New research at Riņņukalns, a Neolithic freshwater shell midden in northern Latvia

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The prehistoric shell middens of Atlantic Europe consist of marine molluscs, but the eastern Baltic did not have exploitable marine species. Here the sole recorded shell midden, at Riņņukalns in Latvia, is on an inland lake and is formed of massive dumps of freshwater shells. Recent excavations indicate that they are the product of a small number of seasonal events during the later fourth millennium BC. The thickness of the shell deposits suggests that this was a special multi-purpose residential site visited for seasonal aggregations by pottery-using hunter-gatherer communities on the northern margin of Neolithic Europe.

Keywords: eastern Baltic, Latvia, Middle Neolithic, shell midden, *Unio*, freshwater mussel, Typical Comb Ware

Introduction

Shellfish have been a fundamental food resource for human populations since the Palaeolithic, and shells as waste products of their exploitation are preserved as archaeological features in coastal, lacustrine and riverine environments worldwide (Álvarez *et al.* 2011). In Europe, the most prominent features of this type are shell middens created by Late

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Mesolithic hunter-gatherer societies on the Atlantic littoral (Milner *et al.* 2007; Gutiérrez-Zugasti *et al.* 2011). Marine shellfish were also a fundamental food resource of Mesolithic people on the south-western margin of the Baltic Sea, where large and famous middens comparable to those on the Atlantic coast are preserved (Andersen 2007: 32).

The marine molluscs of the eastern Baltic did not include species large enough to be important as food, which explains the absence of prehistoric coastal shell middens in this area. Freshwater mussels did, however, represent a food resource in the Stone Age. There are thin layers or small heaps of mussel shells at various inland prehistoric sites in the circum-Baltic region, and their shells were widely used as temper in early ceramics. Nevertheless, only a few freshwater shell middens exist (Noe-Nygaard 1995: 64; Koch 2003: 217–18), and only one such site is known in the eastern Baltic.

This site is Riņņukalns, on the bank of the River Salaca at its outlet from Lake Burtnieks in northern Latvia (Figures 1 & 2). The midden, forming a mound on the riverbank measuring *c.* 20 × 30m, was first excavated in the 1870s, and sporadically re-investigated until the 1940s. After a break of almost 70 years, we have resumed research on this important site. Excavation in 2011 demonstrated that significant parts of the midden are still intact, yielding rich assemblages of fish bone and mollusc shell, as well as herbivore, human and bird bones, together with artefactual remains.

Research history

In the late nineteenth and early twentieth centuries, Riņņukalns (formerly also named 'Rinnekalns' or 'Rinnehügel') was considered one of the most famous Stone Age sites in the eastern Baltic (Ebert 1913: 507, 1927–1928). It was first recognised as a prehistoric site by local antiquarian Count Carl Georg Sievers, who started excavations in 1873 and 1874 (Sievers 1875, 1877). He observed well-stratified layers of freshwater mussel shells and fish, ash and charred remains including larger animal bones and fragments of worked bone and other artefacts (stone, amber and pottery). This stratified sequence was 0.8–1.1m thick. The underlying sediment was also rich in shell remains, animal bones, pottery and bone artefacts. Of special importance were at least four human burials, with some bone and stone grave goods, which were found in the lower shell deposit under intact layers of the shell midden (Bērziņš *et al.* forthcoming). Sievers considered these human remains, in contrast to others found in the upper strata, as Stone Age burials. The midden itself he described as a residential site of Stone Age hunters, fishers and gatherers.

This interpretation was challenged, and both the anthropogenic origin of the shell midden and the age of the Stone Age graves were questioned (Grewingk 1876, 1877). It was after a visit to Riņņukalns by Rudolf Virchow, who essentially confirmed the observations of Sievers (Virchow 1877), and the discovery of the Kunda site in present-day northern Estonia, that the interpretation of Riņņukalns as a Stone Age site was widely accepted (Grewingk 1884). The age of the presumed Stone Age graves remained in dispute, because renewed excavation in 1881 uncovered only early modern graves (Sommer 1884). Although the site was thereafter widely considered exhausted, successful smaller excavations of undisturbed layers were carried out later by Karl von Löwis of Menar (1895), Max Ebert (1913) and finally Eduards Šturms in 1943 (unpublished). However, due to the chequered history of

Figure 1. Map of Latvia and Estonia showing sites mentioned in the text.

the twentieth century, its research potential was almost forgotten, and Riņņukalns seemed to be only of interest in relation to research history.

