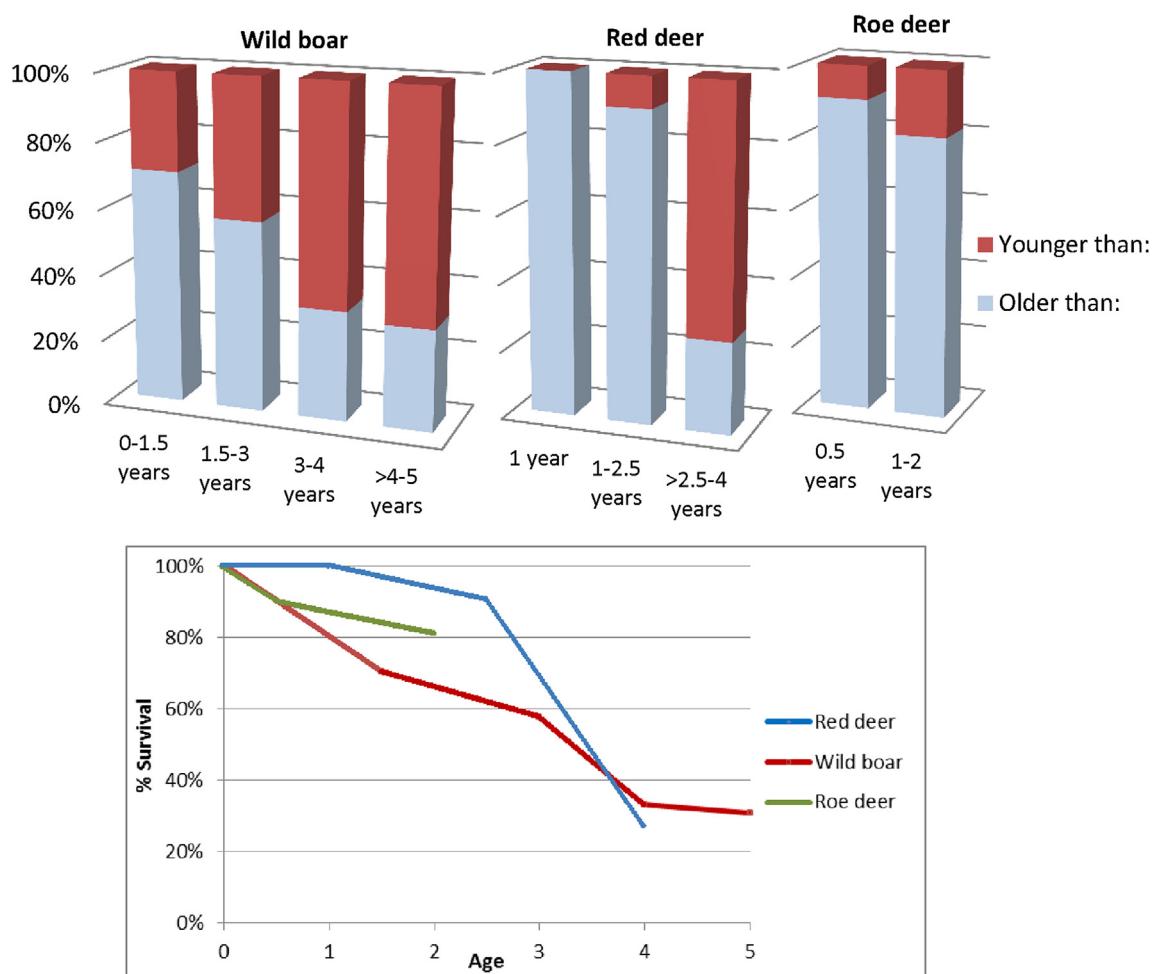


Fig. 8. Upper: Kill-off patterns based on the epiphyseal fusion ages of different elements of the post-cranial skeleton for wild boar, red deer and roe deer at Norje Sunnansund. Survivorship equals frequency of fused epiphysis in each age category, which in turn represents animals killed at an older age. Based on NISP in each age category for: Wild boar: 0–1.5 years n = 17, 1.5–3 years n = 26, 3–4 years n = 6, >4–5 years n = 26. Red deer: 1 year n = 3, 1–2.5 years n = 22, >2.5–4 years n = 11. Roe deer: 0.5 year n = 21, 1.5–2 years n = 32.

of trees and plants (Anderson, 2005). However, as Kelly so eloquently puts it '*The question is not whether foragers conserve their resources. Some do and some do not. The question is: under what conditions would we expect to see behaviors that intentionally manage and conserve resources, as well as cultural concepts that encourage such behaviors'* (Kelly, 2013:112).

Arguments for selective red deer hunting strategies among Mesolithic foragers were made at the beginning of the 1970s, with claims of a large majority of males in the faunal assemblage from Star Carr in Britain (Jarman, 1972). However, when calculating the sex ratio the numbers included antler fragments and, as only males have antlers, which can also be collected when they are shed, Jarman (1972)'s arguments were seriously biased. Furthermore, hinds can also be culled in order to maximize the body and antler size of living stags (Clutton-Brock and Albon, 1989), which, if applied, imply the collection of shed antlers. The collection of shed antlers is commonly observed at both Norje Sunnansund, where 80% of the red deer antlers⁴ ($n = 5$) originated from a shed antler, and in other Mesolithic contexts (Legge and Rowley-Conwy, 1988). Because of the lack of complete bones for analyzing osteometric sex ratios and the lack of sex-determinable pelvis, age profiling may be the only realistic means of investigating hunting strategies. Although rare in Mesolithic contexts, selective red deer hunting has been suggested in the oldest phase at coastal Tågerup, southwestern Sweden, dated to the Middle Mesolithic period. At this site, young red deer as well as red deer in their prime are absent from the bone assemblage, similar to the pattern seen at Norje Sunnansund, whereas both roe deer and wild boar appeared to be non-selectively hunted, displaying animals from all age groups (Eriksson and Magnell, 2001). This pattern is also observable at the Early Mesolithic Swedish west-coast site of Huseby Klev, although a low number of age-assessable fragments complicates the interpretation (Boethius, 2017a). Thereby, Kelly's question of '*under what conditions*' a selective hunt for different ungulate age groups is implemented can perhaps be answered if it can be said that this strategy is common on settlements close to large aquatic resources.

Because of the benefits of these particular types of hunting strategy, it could be argued that they are the unintentional and epiphenomenal by-product of optimal foraging decisions (Alvard, 1993; Aswani, 1998) or that they emerged as a response to an earlier depletion of required resources (Berkes and Turner, 2006). The actions taken to secure a sustainable caribou harvest following the over-exploitation of caribou by Chisasibi Cree native Canadians indicate that restrictive hunts and managing strategies can emerge as a response to human-induced local extirpation (Berkes and Turner, 2006:483). Given how common both aurochs and elk are in the archaeological material from contemporaneous inland sites, it could be argued that there is no apparent reason for them to be absent at coastal sites unless human over-exploitation had depleted the coastal zones of the largest animals with the slowest reproduction rates. If this was the case, the over-exploitation must have happened prior to the human occupation of Norje Sunnansund, but, as no prior settlements have been found, because they would be located under the current water level as a result of the transgression following the melting of the ice, this interpretation is speculative. However, the available evidence suggests a lack of larger ungulates in coastal areas that, in combination with selective red deer hunting strategies, implies prior over-exploitation of aurochs and elk in coastal zones, followed by more restrictive hunting strategies. A local extirpation or low numbers of larger ungulates in coastal areas might also imply

larger human populations than previously realized. Therefore, ungulate hunting strategies and kill-off patterns are something that should be taken into account when discussing human impact on the environment, even as far back as the Early Mesolithic.

Conservative hunting strategies, independent of the reason for their implementation, would only be possible in sedentary, aggregated societies not yet experiencing overcrowding, which would be the case as long as the areas occupied by neighboring groups of people did not intrude on the territory of the original group. If at some point an area became too crowded, people would start to move and permanently settle in areas within the group's territory, with the abandonment of restrictive hunting strategies. This would be done for pragmatic reasons, as it could not be assumed that another group of people would practice similar hunting strategies. The potential of another group to extract too large a toll on prime animals, females and juveniles would force the original group to do likewise, otherwise they would risk being without any of the resource. Therefore, conservative hunting strategies applied to cervid species should only be observable in sedentary societies not yet experiencing competition. This phenomenon is possibly observable in the Late Mesolithic Ertebølle phase of Tågerup (Eriksson and Magnell, 2001), where such a change in red deer kill-off pattern is hinted at, even though the interpretation is complicated by only small numbers of age-determinable fragments in the Ertebølle phase.

3.1.4. Opportunistic hunting

There is no compelling evidence of a delayed-return economy in animals hunted for fur (here referred to as fur-game) or in bird-hunting strategies. The abundance of the different species represented, in combination with the limited number of identified specimens from each species, gave the impression of more opportunistic hunting. However, the fur-game and bird species present did provide some interesting topics for discussion concerning selective hunting strategies and possible seasonality indicators.

3.1.4.1. Animals hunted for fur

3.1.4.1.1. Animals hunted for fur results. There was no evidence of juvenile fur-game, a total of 72 fur-game bone elements have fused epiphyses and not one single bone from any of the fur-game show an unfused epiphysis, even though different species with varied reproductive strategies were represented. Most of the fur animal assemblage from Norje Sunnansund comprised small species, the most common being squirrels, pine martens and otters; however, larger species such as badger, fox, bear, beaver and wolf are also frequently occurring (Fig. 9).

If studying fur-game elemental frequencies it is possible to distinguish a size specific pattern (Fig. 10). Small fur-game, in general, lack elements from the body core, while the larger species have a more evenly represented elemental distribution. However, as the body core elements are smaller and less dense than the other parts of the body this might be a taphonomic issue, as the different parts of the body otherwise, in general, are represented. Thereby, it appears as if complete bodies often have been transported to the settlement, albeit with some exceptions. Limb bone fragments from pine marten and red fox are relatively rare, indicating that these species might have been skinned at the trapping location without the meat having been brought back to the site. Similarly, beavers are largely represented by cranial fragments (mainly teeth), which might indicate that their skulls have been collected to acquire the teeth to use as tools, something which has been observed at other Mesolithic sites (Hatting, 1969).

3.1.4.1.2. Animals hunted for fur discussion. The fur-game age pattern is interesting and can be interpreted both as reflecting the season of catch and as the result of selective hunting strategies,

⁴ I.e. of the antlers which were assignable to either a shed antler or a killed animal (e.g. were antler is still attached to a skull); on most of the antler fragments from the site this cannot be determined.

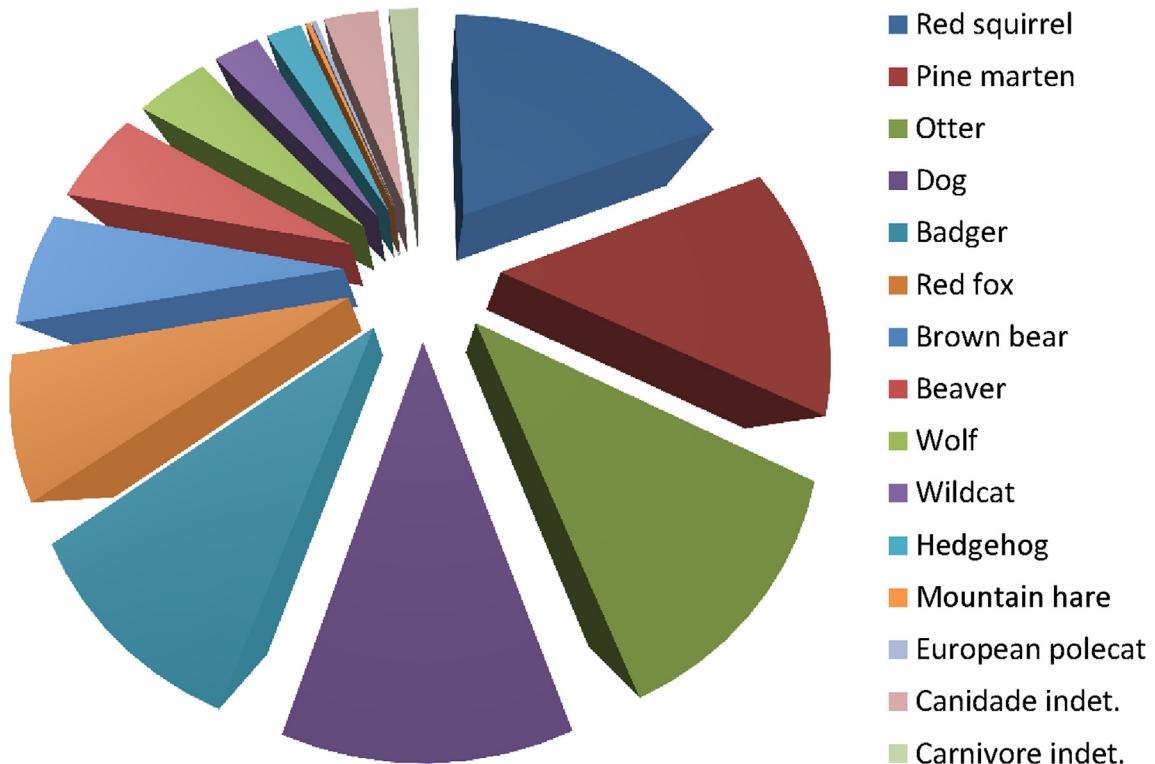


Fig. 9. Relative abundance of animals hunted for fur species. NISP = 300: red squirrel (*Sciurus vulgaris*) = 57, pine marten (*Martes martes*) = 42, otter (*Lutra lutra*) = 36, dog (*Canis familiaris*) = 32, badger (*Meles meles*) = 29, red fox (*Vulpes vulpes*) = 22, brown bear (*Ursus arctos*) = 19, beaver (*Castor fiber*) = 17, wolf (*Canis lupus*) = 14, wildcat (*Felis silvestris*) = 9, hedgehog (*Erinaceus europaeus*) = 7, mountain hare (*Lepus timidus*) = 1, European polecat (*Mustela putorius*) = 1, canidate indet. = 11, carnivora indet. = 6.