New investigations

Archaeological investigation resumed in 2009 and 2010. Underwater archaeological surveys discovered the first finds of animal bones and bone artefacts on the bed of the River Salaca, directly in front of the site (Figure 3 & Table 1). These were found lying on the stony riverbed, now covered by up to 0.5m of mud, along the edge of the river where the current flows slowly. Further underwater finds were made in front of a second site, Kaulēnkalns, on the riverbank opposite Riņņukalns.

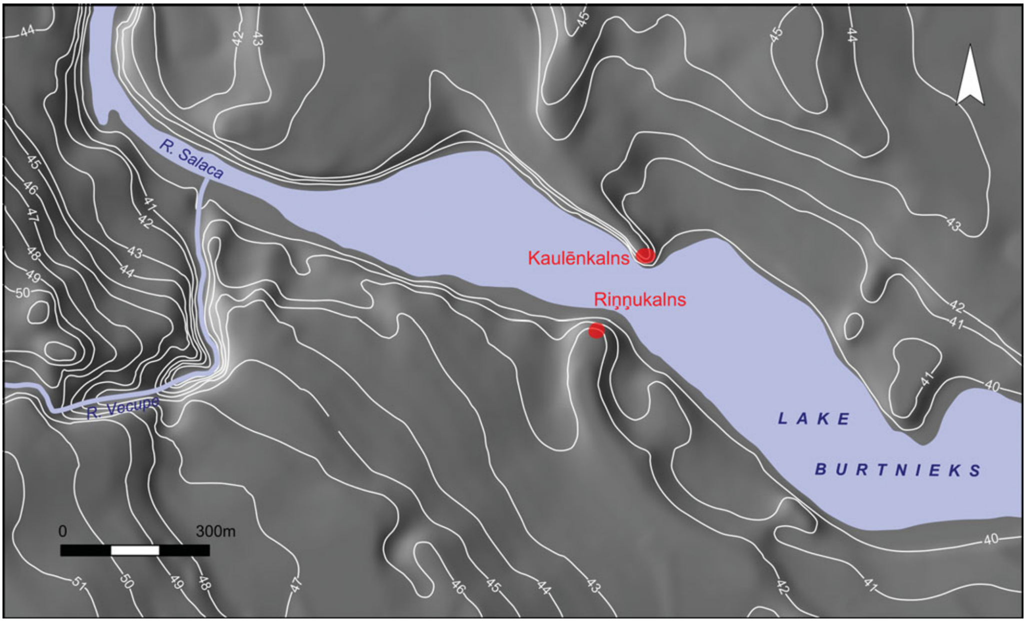

Figure 2. Outlet of the River Salaca from Lake Burtnieks, northern Latvia, showing the location of the Riņņukalns and Kaulēnkalns sites.

Figure 3. Riņņukalns shell midden: view from the Kaulēnkalns site on the opposite shore.

Table 1. **Radiocarbon results from the underwater survey 2010 and the Trench 1 midden sequence 2011, calibrated using IntCal09 (Reimer *et al*. 2009) and OxCal v4.2 (Bronk Ramsey 2009).**