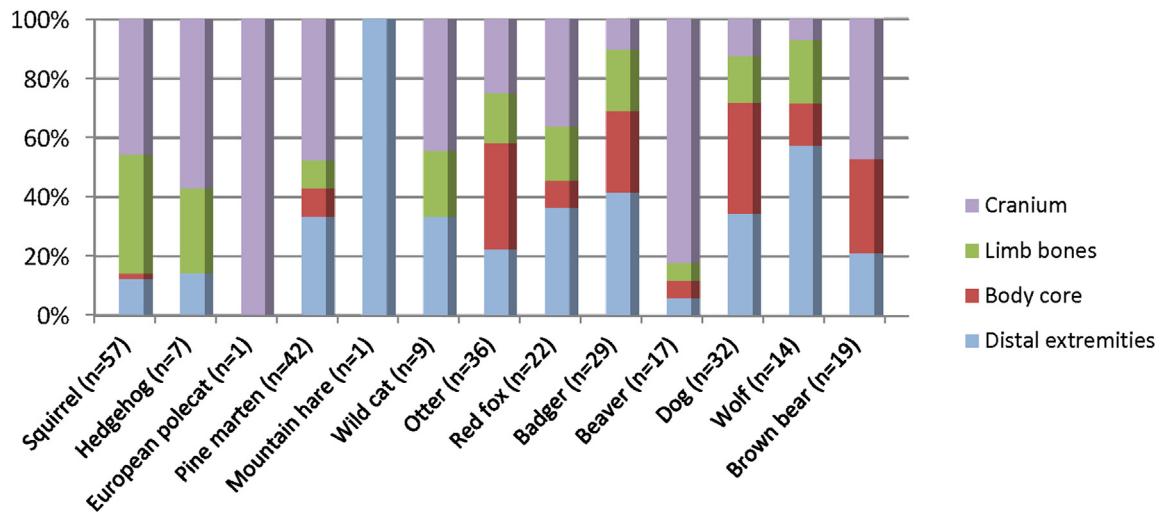


Fig. 10. Elemental distribution of fur animal species ordered according to size and based on NISP.

depending on the individual species. The presence of fur-game species in bone assemblages has commonly been argued to indicate a winter occupation (Enghoff, 2011). Fur-games can be hunted all year round, but winter pelts from most fur species are more desirable than the summer pelts (Andersson, 2006) because their insulating properties are optimal (Hart, 1956). A higher frequency of fur-game hunting can therefore be expected during the winter season, if there are indications of a sedentary lifestyle with occupation during most of the year.

Small fur-game were probably hunted using passive, unselective methods, such as wires and traps, because it is the easiest way to catch small animals (Ekman, 1910); however, it is also possible to

hunt small fur game using active methods. The most frequently occurring fur-game are squirrel and pine marten, which are fast-growing species who are completely full-grown within a year of birth (Degn, 1973; Trolle-Lassen, 1986). Thereby, the presence of only fully grown small fur-game species suggest that they were hunted towards the end of winter, by which time the cubs born last spring would have matured and their epiphyses fused. It could be argued that juveniles have a different moving pattern than adults and stay secluded in the burrow or nest while the adult animals forage for food. However, while this is true during the first months after birth it changes gradually and well before small fur-game, e.g. squirrels and pine martens, are fully grown they move and forage

for food alike their parents. Furthermore, it can be argued that bones from juveniles preserve badly, and that the pattern is the result of taphonomic loss. However, this was counter-indicated by the large number of fish bones recovered from the site, which are normally less well preserved than bones from young mammals. Thereby, the hunt of small fur-game appears to have taken place during the winter when their bones had fused epiphyses, indicating that they were fully grown and close to one year old. This seasonality indicator is further enhanced if comparing epiphyseal fusion data from sites, such as late Mesolithic Tybrind Vig in Denmark, where large amounts of pine martens have been hunted. Here epiphyseal data suggest that pine martens were mainly hunted in late autumn, with two thirds of the bone elements from the assemblage still unfused (Trolle-Lassen, 1986).

Similar to the small fur-game; only fully grown large fur-game is present in the material. However, animals such as badger, fox, bear, beaver and wolf ages slower than the above mentioned small fur-game and as such their fully grown bodies cannot be an indication of the hunt occurring during the winter and the pattern seen in the epiphyseal fusion stage of large fur-game must be understood differently. Considering the presence of exclusively fully grown fur-game in combination with the elemental distribution it appears as if adult large fur-game species could have been selectively targeted, possibly for their larger pelts. This implies a similar hunting strategy compared to cervid species if they can be said to have been selectively hunted around the time when they reached full body size (see paragraph 3.1.3.1.). Furthermore, it could also be suggested that different fur-game species were differently utilized, some having been brought back to the settlement more or less complete, presumably because their meat or other products were needed, while other species were skinned at the kill site and only the skins, with attached skull and feet, have been brought back to the settlement.

The smaller fur-game species could also have been selectively targeted; however, given that passive hunting methods are often used while hunting small game and because even if active methods were used it would have been an effort to single out only fully adult animals, typically as species such as pine marten receive their adult winter fur at the onset of the first winter (Trolle-Lassen, 1986) and thus would appear similar, at a distance, to older adults. Thereby, it is more likely that the observed pattern is an indication that small fur-game were primarily hunted during the end of the winter season.

3.1.4.2. Bird hunting

3.1.4.2.1. Bird hunting results. The birds from Norje Sunnansund were diverse and represented by species from many different biomes, such as small water courses as well as large lakes, the sea and forests. Bones from migrating birds have traditionally been used to interpret both seasonal occupation and to a lesser extent climate (Bratlund, 1991; Enghoff, 2011:269). In the case of Norje Sunnansund, the evidence provided by the bird species indicated bird hunting at least during the migration periods (Fig. 11). However, they were not necessarily hunted only during migrations. Birds have complex movement patterns, and birds moving to higher latitudes for the summer will be available during the spring and autumn. There can also be variation in the timing of migration within a bird species, with different birds having an individually optimized migration schedule (Battley, 2006; Vardanis et al., 2011).

3.1.4.2.2. Bird hunting discussion. The presence of different seasonal birds throughout the year was similar to the pattern seen in Danish Ertebølle settlements and, as birds from all seasons were present in the assemblage, it was difficult to demonstrate seasonality and site abandonment based solely on bird bones (Rowley-Conwy, 1983). The many bird species found in the bone material represent both migrating and native birds, where migrating birds

from all seasons were present. Even though birds are, in general, easier to catch during the winter, because of their flocking behavior, and consequently fowling is often a cold season activity (Serjeantson, 2009), some of the birds present could also have been hunted during the summer. Therefore it is difficult to observe seasonality or site abandonment based on the bird bones, as the species could have been hunted throughout the year. Thus bird-hunting may be considered an all year around activity, albeit one that was mainly done when the opportunity came and not an actively sought activity, indicated by the large number of species being represented by a limit amount of bird bone fragments.

3.1.5. Rodent intrusions

3.1.5.1. Rodent results. At Norje Sunnansund, rodents (small rodents from the Muridae and Cricetidae families) made up about 13% ($n = 253$) of the total mammal NISP. However, it was difficult to compare these numbers with other Scandinavian sites. At Norje Sunnansund all excavated soil was water sieved, using a 4 mm mesh sized sieve on 55% of the excavation and a 2.5 mm mesh on the remaining 45%, with mesh sizes small enough to recover rodent bones. However, previous excavations on contemporaneous sites have rarely used water sieving over the entire site and therefore small rodent bones were recovered more randomly, preventing an unbiased rodent frequency comparison. For the same reason, it was difficult to make a spatial comparison of rodent presence across Scandinavian archaeological settlements. Furthermore, as many rodents are burrowing species and can be intrusive, it is difficult to know the origin of rodent bones found in archaeological contexts. However, at Norje Sunnansund spatial analysis was possible and, because the entire site was covered by a transgression around the time of abandonment, there were no later intrusions and the rodents found were contemporary with the occupation of the site (Fig. 12). When later intrusions can be ruled out, the spatial distribution of rodents can provide important information because rodents (at least the commonly considered commensal species) are often connected with the presence of built structures and food storage (O'Connor, 2013:50; Tangri and Wyncoll, 1989:91).

3.1.5.2. Rodent discussion. The potential of identifying sedentary societies from an increase in the relative abundance of commensal animals has long been argued in archaeological contexts from the Middle East (Hesse, 1979; Tchernov, 1984). However, on its own the presence of typical commensal animal species does not indicate sedentism, as these species have existed at human settlement sites before sedentary societies emerged (Tangri and Wyncoll, 1989), and an increase in abundance can correspond with an increase in settlement size (O'Connor, 2013:43).

Evidence from Late Pleistocene Natufian settlements in the Levant indicates large quantities of house mouse (*Mus musculus*), black rat (*Rattus rattus*) and house sparrow (*Passer domesticus*) bones in the osteological assemblages (Bar-Yosef and Belfer-Cohen, 1989:473). Although there is not always a consensus of how to interpret typically commensal animals in pre-Neolithic contexts (Tangri and Wyncoll, 1989; Tchernov, 1991; Wyncoll and Tangri, 1991), it is generally agreed that omnivorous commensal animals thrive in the refuse of human societies. The best methods for quantifying the presence of commensal species, in order to understand the level of sedentism, are also heavily debated, and range from counting the relative abundance of typical commensal murids in owl pellets (Tchernov, 1984) to examining their relative abundance in wells (Cucchi et al., 2002). Even though a general approach is biased by taphonomic factors such as inter-specific site variation in excavation methodology and preservation, a quantitative approach can provide information if sites with similar excavation methods and preservation are compared.

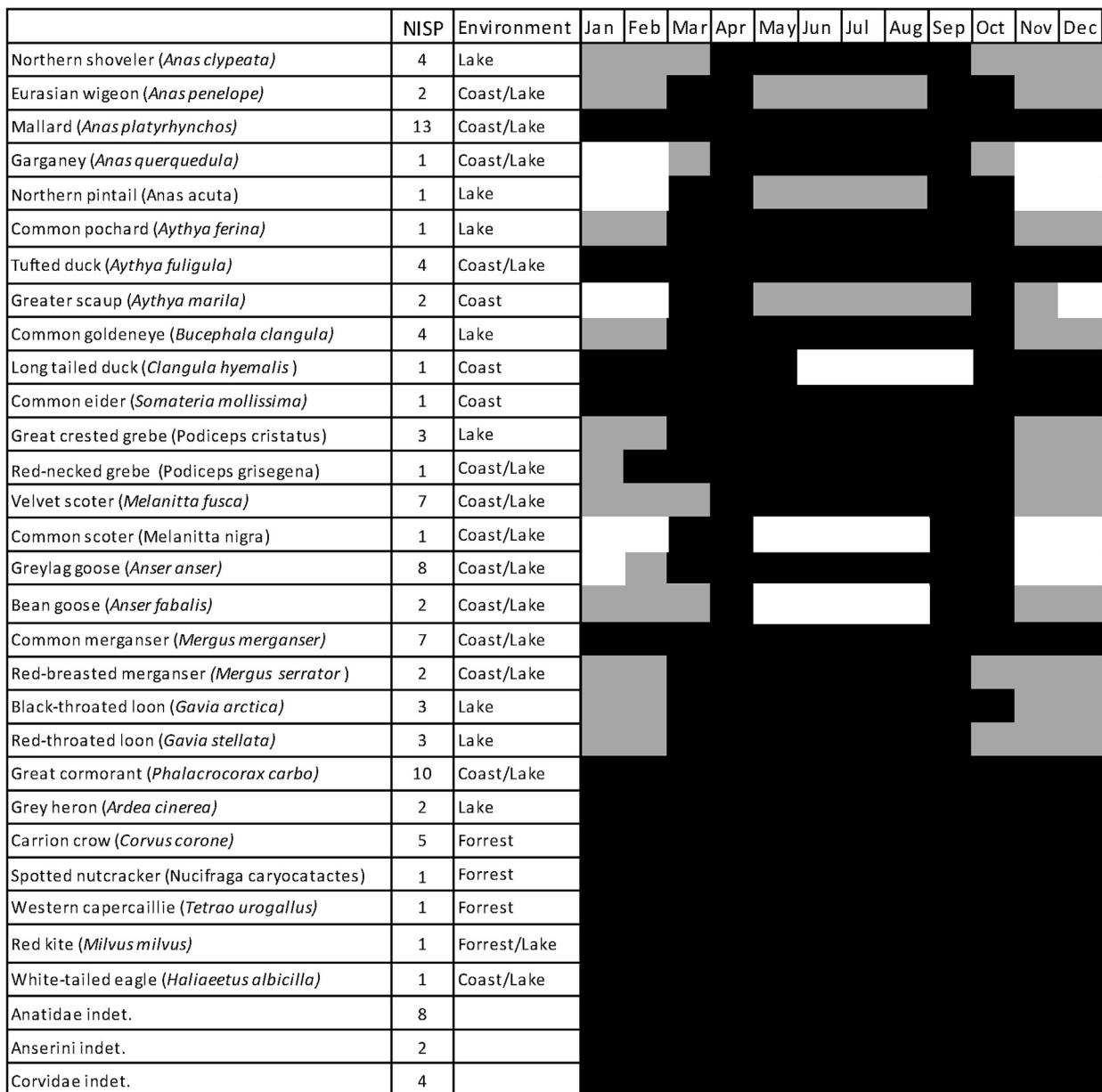


Fig. 11. Hunting seasons for the different bird species represented in the oldest layer, given the assumption that bird migration patterns have not changed significantly during the last 9000 years. Black indicates presence, grey possible presence and white absence. Based on data from Imby (1987) and Ekberg and Nilsson (1994, 1996).

On Norje Sunnansund it is apparent that most rodent bones were clustered in one specific area of the excavation (Fig. 12). This corresponds with the location of the fish fermentation feature. This is interesting, given the nature and common abundance of commensal rodent species in permanent structures and storage facilities, as noted above. However, determining which species are commensal is not straight forward, and can depend on location and environmental conditions, with different species living commensally at different human settlements (O'Connor, 2013:11). The most commonly considered commensal rodents today are probably rats and the house mouse. These murid species had not been introduced to Scandinavia 9000 years ago, but other rodents can behave in a similar manner and non-typical rodents can be considered commensal. Bearing in mind the discrepancy in which species can be considered commensal in different areas under differing circumstances (O'Connor, 2013:11), and the arguments regarding a larger commensal species diversity in the past (O'Connor,

2013:134), the implications of the concentrated presence of rodent bones centered on the fermentation pit at Norje Sunnansund, as shown in Fig. 12, are important; as it implies that native Scandinavian murine and cricetine species are comparable with the commensally recognized house mouse (*Mus musculus*) and rat species (*Rattus norvegicus/rattus*), especially if the latter species are not present at a certain location and if conditions are favorable.

The evidence from Norje Sunnansund strengthens the view that different species can become commensal, if the right conditions are met. At Norje Sunnansund, most of the identified rodent bone fragments come from water voles (*Arvicola amphibius*), yellow-necked mice (*Apodemus flavicollis*) and field voles (*Microtus agrestis*), which are generally herbivorous and not omnivorous species. However, water voles have been known to eat toads, for example there are accounts of numerous half-eaten toads in connection with water vole droppings and cut sedges (Oda Dijksterhuis, Canal & River Trust, personal communication, April 7, 2016), and fish

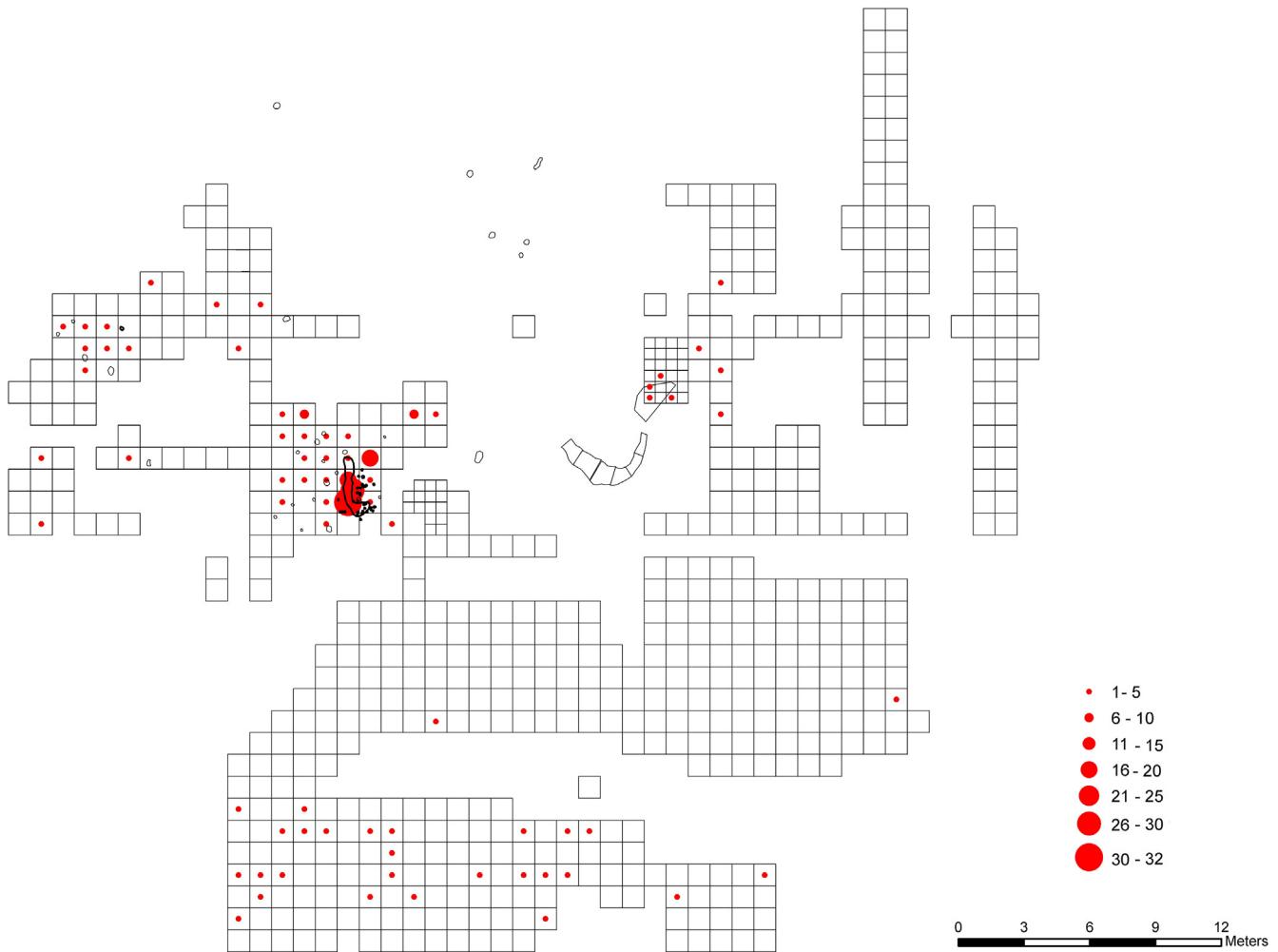


Fig. 12. The distribution and frequency of rodents at Norje Sunnansund based on NISP (red dots) within the excavation units and features from the site. NISP: water vole (*Arvicola amphibius*) = 63, yellow-necked mouse (*Apodemus flavicollis*) = 9, field vole (*Microtus agrestis*) = 9, rodent indet. (Muridae/Cricetidae) = 158. The rodent bones from the preliminary excavation not included in the figure. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

(Curry-Lindahl, 1988:270) under certain circumstances, suggesting a need to add protein to their diet. Yellow-necked mice are known to sometimes eat mammal cadavers (Curry-Lindahl, 1988:287). The presence of field voles around the fermentation pit is harder to explain because they are grass eaters that have never been observed to eat animals. However, field voles are commonly known to eat bark during the winter when fresh grass is sparse (Jensen, 2004:169), and interestingly the fermentation facility was covered with bark to aid the fermentation process (Boethius, 2016), which might, as well as the shelter offered by the construction, be the explanation for their presence. The evidence from Norje Sunnansund seems to suggest that some normally herbivorous cricetids and murinids can be omnivorous if specific criteria are met, such as easily available protein-rich food, for example the residue after a successful fermentation. Furthermore, it suggests that rodent species not commonly considered commensal can utilize a commensal living space, possibly more so when more typical commensal species are not present, which is known to modern pest-control agencies and ecologists as they are well aware of house intrusions by yellow-necked mice and backyard destruction by water voles (Anticimex, 2013; Jensen, 2004). Their increased rodent abundance in the vicinity of the fermentation facility suggests that the construction was a permanent installation, offering shelter and food for the rodents, the wall and roof structure providing them with a suitable habitat. Even though a permanent construction on a

settlement should not be regarded as evidence of permanent occupation (Boyd, 2006:170), because the structure could be returned to over different time intervals, the increased abundance of rodents around this structure suggests a pattern similar to commensal animals in early sedentary farming settlements in the Middle East, where they have been observed in large numbers within the permanent house and storage structures, e.g. at Çatalhöyük in Turkey (Jenkins, 2012:397; Jenkins, 2009; O'Connor, 2013:49, 128). In addition, studies from modern Turkey have shown that commensal rodents can consume or damage 5–15% of harvested and stored crops (McCormick, 2003), so the large quantity of rodent bone in and around the fermentation pit could even be reflected in the decision to stop fermenting fish there, as suggested by the deposition of a fish-skeleton patterned ornate bone knife on top of the fermentation pit (Boethius, 2016): increasing destruction of the fermenting fish by rodents could have ended the usefulness of that location for the pit. Eight more small fragments of other fish skeleton knives were also found during the excavation (Fig. 13), possibly indicating the presence of other abandoned fermentation facilities at the site.