Findspot/layer	Laboratory number	Identification	δ^{15}N (‰)‡	δ^{13}C (‰)‡	Conventional ^{14}C age (BP)	Calibrated date (95% confidence)
Salaca riverbed						
Kaulēnkalns bank	KIA-43696	antler handle, red deer (*Cervus elaphus*)		–23.8	7105±30	6030–5910 cal BC
Riņņukalns bank	KIA-43697	cattle/aurochs (cf. *Bos* sp.)	5.34	–23.22	4360±25	3090–2900 cal BC
Excavation 2011, Trench 1						
Layer 6	KIA-45798	cattle/aurochs (cf. *Bos* sp.), R humerus	6.26	–22.61	4725±30	3640–3370 cal BC
Layer 7	KIA-45799	wild boar (*Sus scrofa*), phalanx II	5.12	–22.46	4540±25	3370–3100 cal BC
Layer 7	KIA-45800	human (*Homo sapiens*), neonate, <1 year; R humerus	12.55	–20.44	440±25	cal AD 1420–1470*
Layer 9	KIA-45801	cattle/aurochs (*Bos* sp.), R metatarsal	6.42	–23.08	4620±35	3510–3340 cal BC
Layer 10	KIA-45802	cattle/aurochs (*Bos* sp.), L proximal tibia, unfused epiphysis	6.35	–22.84	4575±35	3500–3120 cal BC
Layer 15	KIA-45803	human (*Homo sapiens*), juvenile, 12–18; R maxilla	11.98	–24.85	4935±25	3780–3650 cal BC*
Layer 15	KIA-45804	charcoal, *Alnus* sp.			4755±30	3640–3380 cal BC
Layer 15	KIA-45805	Podicipedidae, cf. red-necked grebe (*Podiceps grisegena*), humerus	10.88	–17.09	4840±25	#
Layer 17	KIA-45809	charcoal, *Corylus* sp.			4560±20	3370–3130 cal BC
Layer 19	KIA-45806	red deer (*Cervus elaphus*), L radial carpal				no yield
Layer 20	KIA-45807	bone, indet. (cf. medium–large mammal)				no yield
Layer 20	KIA-45808	charcoal, indet. bark			6440±30	5480–5320 cal BC

‡stable isotopes were measured using Isotope Ratio Mass Spectrometry on a Thermo Flash 1112 Elemental Analyser coupled to a Thermo Delta plus XL mass spectrometer. Typical measurement errors of ±0.2‰ are quoted for both δ^{15}N and δ^{13}C in both samples and standards. Duplicate results were obtained, and agree within the quoted errors; mean values are shown.

* maximum age—would be more recent if diet incorporated significant amounts of fish.

cannot be calibrated because of dietary reservoir effects.

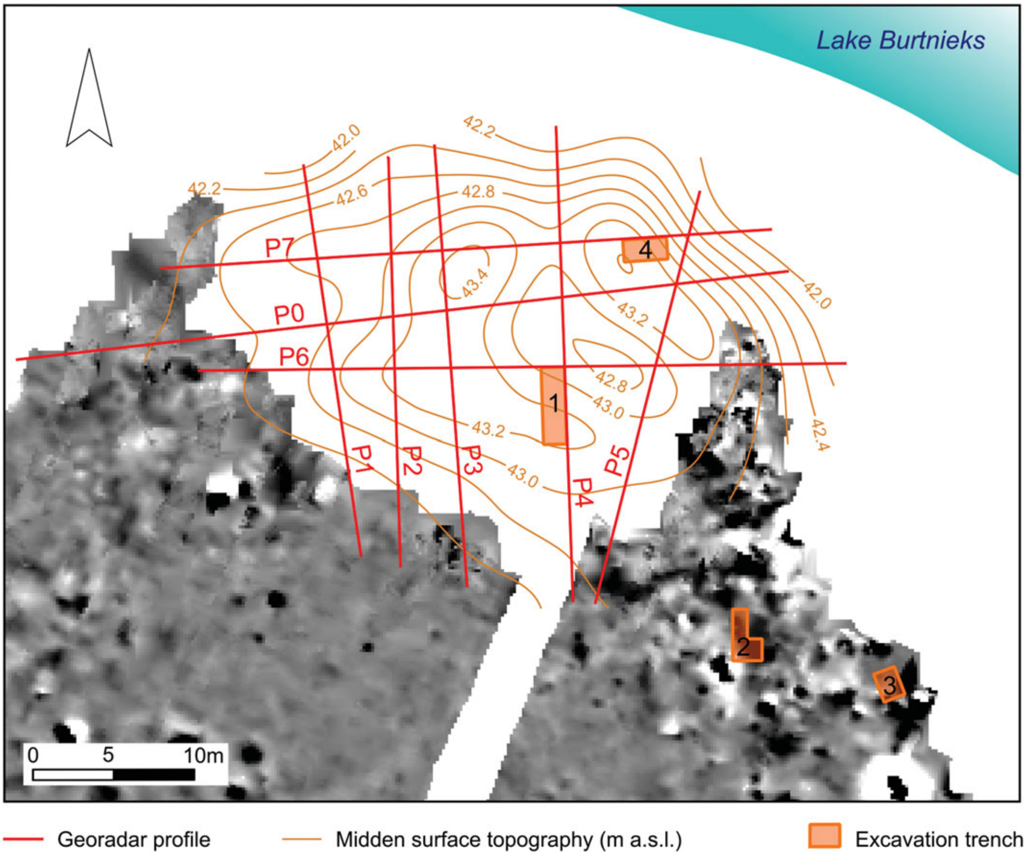

Figure 4. Plan of the midden and adjacent area, showing part of the magnetometer survey, georadar profiles and excavation trenches.

On the Riņņukalns site itself, hollows were observed that might have been left from the nineteenth-century trenches, and the question arose as to whether it really had been completely destroyed, or whether undisturbed cultural deposits might still be preserved.

In spring 2011, a geophysical survey was carried out at the site. Geomagnetic prospection using an array of 6 Fluxgate magnetometers (Fa. Dr. Förster, type Ferrex DLG 4.032.82) revealed a few features of possible archaeological significance next to the midden. Coring results supported this preliminary interpretation because the sub-soil was slightly humic and contained small pieces of charcoal. More importantly, a ground-penetrating radar survey, using 2-channel measuring equipment (GSSI, SIR-20) and an antenna frequency of 400MHz, indicated the existence of layered deposits, offering good prospects for the discovery of intact midden stratigraphy (Figures 4 & 5).

To verify the geophysical results and assess the state of preservation, a small-scale excavation was carried out in summer 2011. Two trenches were excavated in the midden itself along the georadar profile lines, to interpret the georadar profiles (Figure 4). The most exciting discoveries were made in Trench 1, a 5m-long trench along the edge of one of the hollows attributed to nineteenth-century excavation, its eastern side precisely following

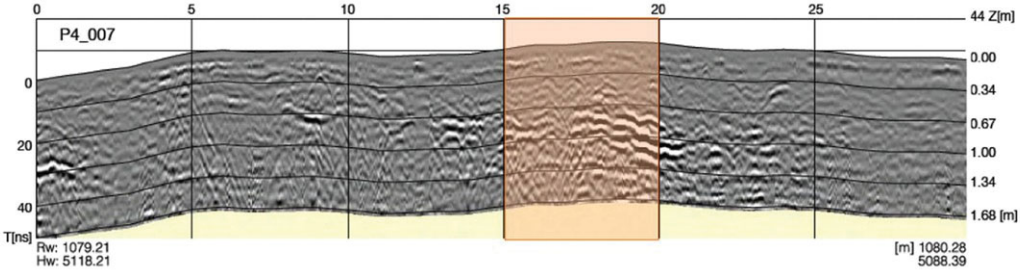

Figure 5. Georadar profile P4 (cf. Figure 3). Highlighted segment corresponds to eastern section of Trench 1.