3.2. Environmental prerequisites

Norje Sunnansund is located in an ecotone environment, which makes the site a typical Mesolithic settlement, when occupation

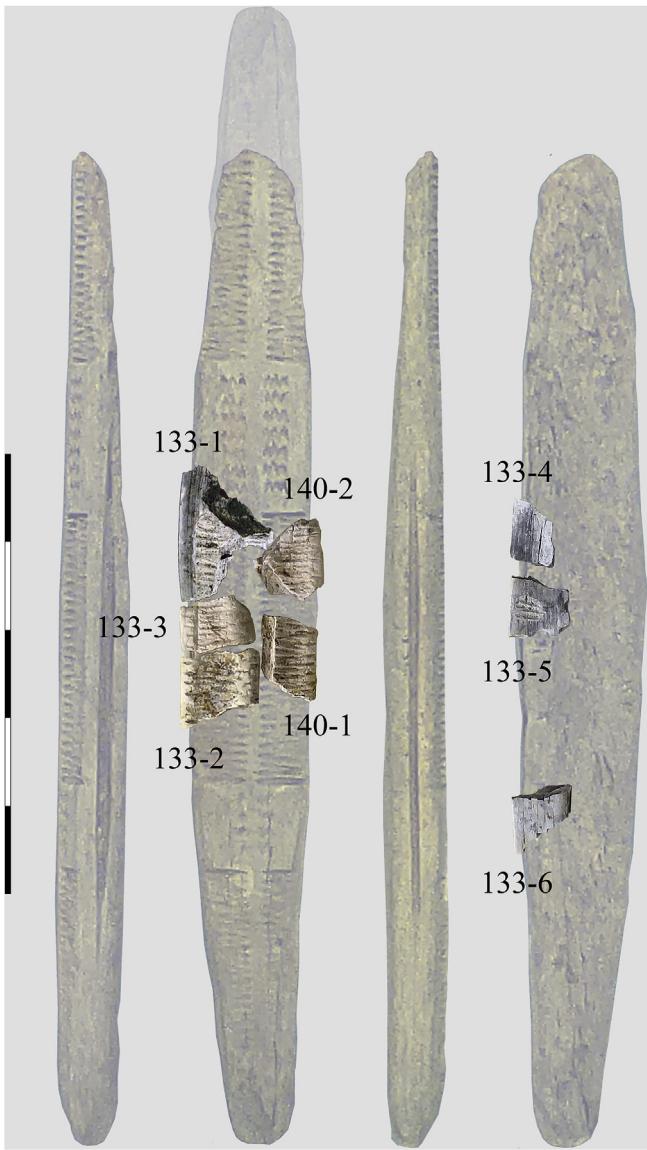


Fig. 13. The fish skeleton bone knife, and small fragments from similar knives found in other areas of the excavation site. Picture by Éva David (David and Kjällquist, in press).

sites are often located at the border of different biomes. The importance of locating settlements on lake borders cannot be understated, because of the exceptional bioproductivity of such areas (Bos et al., 2006; Mellars and Dark, 1998), and emphasizes the need to use the environment in an optimal way. In this type of environment there is access to a large set of faunal and plant resources. In the case of Norje Sunnansund, this includes vegetation zones on the shores of the different water bodies and pine forest on the slopes of Ryssberget and the surrounding flatlands. However, the most striking feature of Norje Sunnansund's location is the access to three diverse sources of water (lake, stream and sea), which facilitated fishing and hunting for seals during different parts of the year. The possibility of exploiting different subsistence resources during different parts of the year is also something that has been stressed as one of the prerequisites for sedentism in more recent foraging societies (Rowley-Conwy, 1983).

3.2.1. Storage facilities

The location of a settlement in a diverse environment is a classic risk-reducing strategy when living a sedentary lifestyle (Rowley-

Conwy and Zvelebil, 1989). The basics of the strategy are that you use as many local resources as possible and strive to create a surplus storage; thereby, if one of the resources should fail there is a back-up ready to be used. Utilizing the environment in this way is a common strategy for coping with seasonal variations and short-term crises in a well-functioning foraging society (Rowley-Conwy and Zvelebil, 1989). The creation of storage facilities is also well known in ethnographic accounts of foraging societies (Eidlitz, 1969; Minc and Smith, 1988) and is considered to be common practice (Ingold, 1983).

Because fish storage was practiced at Norje Sunnansund (Boethius, 2016), following the arguments of Rowley-Conwy and Zvelebil (1989) this implies a delayed-return economy. Although food can be stored in the landscape without constant monitoring (Binford, 1978; Ingold, 1983), indications of a prolonged stay at the site suggest that this was not the case. Moving food reserves often requires a great deal of effort and is often impractical when larger boats and effective trading routes are not available (Rowley-Conwy and Zvelebil, 1989); thereby, the presence of storage at Norje Sunnansund implies a more sedentary lifestyle.

3.2.2. Seasonality indicators

It was possible to investigate the site's seasonality using a variety of different indicators and, as illustrated in Fig. 14, the site appeared to have been inhabited throughout the year from late summer to late spring, although interpretation should be made with some caution due to the conflating of the different phases. Poor organic preservation from the youngest phase have resulted in large taphonomic losses, i.e. disintegration of juvenile bones, most fish bones and plant remains. Consequently, most of the seasonality indicators are from the oldest phase and cannot be studied in the youngest layer. The seasonality indicators were the presence of ringed seal, grey seal and roe deer fetuses, young seal calves, juvenile wild boars, red deer antlers attached to skulls, only fully grown small fur-game species, a wide array of different migratory bird species, intensified roach fishing and the presence of a fish fermentation feature. Further evidence was provided by wild cherry (*Prunus avium*) and bird cherry (*Prunus padus*) cores, hawthorn (*Crataegus*), raspberry (*Rubus idaeus*) and dewberry (*Rubus caesius*) seeds and hazel (*Corylus avellana*) and alder (*Alnus*) catkins (Kjällquist et al., 2016; Lagerås et al., forthcoming).

As indicated in Fig. 14, the relatively large number of seasonality indicators for the coldest part of the year is interesting and suggests an intensification of site use during the winter period. Norje Sunnansund is the only known settlement from Early Mesolithic southern Scandinavia with typically winter seasonal indicators. Almost all other southern Scandinavian sites with preserved organic material from this period are inland sites (apart from Huseby Klev and Balltorp on the west coast of Sweden) and display exclusively summer seasonal indicators (Carter, 2001; Price, 2015:115; Rowley-Conwy, 1993), implying that they might have been occupied only during a limited part of the year, albeit for many reoccurring visits. This distribution is probably because almost the entire European west paleo-coastline, from the Paleolithic period until the beginning of the Middle Mesolithic period, is under water as a result of the transgression following the melting of the ice after the last ice age; the north-west coast of Scandinavia is the exception to this because here the isostatic land rise have equaled the sea level rise, which have made parts of the paleo-coastline from this period visible today (Riede, 2014:567). Therefore, Norje Sunnansund has the potential to increase our understanding and interpretation of the Early Mesolithic period by adding both the dimension of a winter settlement and the dimension of a site located next to a major water body that is not submerged beneath the sea.

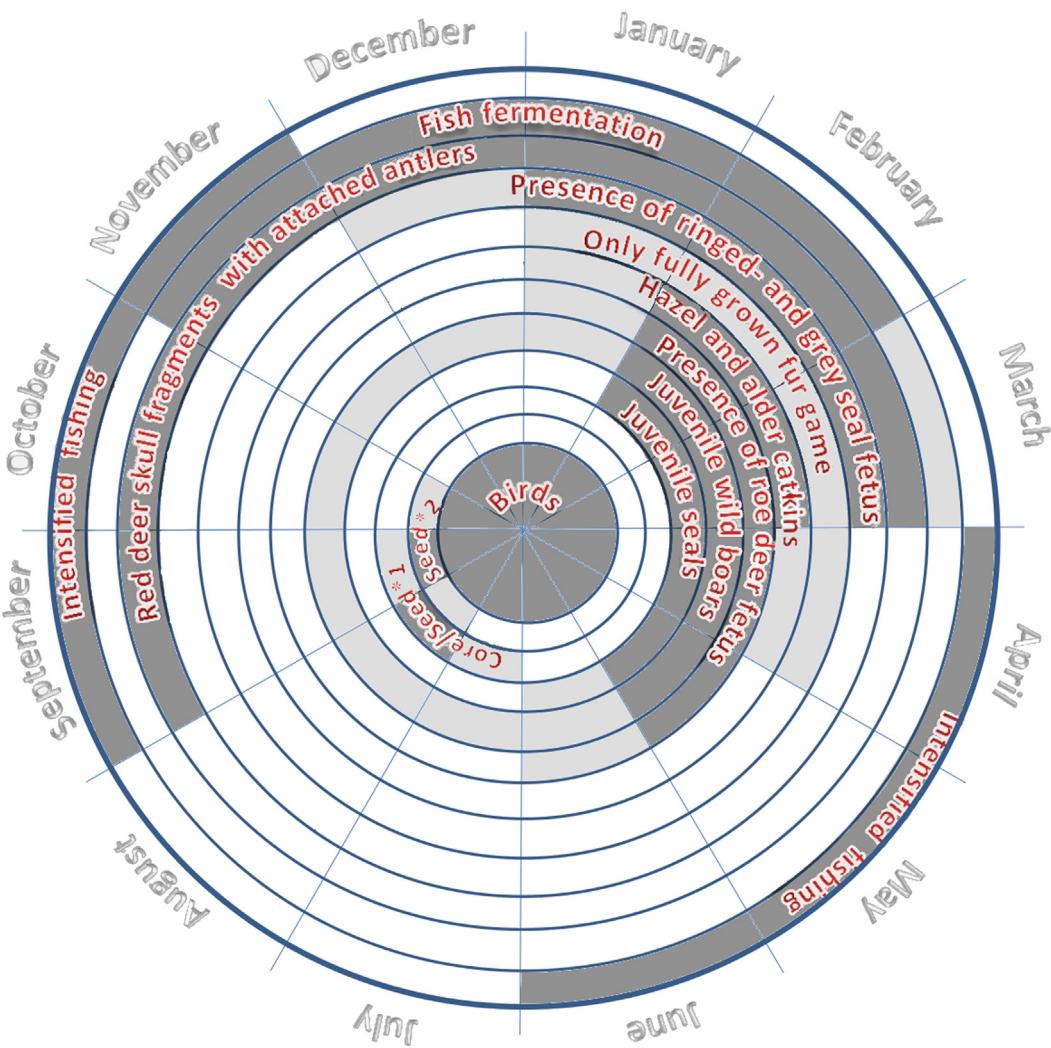


Fig. 14. Seasonality indicators from Norje Sunnansund. Dark grey shows likely seasonality indicators, light grey shows conceivable seasonality indicators.

4. Conclusion

The site of Norje Sunnansund displays a wide array of evidence linking it with a sedentary lifestyle. Fish was the main dietary component and would probably have been a constant and predictable food source at Norje Sunnansund. All year-round fishing was possible because of the three different water bodies surrounding the site, which yielded different catches depending on when and where the fishing took place. Fishing was intensified during the autumn, when large amounts of roach were caught and then fermented during the winter, and during the spring, when fish aggregated for spawning activities. Fish were therefore used to provide both a constant supply of fresh food and a source of stored surplus food to prevent periods of famine. The amount of fish caught at the site was massive and enough to feed a large number of people during most of the year (Boethius, 2017b). The large amounts of caught fish and the means to prepare and store them imply that the inhabitants used the site as a permanent settlement. Furthermore, the rodent spatial distribution suggests that the fish fermentation facility was a permanent structure. Even though the rodent species present in Scandinavia 9000 years ago are not commonly recognized today as commensal species, their spatial distribution at Norje Sunnansund suggests that it is possible for non-commensal species to behave commensally in the absence of competition. Because of the required investment in time and effort

to manufacture the equipment to facilitate large fish catches, and because the fermentation process itself is time consuming, the use of the settlement seems to fit well with an economy based on delayed-return principles.

The evidence from ungulate hunting can also be linked directly to a delayed-return economy; in particular, fully grown but not sexually mature red deer were selectively hunted. This hunting pattern ensures a continued restocking of the animals at the same time as maximizing the amount of meat and raw materials gained from them. However, the indications of a conservative hunt are controversial, exemplified by the debate of the 'ecological Indian'. Krech states that native Americans display no compelling evidence of ecological living and conservation of the environment prior to European contact but much evidence of the opposite (Krech, 2000). Smith and Wishnie (2000) examined the evidence of conservation on a global scale and concluded that there is little evidence of indigenous people practicing environmental conservation and, where it can be seen, it is rarely displayed as animal prey conservation. As this view has come to dominate the debate during the last decade, and as there is limited evidence in the anthropologic literature to suggest otherwise (Hames, 2007), it would be irrational to argue for a global environmental conservation approach by foraging people. The conservation of young red deer in the Norje Sunnansund assemblage does not imply a 'harmony with nature' lifestyle among Early Mesolithic foragers. Aurochs and elk are

almost absent from the bone assemblage, possibly as a result of prior over-exploitation, and seals were hunted indiscriminately during the late winter and early spring, with the hunt focusing on lactating females and their cubs, with no regard to age, sex or whether the females were in-calf. Nevertheless, the hunting of red deer could be considered sustainable and fits the ecological definition of conservation as a ‘costly sacrifice of immediate rewards in return for delayed ones’ (Hames, 2007). However, and importantly, it was not done to maintain red deer as the basis of a subsistence strategy. If that had been the case, it is unlikely that a conservative hunt would have been practiced; if a group of people was at risk of starvation, they would kill and eat whatever was available, but if killing in a suboptimal way would subject the group to risk later, a conservative approach might be considered. As the large amounts of caught fish and the means to store it indicate a primarily fish diet, it appears that the red deer were hunted for both meat and other raw materials. The body of a fully grown red deer yields much more meat, larger skins, thicker tendons and larger and stronger bones for making tools than subadult, smaller individuals. Therefore, a kill-off pattern representing fully grown red deer not yet in their prime would be optimal as it would provide the best raw material while at the same time conserving the reproductive animals. Even though a kill-off sex ratio is missing and the interpretation of a completely optimized hunt is not possible, the evidence for a selective red deer hunt seems compelling. Large fur-game species appear, similar to red deer, selectively hunted when fully grown, even though the available data is limited and taphonomic biases, concerning the preservation of juvenile bones, can have affected the interpretation. This suggests that selective hunting strategies can have been used to target the largest individuals supplying the largest pelts while, at the same time, act to reduce competition from adult predators in the areas surrounding the settlement. The inhabitants of Norje Sunnansund therefore appeared to practice a delayed-return strategy of managing their resources similar to pastoralist behavior, not commonly associated with foraging economies (Ingold, 1983:565).