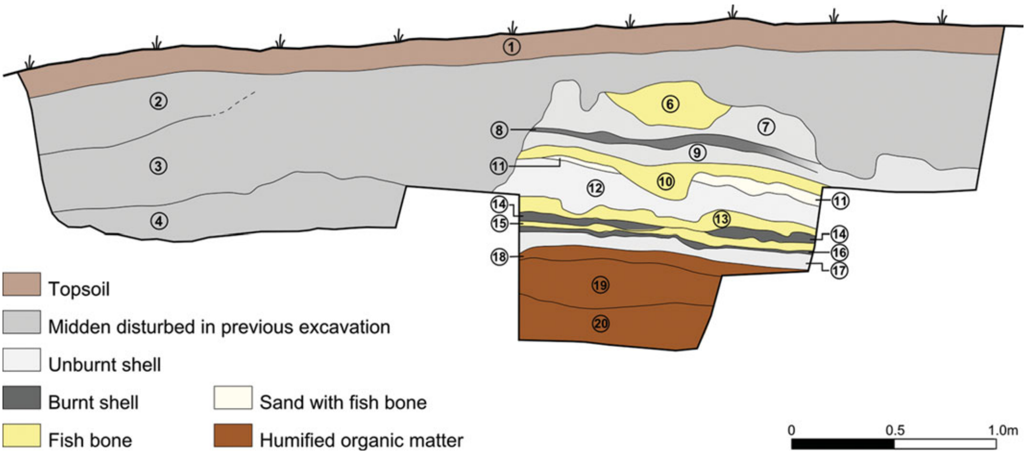

Figure 6. Eastern section of Trench 1, showing the surviving sequence of midden strata.

the line of georadar profile 4. Although the upper layers of the midden had been partially destroyed by early modern graves and previous excavation, the lower part of the midden was intact along the whole length of the trench, and an unexcavated sequence of midden strata was preserved in part of the trench (Figures 6 & 7). This corresponds very well to the georadar image, where the intact layers show up as distinct reflection surfaces (Figure 5). Evidently, there are areas of intact midden stratigraphy beneath nineteenth-century spoil heaps, and even in areas already excavated the base of the midden had not been reached everywhere.

The 2011 excavation showed that the shell midden consisted of alternating layers of unburnt mussel shell, burnt mussel shell and fish bone, containing artefacts, animal and human bone as described by Sievers (1875: 220–22) and Virchow (1877: 398–99). In the best-preserved part of the profile, there were as many as 13 successive intact midden layers. Several black burnt patches that might be remains of small hearths were observed, particularly on top of the fishbone layers. A layer of compact, well-decomposed organic matter, also containing pottery, underlay the basal midden layer in the small area, less than $1m^2$, where the midden was excavated completely.

Artefactual material

Excluding the potsherds, 134 artefacts were recovered in the 2011 excavation. Predominant among these were whole and fragmentary bone and antler tools: arrows, fragments of spears and harpoons, chisels, wedge-shaped tools, awls, bodkins, and parts of composite fishhooks (Figure 8, nos. 1–4). Jewellery consisted of tooth pendants (elk, wild boar and beaver) and bird-bone pendants (Figure 8, nos. 5–10). Flint tools and debitage, a stone axe and some grinding stones were also unearthed.

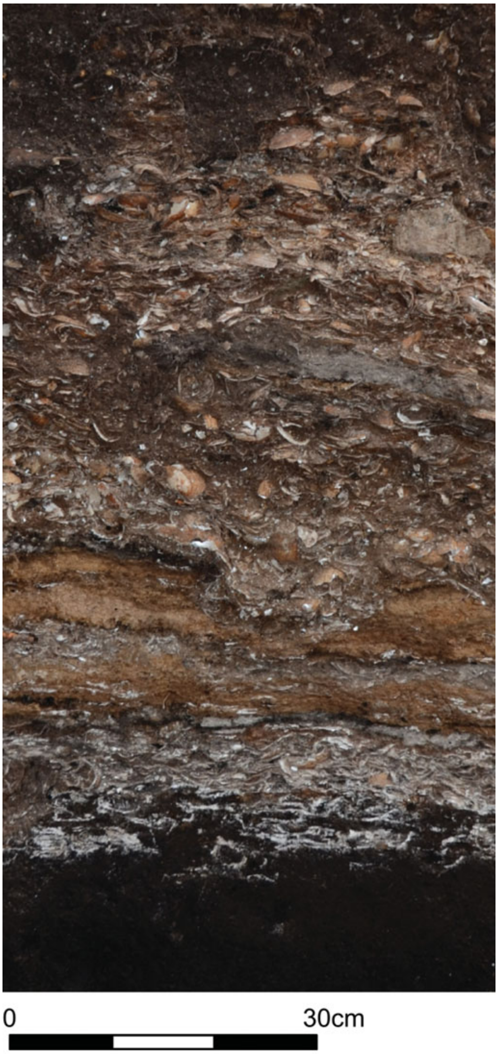

Figure 7. Detail of undisturbed midden stratigraphy in the eastern section of Trench 1.