It is currently unclear whether Norje Sunnansund should be considered an exceptional or a common Early Mesolithic winter/all-year round settlement. Contemporaneous settlement permanence has been suggested outside of Scandinavia, e.g. at Star Carr (Conneller et al., 2012). However, on a more local basis it is unlikely that this matter will be completely resolved until another Early Mesolithic winter settlement/coastal site with preserved organic material is found or until further excavations on known Early Mesolithic sites can be conducted (including on Norje Sunnansund as only small parts of the original site has been excavated). Overall, the material from Norje Sunnansund indicates an Early Mesolithic delayed-return sedentary lifestyle in southern Scandinavia, with subsistence strategies based on storing surplus while at the same time exploiting different aspects of the immediate environment. If Norje Sunnansund is put in the context of wider settlement systems, as defined by Rowley-Conwy (1993), the evidence fit Kent (1989)'s definition of a sedentary society. Albeit a society that has not yet experienced over-crowding and where indications of seasonal occupation decline during the summer is a part of the annual cycle, as illustrated by summer seasonality indications on Norje Sunnansund being limited to the presence of certain bird species and to the cores and seeds from various plants while the other seasons show a greater seasonality indication diversity. The contemporaneous inland sites, all with exclusively summer indicators, therefore could have functioned as seasonal hunting grounds, with smaller hunting parties scattered across the landscape for hunting forays during the summer and into the autumn, after which they rejoined those who stayed at the permanent coastal settlement. This bears some resemblance to previous models where winter camps have been

suggested as aggregated settlements located on the coast (Blankholm, 1996:125–26; Larsson, 1980). However, with the crucial evidence provided by the massive amount of fish, evidence of delayed-return storage facilities, all year-round seasonal indicators, a selective red deer hunt and rodent intrusions in permanent structures, Norje Sunnansund implies that coastal sites did not function as a seasonal stop along transient routes, but instead as a permanent settlement from which summer excursions by smaller groups of people were undertaken. Even though it is not known how representative Norje Sunnansund is compared with other contemporaneous coastal settlements, the presence of at least one sedentary society indicates the beginning of a revolution that ultimately led to the large and widespread, non-egalitarian, socially stratified, aquatically dependent and sedentary communities that can be observed in the Late Mesolithic Ertebølle culture. The knowledge that aquatically dependent, sedentary communities had existed for thousands of years prior to the development of the Neolithic lifestyle indicates that the Mesolithic communities in Scandinavia had experienced a long period of population growth, as suggested by the fact that the only way to increase populations in cold environments is through the exploitation of aquatic resources (Binford, 2001:216). Following thousands of years of exploiting aquatic resources, by the end of the Mesolithic era southern Scandinavia could have been densely populated, even crowded, and as such these communities could indeed be compared with the native American aquatically dependent communities of the north-west coast prior to European contact. Furthermore, a long tradition of aquatically reliant sedentary Scandinavian foragers explains the temporal boundary of the agricultural frontier, for as long as a millennia, when the Neolithic lifestyle reached the southern Baltic (Cummings et al., 2014) and why Scandinavians remained foragers significantly longer than settlements further south: they were numerous enough to withstand contingent territorial claims from advancing farmers and content enough with their lifestyle not to change it.

Acknowledgements

I would like to thank the Berit Wallenberg Foundation (BWS 2012.0047) and Blekinge museum and the project management of the E22 Sövle-Stensnäs project for financing and enabling this research. Furthermore, I would like to thank Ola Magnell, Torbjörn Ahlström and two anonymous reviewers for reading the manuscript and offering comments on the content, and Mathilda Kjällquist for providing interesting discussions and help with some of the figures.

Appendix

The appendices includes number of identified specimens (NISP), minimum number of individuals (MNI), Weight, number of unidentified specimens (NUISP) and number of specimens (NSP) for each animal class found at Norje Sunnansund. The data is presented within the different contexts in addition to the total value used in this study. The old phase includes the oldest cultural layer and some minor features associated with the old phase, but not associated with the fermentation facility. The fermentation facility is contemporaneous with the old phase and includes the finds within the main fermentation facility and its surrounding postholes and stakeholes. The young phase includes the youngest cultural layer. The fluvial mixed layer is a layer deposited in the water close to the beach; it is a mix of both land layers and thus a temporal mix of both settlement phases. MNI have been calculated using overlapping parts of the most frequently occurring element. Age differences have not been considered while calculating MNI. The total MNI is not the sum of the different context MNI but a derived calculation. In the main paper total NISP has been used as the means of quantification.

Appendix Table 1

The mammal bones from Norje Sunnansund.

Mammals (Mammalia)																				
Family	Species	NISP				MNI				Weight (g)				Total						
		Old phase	Fermentation facility	Young phase	Fluvial waste layer	Preliminary excavation	Old phase	Fermentation facility	Young phase	Fluvial waste layer	Preliminary excavation	Old phase	Fermentation facility	Young phase	Fluvial waste layer	Preliminary excavation	NISP	MNI	Weight (g)	
Ungulates																				
Cervidae	Red deer (<i>Cervus elaphus</i>)	194		63	113	3	3		1	3	1	1962		273,3	1601,7	14,2	373	5	3851,6	
	Roe deer (<i>Capreolus capreolus</i>)	218	1	23	29		3		1	2		420,3	0,6	37,8	23,7		271	4	482,4	
	Elk (<i>Alces alces</i>)	4		4	11	2	1	n/a	1	2		79,4		53,1	61,8		19	2	194,3	
Bovidae	Cervidae indet.	24		2	3	2	2				2	63,4	4,7	36,5	4,9		31	n/a	109,5	
	Aurochs (<i>Bos primigenius</i>)	30			2		2				639,4		251,7			32	2	891,1		
Suidae	Wild boar (<i>Sus scrofa</i>)	220	2	49	53	7	3	1	3	2	1	762,3	17,1	117,5	171,2	35,8	331	4	1103,9	
Seals																				
Phocidae	Grey seal (<i>Halichoerus grypus</i>)	57	1	10	9		7	1	2	1		168,4	0,8	30,4	26,1		77	9	225,7	
	Ringed seal (<i>Pusa hispida</i>)	27	1	7	6	1	2	1	2	1	1	30,1	0,74	12,8	22,7	5,1	42	3	71,44	
	Phocidae indet.	118	16	17	21		4	1	1	1		136,1	7,96	21,7	21,2		172	5	186,96	
Animals hunted for fur																				
Ursidae	Brown bear (<i>Ursus arctos</i>)	11		4	4		1		1	1		29,7		31,7	6,6		19	2	68	
Canidae	Wolf (<i>Canis lupus</i>)	3		3	8		1		1	2		5,5		7	70,7		14	2	83,2	
	Red fox (<i>Vulpes vulpes</i>)	12		4	5	1	1		1	1	1	12,1		1,8	3,1	0,3	22	2	17,3	
	Dog (<i>Canis familiaris</i>)	22		3	7		1		1	1		28,1		3,6	11,3		32	2	43	
Mustelidae	Canidae indet.	6		1	4		n/a				1		8,3		1,2	1,6		11	n/a	11,1
	Badger (<i>Meles meles</i>)	23		6		2			1			9,8		5,6			29	2	15,4	
	Otter (<i>Lutra lutra</i>)	21		11	4		1		2	1		9,1		12,4	1,9		36	2	23,4	
	Pine marten (<i>Martes martes</i>)	32		5	4	1	2		1	1	1	8,1		1,3	0,5	1,3	42	3	11,2	
	European polecat (<i>Mustela putorius</i>)	1					1					0,9					1	1	0,9	
Felidae	Wild cat (<i>Felis silvestris</i>)	6		1	2		1		1	1		3		0,2	0,7		9	1	3,9	
	Carnivora indet.	5			1		n/a					3,9			0,2		6	n/a	4,1	
Erinaceidae	European hedgehog (<i>Erinaceus europaeus</i>)	7				3					2,3					7	3	2,3		
Leporidae	Mountain hare (<i>Lepus timidus</i>)	1				1					0,5					1	1	0,5		

Appendix Table 1 (continued)

Mammals (Mammalia)																			
Family	Species	NISP				MNI				Weight (g)				Total					
		Old phase	Fermentation facility	Young phase	Fluvial waste layer	Preliminary excavation	Old phase	Fermentation facility	Young phase	Fluvial waste layer	Preliminary excavation	Old phase	Fermentation facility	Young phase	Fluvial waste layer	Preliminary excavation	NISP	MNI	Weight (g)
Castoridae	Beaver (<i>Castor fiber</i>)	9		4	3	1	2		1	1	1	47,5		4,3	1,4	1,3	17	2	54,5
Sciuridae	Red squirrel (<i>Sciurus vulgaris</i>)	46	1	7	3		6	1	2	1		6	0,06	0,7	0,3		57	8	7,06
Rodents																			
Cricetidae	Water vole (<i>Arvicola amphibius</i>)	36	13	3	11	9	10	2	1	3	1	8,2	1,72	0,3	1,9	0,4	72	12	12,52
	Field (<i>Microtus agrestis</i>)	6	2		1	5	3	1		1	1	0,6	0,2		0,1	0,1	14	5	1
Muridae	Yellow-necked mouse (<i>Apodemus flavicollis</i>)	7	2				4	1				1,3	0,21				9	4	1,51
	Rodent indet. (Rodentia)	109	12	8	29		n/a					8,6	0,85	0,9	2,7		158	n/a	13,05
Humans																			
Hominidae	Human (<i>Homo sapiens</i>)	6		9	20	1	1		5	2	1	13,9		11,2	100,3	2,1	36	5	127,5
Total mammals																			
NISP	Sum of identified mammals	1261	51	244	353	29	66	9	29	30	8	4469	30,24	633,5	2419,9	56,4	1940	91	7618,34
NUSP	Mammal indet. (Mammalia)	11,467	68	2538	2295	60		n/a				3444	11,42	1079	789,8	31,4	16,428	n/a	5356,32
NSP	Number of specimens	12,728	119	2782	2648	89		n/a				7914	41,66	1713	3209,7	87,8	18,368	n/a	12,974,66

Appendix Table 2

The bird bones from Norje Sunnansund.