The small ceramic assemblage from the organic deposit under the shell midden is dominated by Typical Comb Ware (Figure 9, no. 1), tempered with crushed granitic rock and decorated with deep pits and comb impressions. Typical Comb Ware marks the beginning of the Middle Neolithic in the eastern Baltic region (for a chronological table, see Larsson & Zagorska 2006: 3). Dates from the nearby Zvejnieki cemetery place this complex approximately in the period 4460–3800 cal BC (Zagorska 2006: 99–101, tab. IV). By contrast, the pottery from the undisturbed midden layers is shell-tempered, with a striated surface, most commonly decorated with geometric designs of wound cord impressions, occasionally with shallow pits or incised linear decoration (Figure 9, nos. 2–4). Comparable to the ceramics published already by Virchow (1877: pl. XVIII), it fits the general pattern of 'hybrid' late Middle Neolithic pottery in the region, which displays a mix of typological traits from the Comb and Narva ceramic traditions (see Bērziņš 2008: 40).

Most of the other finds can similarly be attributed to the Middle Neolithic period. However, the site as such was already being used at a much earlier date. Thus, certain of the fragmentary bone points from disturbed contexts represent Mesolithic forms. Particularly characteristic is a fish spear with a triangular cross section, recovered in Sievers' excavation.

Human remains

Besides a larger number of human bones found in layers associated with nineteenth-century trenches, which probably derive from early modern burials cut into the midden, disarticulated human bones found in apparently undisturbed shell midden layers were of special interest. Two of these were radiocarbon-dated to test whether they were prehistoric. The first was the right humerus of a neonate, not older than 12 months. It was found at the boundary between the disturbed part and layer 7, the uppermost undisturbed layer (Figure 6), but radiocarbon dating (see below) shows that it is late medieval in date, and clearly reworked during the earlier excavations.

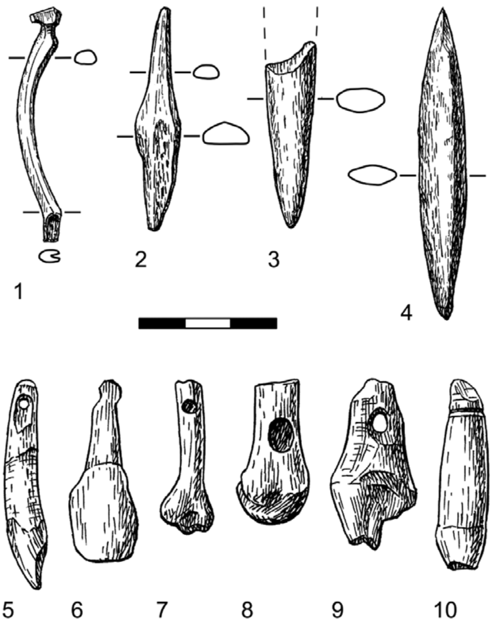

Figure 8. Bone tools from the 2011 excavation: 1) shank of composite fishhook; 2) point of composite fishhook; 3) fragmentary spearhead; 4) arrowhead; 5, 6, 9 & 10) mammal-tooth pendants; 7 & 8) bird-bone pendants. Drawing: Anda Bērziņa.

The second bone fragment was found significantly lower, in the undisturbed layer 15 (Figure 6). The expected prehistoric age was confirmed by radiocarbon dating (see below), providing the first proof of Stone Age human remains at Riņņukalns, and suggesting that at least some of Sievers' Stone Age graves may have been correctly attributed to this period (Bērziņš *et al.* forthcoming). The layer 15 fragment is a part of a maxilla, consisting of parts of the right and the left side of the alveolar process, which fit together at the median palatine suture. The maxilla belonged to a juvenile aged between 12 and 18. The sex was not determinable.

Fish remains

The original excavations at Riņņukalns produced a considerable list of mammal, bird and fish species, including wild animals, domesticates and even marine species (Rütimeyer 1877). However, their stratigraphical positions are questionable. During the 2011 excavation, in addition to a relatively small assemblage of mammal and bird bones, thousands of fish remains were collected (Table 2). So far, 2222 bones (NISP) have been identified at least to family level, and mostly to species level (Figure 10). These bones are from bulk samples taken from three different midden layers in which fish remains were clearly visible. All samples were wet-sieved down to 2mm and fully sorted.

The assemblage is dominated by several cyprinid species, which are archaeozoologically difficult to distinguish (Cyprinidae, 49.0% NISP, 26.5% MNI); seven species are definitely proven. Perch (*Perca fluviatilis*, 26.0% NISP, 26.5% MNI) and eel (*Anguilla anguilla*, 20.7% NISP, 27.3% MNI) are the next most frequent. Of minor importance were pike (*Esox lucius*,

Table 2. Riņņukalns, 2011 excavation. List of identified animals from undisturbed contexts. NISP: Number of Identified Specimens.

Fish	NISP (n)	NISP (%)	Mammal	NISP (n)
Cyprinids	1047	49.0	Beaver (*Castor fiber*)	5
(roach, *Rutilus rutilus*	21)		Cattle/aurochs (*Bos* sp.)	3
(vimba, *Vimba vimba*	8)		Elk (*Alces alces*)	3
(bream, *Abramis brama*	8)		Red deer (*Cervus elaphus*)	1
(ide, *Leuciscus idus*	2)		Wild boar (*Sus scrofa*)	2
(nase, *Chondrostoma nasus*	1)			**14**
(chub, *Squalius ephalus*	1)			
Perch (*Perca fluviatilis*)	577	26.0		
Eel (*Anguilla anguilla*)	460	20.7		
Pike (*Esox lucius*)	52	2.3		
Pike-perch (*Sander lucioperca*)	39	1.8		**NISP**
Burbot (*Lota lota*)	3	0.1	**Bird**	**(n)**
Herring (*Clupea harengus)*	2	0.1	Red-necked grebe	4
Salmonids (*Salmo* sp.)	1	<0.1	(*Podiceps grisegena)*	
Total	**2222**	**100**		**4**

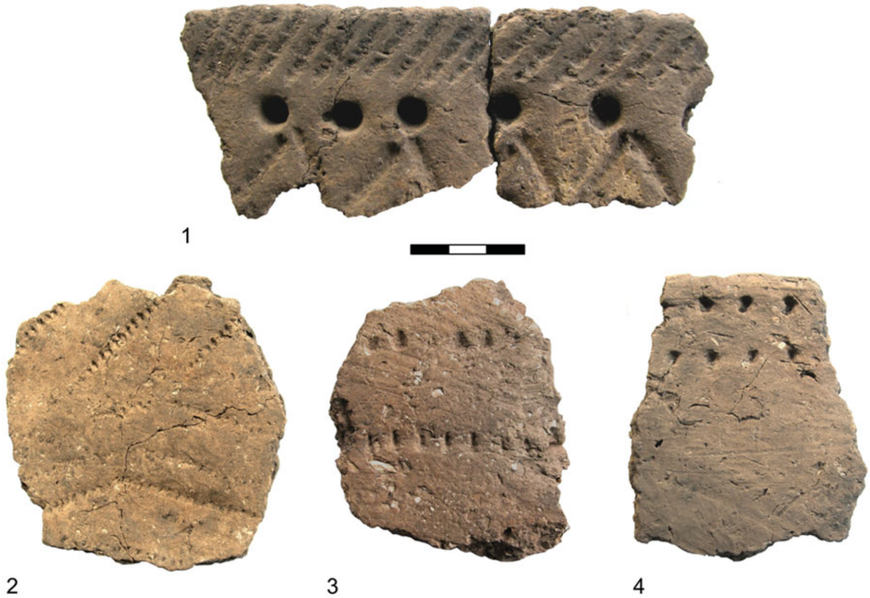

Figure 9. Ceramics from the 2011 excavation: 1) Typical Comb Ware; 2–4) shell-tempered late Middle Neolithic ware.