Birds (Aves)																		
Family	Species	NISP				MNI				Weight (g)				Total				
		Old phase	Fermentation facility	Young phase	Fluvial waste layer	Preliminary excavation	Old phase	Fermentation facility	Young phase	Fluvial waste layer	Preliminary excavation	Old phase	Fermentation facility	Young phase	Fluvial waste layer	Preliminary excavation	NISP	MNI
Anatidae	Northern shoveler (<i>Anas clypeata</i>)	3		1			1		1		0,8		0,2			4	2	1
	Eurasian wigeon (<i>Anas penelope</i>)	1			1		1			1	0,4		0,2			2	1	0,6
	Mallard (<i>Anas platyrhynchos</i>)	9		4			2		1		9,4		2,6			13	2	12
	Garganey (<i>Anas querquedula</i>)	1					1				0,5					1	1	0,5
	Northern pintail (<i>Anas acuta</i>)	1					1				0,3					1	1	0,3
	Common pochard (<i>Aythya ferina</i>)	1					1				0,2					1	1	0,2
	Tufted duck (<i>Aythya fuligula</i>)	3			1		1			1	1,2		1			4	2	2,2
	Greater scaup (<i>Aythya marila</i>)	2					1				1,3					2	1	1,3
	Common goldeneye (<i>Bucephala clangula</i>)	4					1				1,5					4	1	1,5
	Long tailed duck (<i>Clangula hyemalis</i>)	1					1				0,2					1	1	0,2
	Common eider (<i>Somateria mollissima</i>)	1					1				1					1	1	1
	Velvet scoter (<i>Melanitta fusca</i>)	5	1		1		2	1		1	7,5	1		0,3		7	2	8,8
	Common scoter (<i>Melanitta nigra</i>)			1				1					1,5			1	1	1,5
	Common merganser (<i>Mergus merganser</i>)	4	2		1		1	1		1	3,3	1,1		1		7	1	5,4
	Red-breasted merganser (<i>Mergus serrator</i>)	2					1				0,4					2	1	0,4
	Greylag goose (<i>Anser anser</i>)	6			2		1			1	6,8		5			8	1	11,8
	Bean goose (<i>Anser fabalis</i>)	1			1		1			1	5		2			2	1	7
	Anserini indet.	2					1				1,5					2	1	1,5
	Anatidae indet.	7		1			1		1		2,5		0,2			8	1	2,7
Podicipedidae	Great crested grebe (<i>Podiceps cristatus</i>)			2	1				1			2,3	1,6			3	1	3,9
	Red-necked grebe (<i>Podiceps grisegena</i>)				1				1				1			1	1	1
Gaviidae	Black-throated loon (<i>Gavia arctica</i>)	3					1				5					3	1	5
	Red-throated loon (<i>Gavia stellata</i>)	2			1		1		1		2		0,3			3	1	2,3

Appendix Table 2 (continued)

Birds (Aves)																				
Family	Species	NISP						MNI						Weight (g)						Total
		Old phase	Fermentation facility	Young phase	Fluvial waste layer	Preliminary excavation	Old phase	Fermentation facility	Young phase	Fluvial waste layer	Preliminary excavation	Old phase	Fermentation facility	Young phase	Fluvial waste layer	Preliminary excavation	NISP	MNI	Weight (g)	
Phalacrocoracidae	Great cormorant (<i>Phalacrocorax carbo</i>)	7		2	1	1			1		10,6			3	1,3	10	1	14,9		
Ardeidae	Grey heron (<i>Ardea cinerea</i>)	2					1				1,2					2	1	1,2		
Corvidae	Carrion crow (<i>Corvus corone</i>)	4	1				1				1,9	0,2				5	1	2,1		
	Spotted nutcracker (<i>Nucifraga caryocatactes</i>)		1				1				0,13					1	1	0,13		
Phasianidae	Corvidae indet.	4					3				2,5					4	3	2,5		
	Western capercaillie (<i>Tetrao urogallus</i>)	1					1				1					1	1	1		
Accipitridae	Red kite (<i>Milvus milvus</i>)	1					1				0,3					1	1	0,3		
Accipitridae	White-tailed eagle (<i>Haliaeetus albicilla</i>)	1					1				2					1	1	2		
Total birds																				
NISP	Sum of identified bird specimens	79	5	10	11	1	31	3	6	9	1	70,3	2,43	7,1	15,1	1,3	106	37	96,23	
NUSP	Indeterminable bird specimens (Aves)	62	2	2	4	2	n/a					17,6	0,09	0,5	3,9	1,8	70	n/a	23,89	
NSP	Number of bird specimens	141	7	12	15	3	n/a					87,9	2,52	7,6	19	3,1	176	n/a	120,12	

Appendix Table 3

The fish bones from Nørje Sunnansund.¹ Quantifications are based on a partial analysis of the entire fish bone assemblage. The analyzed fish bones were randomly selected from different areas of the three cultural layers while the fish bone remains in the fermentation facility was comprehensively analyzed. Dependent on phase the proportion of analyzed fish bones vary: old phase ≈ 6,9%, fermentation facility 100%, young phase ≈ 39%, fluvial mixed layer ≈ 7%.² MNI in the fermentation facility have been derived without including the fish bones within the postholes, stakeholes or the eastern part of the feature sieved using a 5 mm mesh (for further specification see Boethius, 2016, 2017b).³ No attempts have been made to derive the total fish MNI.

Fish (Pisces)		NISP												MNI												Weight (g)												Total												
Family	Species	Old phase				Fermentation facility				Young phase				Fluvial waste layer				Preliminary excavation				Old phase				Fermentation facility				Young phase				Fluvial waste layer				Preliminary excavation				NISP			MNI			Weight (g)		
		Old phase	Fermentation facility	Young phase	Fluvial waste layer	Old phase	Fermentation facility	Young phase	Fluvial waste layer	Old phase	Fermentation facility	Young phase	Fluvial waste layer	Old phase	Fermentation facility	Young phase	Fluvial waste layer	Old phase	Fermentation facility	Young phase	Fluvial waste layer	Old phase	Fermentation facility	Young phase	Fluvial waste layer	Old phase	Fermentation facility	Young phase	Fluvial waste layer	Old phase	Fermentation facility	Young phase	Fluvial waste layer	Preliminary excavation	Total NISP	Total MNI	Total Weight (g)													
Cyprinidae	Cyprinids indet. (Cyprinidae)	3162	7418	51	73	4	91	213	4	3	1	99,67	192,43	3,3	2,9	0,3	10,708	n/a*	298,599																															
	Cyprinids (<i>Rutilus/ Leuciscus</i>)	127	34									4,1	1,2																							161	n/a*	5,3												
	Roach (<i>Rutilus rutilus</i>)	347	665	1	3							24,7	36,12	0,2	0,3																			1016	n/a*	61,32														
	Silver bream (<i>Blica bjoerkna</i>)		3										0,2																							3	n/a*	0,2												
	Bream (<i>Abramis brama</i>)	6	13			1						0,6	1,06																						20	n/a*	1,96													
	European chub (<i>Squalius cephalus</i>)	2	4									0,2	0,32																						6	n/a*	0,52													
	Crucian carp (<i>Carassius carassius</i>)	2	5			1						0,2	0,4																						8	n/a*	0,7													
	Rudd (<i>Scardinius erythrophthalmus</i>)	3	9	1								0,5	0,88	0,2																				13	n/a*	1,58														
	Dace (<i>Leuciscus leuciscus</i>)	2	9									0,2	0,26																						11	n/a*	0,46													
	Tench (<i>Tinca tinca</i>)	5	13		1							0,5	1,4		0,1																			19	n/a*	2														
Percidae	Bleak (<i>Alburnus alburnus</i>)	1	5									0,1	0,32																						6	n/a*	0,42													
	Ide (<i>Leuciscus idus</i>)	2	5									0,2	0,5																						7	n/a*	0,7													
	Perch (<i>Perca fluviatilis</i>)	926	1327	122	201	152	35	35	5	10	6	39,66	31,87	6,5	8,6	5,1	2728	n/a*	91,73																															
	Pike perch (<i>Sander lucioperca</i>)	20	5	9	19		1	1	1	2		2,1	0,24	1,7	1,9		53	n/a*	5,94																															
Esocidae	Ruffe (<i>Gymnocephalus cernua</i>)	1	34					1	1			0,1	0,3																					35	n/a*	0,4														
	Percidae indet.		13								1																									13	n/a*	0,5												
	Pike (<i>Esox lucius</i>)	419	588	37	51	3	10	11	2	5	1	50,47	51,67	6,6	7,1	0,5	1098	n/a*	116,34																															
Lotidae	Burbot (<i>Lota lota</i>)	25	55	1	2		1	4	1	1		1,8	3,05	0,1	0,2		83	n/a*	5,15																															
	Arctic char (<i>Salvelinus alpinus</i>)		3					1				0,09					3	n/a*	0,09																															
Salmonidae	Whitefish (<i>Coregonus sp.</i>)	11	19	1	1		1	1	1	1		0,9	1,3	0,1	0,1		32	n/a*	2,4																															
	Trout (<i>Salmo trutta</i>)	1					1					0,1					1																																	
	Salmonids indet. (Salmonidae)	5	2				1	1				0,5	0,21				7	n/a*	0,71																															
	Salmon (<i>Salmo salar</i>)				1					1																										1	n/a*	0,1												
	Eel (<i>Anguilla anguilla</i>)	58	79	1		2	2		1			2,2	1,6				138	n/a*	4																															
Osmeridae	Smelt (<i>Osmerus eperlanus</i>)		10					2					0,43					10	n/a*	0,43																														

Appendix Table 3 (continued)

Fish (Pisces)		Species	NISP			MNI			Weight (g)			Total	
Family			Old phase facility	Fermentation phase	Young phase	Fluvial waste layer	Preliminary excavation	Old phase facility	Fermentation phase	Young phase	Fluvial waste layer	Preliminary excavation	
Total pisces													
NISP	Sum of identified fish	5125	10,318	223	354	160	144	273	14	24	8	228.8	326.35
NISP	Indeterminable fish specimens (pisces)	1010	3186	22	110	86	n/a					28.13	52.75
NISP	Number of fish specimens	6135	13,504	245	464	246	n/a					256.9	379.1

References

- Aaris-Sørensen, K., 1978. Knoglematerialet fra den mellemneolitiske boplads ved Korsnäs, Riksantikvarieämbetet och Statens Historiska Museer Rapport (Stockholm).
- Albrethsen, S.E., Brinch Petersen, E., 1976. Excavation of a Mesolithic cemetery at Vedbæk, Denmark. *Acta Archaeol.* 47, 1–28.
- Almkvist, L., Olsson, M., Söderberg, S., 1980. Sålar i Sverige. Svenska Natur-skyddsföreningen, Stockholm. ISBN 91-558-5171-1 (in Swedish).
- Alvard, M.S., 1993. Testing the "ecologically noble savage" hypothesis: interspecific prey choice by Piro hunters of Amazonian Peru. *Hum. Ecol.* 21, 355–387.
- Anderson, K., 2005. Tending the Wild: Native American Knowledge and the Management of California's Natural Resources. University of California Press, Berkeley.
- Andersson, E.I., 2006. Kläderna och människan i medeltidens Sverige och Norge. Göteborg University.
- Andrén, T., Björck, S., Andrén, E., Conley, D., Zillén, L., Anjar, J., 2011. The Development of the Baltic Sea Basin during the Last 130 ka, the Baltic Sea Basin. Springer, pp. 75–97.
- Anticimex, 2013. Facts on Rats and Resistance (Stockholm).
- Antonsson, K., 2006. Holocene Climate in Central and Southern Sweden: Quantitative Reconstructions from Fossil Data. Uppsala University, Uppsala.
- Arnold, J.E., 1996. The archaeology of complex hunter-gatherers. *J. Archaeol. Method Theory* 3, 77–126.
- Aswani, S., 1998. Patterns of marine harvest effort in southwestern New Georgia, Solomon Islands: resource management or optimal foraging? *Ocean Coast. Manag.* 40, 207–235.
- Bar-Yosef, O., Belfer-Cohen, A., 1989. The origins of sedentism and farming communities in the Levant. *J. World Prehistory* 3, 447–498.
- Battley, P.F., 2006. Consistent annual schedules in a migratory shorebird. *Biol. Lett.* 2, 517–520.
- Bay-Petersen, J., 1978. Animal exploitation in mesolithic Denmark. In: Mellars, P.A. (Ed.), The Early Postglacial Settlement of Northern Europe. Duckworth, London, pp. 115–146.
- Bender, B., 1978. Gatherer-hunter to farmer: a social perspective. *World Archaeol.* 10, 204–222.
- Berkes, F., Turner, N.J., 2006. Knowledge, learning and the evolution of conservation practice for social-ecological system resilience. *Hum. Ecol.* 34, 479–494.
- Binford, L.R., 1968. Post-pleistocene adaptations. In: Binford, L.R., Binford, S.R. (Eds.), New Perspectives in Archeology. Aldine, Chicago, pp. 313–341.
- Binford, L.R., 1978. Nunamiat Ethnoarchaeology. Academic Press New York.
- Binford, L.R., 1981. Bones: Ancient Men and Modern Myths. Academic Press, New York.
- Binford, L.R., 2001. Constructing Frames of Reference: an Analytical Method for Archaeological Theory Building Using Ethnographic and Environmental Data Sets. University of California Press, Berkeley.
- Blankholm, H.P., 1996. On the Track of a Prehistoric Economy: Maglemosian Subsistence in Early Postglacial South Scandinavia. Aarhus Universitetsforlag.
- Boethius, A., 2016. Something rotten in Scandinavia: the world's earliest evidence of fermentation. *J. Archaeol. Sci.* 66, 169–180.
- Boethius, A., 2017a. Huseby klev and the quest for pioneer subsistence strategies: diversification of a maritime lifestyle. In: Persson, P., Skar, B., Breivik, H.M., Riede, F., Jonsson, L. (Eds.), The Ecology of Early Settlement in Northern Europe – Conditions for Subsistence and Survival. Equinox, Sheffield (in press).
- Boethius, A., 2017b. The use of aquatic resources by Early Mesolithic foragers in southern Scandinavia. In: Persson, P., Skar, B., Breivik, H.M., Riede, F., Jonsson, L. (Eds.), The Ecology of Early Settlement in Northern Europe – Conditions for Subsistence and Survival. Equinox, Sheffield (in press).
- Bos, J.A., Urz, R., 2003. Late Glacial and early Holocene environment in the middle Lahm river valley (Hessen, central-west Germany) and the local impact of early Mesolithic people—pollen and macrofossil evidence. *Veg. Hist. Archaeob.* 12, 19–36.
- Bos, J.A., van Geel, B., Groenewoudt, B.J., Lauwerier, R.C.M., 2006. Early Holocene environmental change, the presence and disappearance of early Mesolithic habitation near Zutphen (The Netherlands). *Veg. Hist. Archaeob.* 15, 27–43.
- Bosold, K., 1966. Geschlechts- und Gattungsunterschiede an Metapodien und Phalangen mitteleuropäischer (Wildwiederkäuer, München).
- Boyd, B., 2006. On 'sedentism' in the Later Epipalaeolithic (Natufian) Levant. *World Archaeol.* 38, 164–178.
- Bratlund, B., 1991. The bone remains of Mammals and birds from the Bjørnsholm Shell-mound: a preliminary report. *J. Dan. Archaeol.* 10, 97–104.
- Briedermann, L., 1990. Schwarzwild (Dt. Landwirtschaftsverl., Berlin).
- Brown, J.A., 1985. Long-term trends to sedentism and the emergence of complexity in the American midwest. In: Price, D.T., Brown, J.A. (Eds.), Prehistoric Hunter-gatherers: the Emergence of Cultural Complexity. Academic press, Orlando.
- Burch, E., 2007. Rationality and Resource Use Among Hunters: Some Eskimo Examples. University of Nebraska, Lincoln.
- Carter, R.J., 2001. Dental indicators of seasonal human presence at the Danish boreal sites of Holmegaard I, IV and V and mullerup and the Atlantic sites of Tybrind Vig and Ringkloster. *Holocene* 11, 359–365.
- Clutton-Brock, T.H., Albon, S.D., 1989. Red Deer in the Highlands. Blackwell Scientific, Oxford.
- Clutton-Brock, T.H., Guinness, F.E., 1982. Red Deer: Behavior and Ecology of Two Sexes. University of Chicago Press.

- Clutton-Brock, T.H., Albon, S., Gibson, R., Guinness, F.E., 1979. The logical stag: adaptive aspects of fighting in red deer (*Cervus elaphus* L.). *Anim. Behav.* 27, 211–225.
- Clutton-Brock, T.H., Albon, S.D., Guinness, F.E., 1986. Great expectations: dominance, breeding success and offspring sex ratios in red deer. *Anim. Behav.* 34, 460–471.
- Conneller, C., Milner, N., Taylor, B., Taylor, M., 2012. Substantial settlement in the European early Mesolithic: new research at star Carr. *Antiquity* 86, 1004–1020.
- Cucchi, T., Vigne, J.-D., Auffray, J.-C., Croft, P., Peltenburg, E., 2002. Introduction involontaire de la souris domestique (*Mus musculus domesticus*) à Chypre dès le Néolithique précéramique ancien (fin IX e et VIII e millénaires av. J.-C.). *Comptes Rendus Palevol* 1, 235–241.
- Cummings, V., 2013. The Anthropology of Hunter-Gatherers: Key Themes for Archaeologists. Bloomsbury Academic, London.
- Cummings, V., 2014. Hunter-gatherers in the post glacial world. In: Cummings, V., Jordan, P., Zvelebil, M. (Eds.), *The Oxford Handbook of the Archaeology and Anthropology of Hunter-gatherers*. Oxford University Press, Oxford.
- Cummings, V., Jordan, P., Zvelebil, M., 2014. *The Oxford Handbook of the Archaeology and Anthropology of Hunter-gatherers*. OUP Oxford.
- Curry-Lindahl, K., 1969. *Fiskarna i färg*, seventh ed. Almqvist & Wiksell, Stockholm.
- Curry-Lindahl, K., 1988. *Däggdjur. groddjur & kräldjur*. Norstedt.
- David, É., Kjällquist, M., 2017. Transmission of the Mesolithic Northeastern crafting tradition. The Norje Sunnansund style introduced in the Maglemosian area around 9.3 ka BP. In: Glørstad, H., Knutsson, K., Knutsson, H., Apel, J. (Eds.), *The Technology of Early Settlement in Northern Europe – Transmission of Knowledge and Culture*. Equinox, Sheffield (in press).
- Davis, B., Brewer, S., Stevenson, A., Guiot, J., 2003. The temperature of Europe during the Holocene reconstructed from pollen data. *Quat. Sci. Rev.* 22, 1701–1716.
- Degn, H.J., 1973. Systematic Position, Age Criteria and Reproduction of Danish Red Squirrels (*Sciurus vulgaris* L.).
- Eiditz, K., 1969. Food and Emergency Food in the Circumpolar Area. Almqvist & Wiksell, Uppsala.
- Ekberg, B., Nilsson, L., 1994. Skånes fåglar i dag och i gången tid. Del 1 Lommar till och med alkor (Kristianstad).
- Ekberg, B., Nilsson, L., 1996. Skånes fåglar i dag och i gången tid. Del 2 Stäpphöna till och med kornsparv (Kristianstad).
- Ekman, S., 1910. Norrlands jakt och fiske. Almqvist & Wiksell, Uppsala.
- Elias, S., Schreve, D., 2007. Late Pleistocene megafaunal extinctions. In: Elias, S. (Ed.), *Encyclopedia of Quaternary Science*, vol. 4. Elsevier Science Publishers, Amsterdam, pp. 3202–3217.
- Enghoff, I.B., 2011. Regionality and Biotope Exploitation in Danish Ertebølle and Adjoining Periods. Det Kongelige Danske Videnskabernes Selskab, Copenhagen.
- Ericson, P.G., Storå, J., 1999. A manual to the Skeletal Measurements of the Seal Genera *Halichoerus* and *Phoca* (Mammalia: Pinnipedia). Department of Vertebrate Zoology, Swedish Museum of Natural History, Stencil, Stockholm.
- Eriksson, M., Magnell, O., 2001. Det djuriska Tägerup. Nya rön kring Kongemose-och Erteböllekulturens jakt och fiske. In: Karsten, P., Knarrström, B. (Eds.), Tägerup. Specialstudier. UV Syd, Avd. för arkeologiska undersökningar, Lund, pp. 156–237.
- Erlandson, J.M., Rick, T.C., 2008. Archaeology, marine ecology, and human impacts on marine environments. In: Erlandson, J.M., Rick, T.C. (Eds.), *Human Impacts on Ancient Marine Ecosystems: a Global Perspective*, pp. 1–19.
- Flannery, K., 1969. Origins and ecological effects of early domestication in Iran and the Near East. In: Ucko, P.J., Dimbleby, G. (Eds.), *The Domestication and Exploitation of Plants and Animals*. Aldine Publishing Co, Chicago, pp. 73–100.
- Feitmann, D., Mudelsee, M., Burns, S.J., Bradley, R.S., Kramers, J., Matter, A., 2008. Evidence for a widespread climatic anomaly at around 9.2 ka before present. *Paleoceanography* 23, 1–6.
- Hadevik, C., Hammarstrand Dehman, K., Serlander, D., 2008. Arkeologiska förundersökningar i form av schaktningsövervakning 2003–2007 Malmö C Nedre – i samband med bygget av tunnel och ny stationsbyggnad, Enheten för Arkeologi Rapport 2008:030, Malmö.
- Hames, R., 2007. The ecologically noble savage debate. *Annu. Rev. Anthropol.* 36, 177–190.
- Hansson, A., Nilsson, B., Sjöström, A., Björck, S., Holmgren, S., Linderson, H., Magnell, O., Rundgren, M., Hammarlund, D., 2016. A submerged Mesolithic lagoonal landscape in the Baltic Sea, south-eastern Sweden—Early Holocene environmental reconstruction and shore-level displacement based on a multi-proxy approach. *Quat. Int.* <http://dx.doi.org/10.1016/j.quaint.2016.07.059> (in press).
- Härkönen, T., 2011. *Klimatförändringar – så påverkas våra särar*. In: Lewander, M., Karlsson, M., Lundberg, K. (Eds.), *Havet 2011 Om miljötillståndet i Våra Havsområden*. Havsmiljöinstitutet.
- Harris, D.R., 1977. Settling down: an evolutionary model for the transformation of mobile bands into sedentary communities. In: Friedman, J., Rowlands, M.J. (Eds.), *The Evolution of Social Systems*. Duckworth, London, pp. 401–417.
- Hart, J., 1956. Seasonal changes in insulation of the fur. *Can. J. Zool.* 34, 53–57.
- Hatting, T., 1969. Et bæverens tænder benyttet som redskaber i stenalderen i Danmark. *Aarbøger Nordisk Oldkyndighed og Hist.* 116–126.
- Hayden, B., 2014. Social complexity. In: Cummings, V., Jordan, P., Zvelebil, M. (Eds.), *The Oxford Handbook of the Archaeology and Anthropology of Hunter-gatherers*. Oxford University Press, Oxford.
- Heinrich, D., 1991. Untersuchungen an Skelettresten wildlebender Säugetiere aus dem mittelalterlichen Schleswig: Ausgrabung Schild 1971–1975 (Wachholz). Hesse, B., 1979. Rodent remains and sedentism in the Neolithic: evidence from tepe Ganj Dareh, western Iran. *J. Mammal.* 60, 856–857.
- Hole, F., 1984. A reassessment of the Neolithic revolution. *Paléorient* 49–60.
- Holst, D., 2010. Hazelnut economy of early Holocene hunter-gatherers: a case study from Mesolithic Duvensee, northern Germany. *J. Archaeol. Sci.* 37, 2871–2880.
- Hunn, E., Johnson, D., Russell, P., Thornton, T., 2003. Huna Tlingit traditional environmental knowledge, conservation, and the Management of a “Wilderness” Park. *Curr. Anthropol.* 44, S79–S103.
- Huntley, B., 1993. Rapid early-Holocene migration and high abundance of hazel (*Corylus avellana* L.): alternative Hypotheses. In: Chambers, F.M. (Ed.), *Climate Change and Human Impact on the Landscape : Studies in Palaeoecology and Environmental Archaeology*. Springer, London, pp. 205–215.
- Imby, L., 1987. Svenska fåglar: en fälthandbok. Prisma, Stockholm.
- Ingold, T., 1983. The significance of storage in hunting societies. *Man* 18, 553–571.
- Jarman, M.R., 1972. European red deer economies and the advent of the Neolithic. In: Higgs, E.S. (Ed.), *Papers in Economic Prehistory, Studies by Members and Associates of the British Academy Major Research Project in the Early History of Agriculture*. Cambridge University Press, Cambridge.
- Jenkins, E.L., 2009. Unwanted Inhabitants? the Microfauna from Çatalhöyük and Pinarbaşı. VDM-Verlag.
- Jenkins, E., 2012. Mice, scats and burials: unusual concentrations of microfauna found in human burials at the Neolithic site of Çatalhöyük, Central Anatolia. *J. Soc. Archaeol.* 12, 380–403.
- Jensen, B., 2004. Nordens däggdjur, second ed. Prisma, Stockholm.
- Jeziorski, W., 1977. Longevity and mortality rate in a population of wild boar. *Acta Theriol.* 22, 337–348.
- Jochim, M.A., 2011. The Mesolithic. In: Milisauskas, S. (Ed.), *European Prehistory*. Springer, New York, pp. 115–142.
- Jonsson, L., 1996. Fauna och landskap i Göteborgstrakten under boreal tid. Djurbensfynden från den boreala kustboplatsen vid Balltorp, Mölndals kommun, Vg, Riksantikvarieämbetet UV Väst Rapport 1996.
- Jonsson, L., 2014. Osteologisk analys – djurbenen från den preboreala kustboplatsen i Balltorp, RAÄ 182 i Mölndal, Västergötland. In: Johansson, G. (Ed.), En 10 000 år gammal boplats med organiskt material i Mölndal; Ytterligare en överlagrad Sandarnaboplats vid Balltorp Västra Götalands län, Västergötland, Mölndal stad, Balltorp 1:124, Mölndal 182, UV-väst rapport 2014, p. 91.
- Jordan, P., Zvelebil, M., 2009. Ex Oriente Lux: the prehistory of hunter-gatherer ceramic dispersals. In: Jordan, P., Zvelebil, M. (Eds.), *Ceramics before Farming: the Dispersal of Pottery Among Prehistoric Eurasian Hunter-gatherers*. Left Coast Press, Walnut Creek.
- Karsten, P., Knarrström, B., Hyll, S., 2003. The Tägerup Excavations. UV Syd, Avd. för arkeologiska undersökningar, Riksantikvarieämbetet, Lund.
- Kelly, R.L., 1983. Hunter-gatherer mobility strategies. *J. Anthropol. Res.* 39, 277–306.
- Kelly, R.L., 1992. Mobility/sedentism: concepts, archaeological measures, and effects. *Annu. Rev. Anthropol.* 21, 43–66.
- Kelly, R.L., 2013. *The Lifeways of Hunter-gatherers: the Foraging Spectrum*. Cambridge University Press, Cambridge.
- Kent, S., 1989. *Cross-cultural Perceptions of Farmers as Hunters and the Value of Meat. Farmers as Hunters*. Cambridge University Press, Cambridge, UK, pp. 1–17.
- Kjällquist, M., Boethius, A., Emilsson, A., 2016. Norje Sunnansund : boplatslämningar från tidigmesolitikum och järnålder : särskild arkeologisk undersökning 2011 och arkeologisk förundersökning 2011 och 2012, Ysane socken, Söderåsens kommun i Blekinge län (Blekinge museum, Karlskrona).
- Klein, R.G., 1969. *Man and Culture in the Late Pleistocene: a Case Study*. Chandler Publishing Company, San Francisco.
- Klima, B., 1962. The first ground-plan of an upper Paleolithic loess settlement in Middle Europe and its meaning. In: Braudwood, R.J., Willey, G.R. (Eds.), *Courses toward Urban Life: Archeological Considerations of Some Cultural Alternates*. Aldine, Chicago, pp. 193–210.
- Krech, S., 2000. *The Ecological Indian: Myth and History*. WW Norton & Company, New York.
- Lagerås, P., Broström, A., Svensson, N.-O., 2017. Forthcoming. Insamling av ätliga växter och ved under mesolitikum. En diskussion baserad på makrofossil och trädslag från västra Blekinge. In: Rudebeck, E., Anglert, M. (Eds.), *Att leva vid Vesan. Arkeologi längs nya väg E22 i västra Blekinge*. Blekinge museum, Karlshamn (in press).
- Larsson, L., 1980. Some aspects of the Kongemose Culture of Southern Sweden. *Meddelanden från Lunds universitets Historiska museum* 1979–80, pp. 5–22.
- Larsson, L., 1988. The Skateholm Project I: Man and Environment. Almqvist & Wiksell International, Lund.
- Legge, A.J., Rowley-Conwy, P., 1988. Star Carr Revisited: a Re-analysis of the Large Mammals. Centre for Extra-mural Studies. Birkbeck College, University of London, London.
- Lindqvist, C., Possnert, G., 1997. The subsistence economy and diet at Jakobs/Ajvide and Stora Förvar, Eksta Parish and other Prehistoric Dwelling and burial sites on Gotland in long term perspective. In: Burenhult, G. (Ed.), *Remote Sensing*, vol. 1 (applied techniques for the study of cultural resources and the localization, identification and documentation of sub-surface prehistoric remains in Swedish archaeology, Tjörnarp).
- Lowe, J.J., Walker, M.J., 2015. *Reconstructing Quaternary Environments*, 3. ed. Routledge, New York.
- Lyman, R.L., 1991. *Prehistory of the Oregon Coast*. Academic, New York.
- Magnell, O., 2006. Tracking Wild boar and Hunters: osteology of Wild boar in Mesolithic South Scandinavia. Lund University, Lund.
- Magnell, O., 2017. Climate and wild game populations in South Scandinavia at

- Holocene thermal maximum. In: Monks, G. (Ed.), *Climate Change, Human Response and Zoorchaeology. Proceedings from the 11th International Conference of Archaeozoology*, Paris 23–28th August, 2010. Vertebrate Paleobiology and Paleoanthropology Series. Springer Verlag in Print.
- Marlowe, F.W., 2005. Hunter-gatherers and human evolution. *Evol. Anthropol. Issues, News, Rev.* 14, 54–67.
- Mason, S., 2000. Fire and Mesolithic subsistence—managing oaks for acorns in northwest Europe? *Palaeogeogr. Palaeoclimatol. Palaeoecol.* 164, 139–150.
- McCormick, M., 2003. Rats, communications, and plague: toward an ecological history. *J. Interdiscip. Hist.* 34, 1–25.
- Meillassoux, C., 1973. *On the Mode of Production of the Hunting Band*. Oxford University Press.
- Mellars, P.A., Dark, P., 1998. *Star Carr in Context: New Archaeological and Palaeoenvironmental Investigations at the Early Mesolithic Site of Star Carr*, North Yorkshire. McDonald Inst of Archeological.
- Minc, L.D., Smith, K.P., 1988. The spirit of survival: cultural responses to resource variability in North Alaska. In: Halstead, P., O'Shea, J. (Eds.), *Bad Year Economics: Cultural Responses to Risk and Uncertainty*. Cambridge University Press, Cambridge, pp. 8–39.
- Murdoch, J., 1892. Ethnological Results of the Point Barrow Expedition. Smithsonian Institution, Washington, DC.
- Nilsson Stutz, L., 2003. *Embodied Rituals and Ritualized Bodies: Tracing Ritual Practices in Late Mesolithic Burials*. Lund University.
- Nilsson Stutz, L., 2014. Mortuary practices. In: Cummings, V., Jordan, P., Zvelebil, M. (Eds.), *The Oxford Handbook of the Archaeology and Anthropology of Hunter-gatherers*. Oxford University Press, Oxford, pp. 712–728.
- O'Connor, T., 1982. Animal bones from Flaxengate, Lincoln, C 870–1500 (London).
- O'Connor, T., 2013. *Animals as Neighbors: the Past and Present of Commensal Animals*. Michigan State University Press.
- Okarma, H., 1995. The trophic ecology of wolves and their predatory role in ungulate communities of forest ecosystems in Europe. *Zesz. Probl. Postepow Nauk. Rol.* 40, 335–386.
- Pedersen, L., 1995. 7000 years of fishing: stationary fishing structures in the Mesolithic and afterwards. In: Fischer, A. (Ed.), *Man and Sea in the Mesolithic : Coastal Settlement above and below Present Sea Level : Proceedings of the International Symposium, Kalundborg, Denmark 1993*. Oxbow monograph, pp. 75–86. Oxford.
- Price, T.D., 2015. *Ancient Scandinavia: an Archaeological History from the First Humans to the Vikings*. Oxford University Press, New York.
- Price, T.D., Brown, J.A., 1985. *Prehistoric Hunter-Gatherers: the Emergence of Cultural Complexity*. Academic Press, Orlando.
- Rasmussen, S.O., Vinther, B.M., Clausen, H.B., Andersen, K.K., 2007. Early Holocene climate oscillations recorded in three Greenland ice cores. *Quat. Sci. Rev.* 26, 1907–1914.
- Riede, F., 2014. The resettlement of northern Europe. In: Cummings, V., Jordan, P., Zvelebil, M. (Eds.), *The Oxford Handbook of the Archaeology and Anthropology of Hunter-gatherers*. Oxford University Press, Oxford, pp. 556–581.
- Rowley-Conwy, P., 1983. Sedentary hunters: the Ertebølle example. In: Bailey, G.N. (Ed.), *Hunter-gatherer Economy in Prehistory*. Cambridge University Press, Cambridge, pp. 1–26.
- Rowley-Conwy, P., 1993. Season and reason: the case for a regional interpretation of Mesolithic settlement patterns. *Archeol. Pap. Am. Anthropol. Assoc.* 4, 179–188.
- Rowley-Conwy, P., 2001. Time, change and the archaeology of hunter-gatherers: how original is the 'Original Affluent Society'. In: Panter-Brick, C., Layton, R.H., Rowley-Conwy, P. (Eds.), *Hunter-gatherers: an Interdisciplinary Perspective*. Cambridge University Press, Cambridge, p. 39.
- Rowley-Conwy, P., Zvelebil, M., 1989. Saving it for later: storage by prehistoric hunter-gatherers in Europe. In: Halstead, P., O'Shea, J. (Eds.), *Bad Year Economics: Cultural Responses to Risk and Uncertainty*. Cambridge University Press, Cambridge, pp. 40–56.
- Sahlins, M.D., 1972. *Stone Age Economics*. Transaction Publishers, London.
- Seifert, T., Tauber, F., Kayser, B., 2001. A High Resolution Spherical Grid Topography of the Baltic Sea, second ed. Baltic Sea Science Congress, Stockholm 25–29. November 2001, Poster# 147. Online: www.iowarnemuende.de/iowtopo.
- Sergeantson, D., 2009. *Birds*. Cambridge University Press, Cambridge.
- Smith, E.A., Wishnie, M., 2000. Conservation and subsistence in small-scale societies. *Annu. Rev. Anthropol.* 29, 493–524.
- Soffer, O., 1985. *The Upper Paleolithic of the Central Russian Plain*. Academic Press, San Diego.
- Sørensen, M., Rankama, T., Kankaanpää, J., Knutsson, K., Knutsson, H., Melvold, S., Erikson, B.V., Glørstad, H., 2013. The first eastern migrations of people and knowledge into Scandinavia: evidence from studies of Mesolithic technology, 9th–8th millennium BC. *Nor. Archaeol. Rev.* 46, 19–56.
- Storå, J., 2001. *Reading Bones: Stone Age Hunters and Seals in the Baltic* (Stockholm).
- Sutton, M., 2016. *Archaeology: the Science of the Human Past*, fourth ed. Routledge, New York.
- Tangri, D., Wynne, G., 1989. Of mice and men: is the presence of commensal animals in archaeological sites a positive correlate of sedentism? *Paléorient* 85–94.
- Tarasov, P., Williams, J., Kaplan, J., Österle, H., Kuznetsova, T., Wagner, M., 2012. Environmental change in the temperate grasslands and steppe. In: Matthews, J.A. (Ed.), *The SAGE Handbook of Environmental Change, Human Impacts and Responses*. Sage, London, pp. 215–244.
- Tchernov, E., 1984. Commensal animals and human sedentism in the Middle East. *Animals Archaeol.* 3, 91–115.
- Tchernov, E., 1991. Of mice and men. Biological markers for long-term sedentism; a reply. *Paléorient* 153–160.
- Tilley, C., 1996. *An Ethnography of the Neolithic*. Cambridge University Press, Cambridge.
- Tome, C., Vinge, J.-D., 2003. Roe deer (*Capreolus capreolus*) age at death estimates: new methods and modern reference data for tooth eruption and wear, and for epiphyseal fusion. *Archaeofauna* 157–173.
- Trolle-Lassen, T., 1986. Human exploitation of the pine marten (*Martes martes L.*) at the Late Mesolithic settlement of Tybrind Vig in western Funen. *Striae* 24, 119–124.
- Vardanis, Y., Klaassen, R.H., Strandberg, R., Alerstam, T., 2011. Individuality in bird migration: routes and timing. *Biol. Lett.* rsbl20101180.
- Vincent, J., Bideau, E., Hewison, A., Angibault, J., 1995. The influence of increasing density on body weight, kid production, home range and winter grouping in roe deer (*Capreolus capreolus*). *J. Zool.* 236, 371–382.
- Von Den Driesch, A., 1976. A guide to the measurement of animal bones from archaeological sites: as developed by the Institut für Palaeoanatomie, Domestikationsforschung und Geschichte der Tiermedizin of the University of Munich. Peabody Museum Press.
- Warren, G., 2014. Transformations? The Mesolithic of North-West Europe. In: Cummings, V., Jordan, P., Zvelebil, M. (Eds.), *The Oxford Handbook of the Archaeology and Anthropology of Hunter-gatherers*. Oxford University Press, Oxford.
- Woodburn, J., 1980. Hunters and Gatherers Today and Reconstruction of the Past. Soviet and Western anthropology, pp. 95–117.
- Wynne, G., Tangri, D., 1991. The origins of commensalism and human sedentism. *Paléorient* 157–159.
- Zeder, M.A., 2012. The broad spectrum revolution at 40: resource diversity, intensification, and an alternative to optimal foraging explanations. *J. Anthropol. Archaeol.* 31, 241–264.
- Zeder, M.A., Lemoine, X., Payne, S., 2015. A new system for computing long-bone fusion age profiles in *Sus scrofa*. *J. Archaeol. Sci.* 55, 135–150.