2.3% NISP, 11.4% MNI) and pike-perch (*Sander lucioperca*, 1.8% NISP, 6.1% MNI). Other species are recorded only by single remains (cf. Figure 10). Comparison with the results of monitoring programmes (Birzāks *et al.* 2011) shows that the modern fish community is very similar to that of the Stone Age, confirming that the local ecosystem has been extraordinarily stable for more than 5000 years.

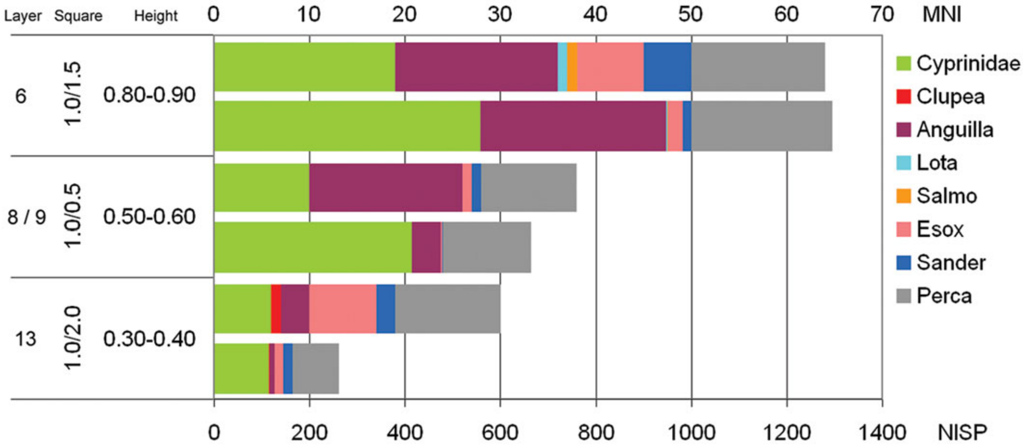

Figure 10. Riņņukalns fish remains. Minimum Number of Individuals (MNI, top) and Number of Identified Specimens (NISP, bottom) in three layers of the shell midden (cf. Figure 6).

Eel bones are significantly more frequent in the upper layers than in the basal ones and the average length of eel vertebrae increases from 3.2mm (n = 6) in the bottom layer, to 5.1mm (n = 38) in the middle layers, and 5.6mm (n = 249) at the top of the midden. This represents an increase in the average length of the eels caught, from *c.* 370mm to *c.* 650mm (Figure 11). The increasing length is a species-specific phenomenon; cyprinids, pike or perch do not show the same development. The estimated average length of perch, for instance, varies between 190 and 240mm in all three samples. Clearly, there was a conscious attempt to catch large eels. This probably indicates a specialised fishing of a migratory species, which has not previously been recorded from the eastern Baltic Neolithic (Lõugas 1996: tab. 2).

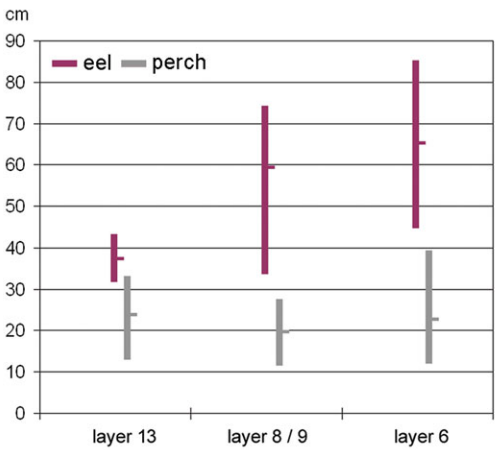

Figure 11. Estimated length of eel and perch in three layers of the Riņņukalns midden, calculated from the length of the vertebrae multiplied by 116 and 65, respectively.

Mollusc remains

The mollusc fauna from the 2011 excavation (Rudzīte *et al.* 2012) is overwhelmingly dominated by swollen river mussel, *Unio tumidus*. Other large edible mussels, *Unio pictorum* (painter's mussel) and *Anodonta* sp., were also present, as well as the much smaller gastropod (snail) species *Viviparus contectus* and *Valvata piscinalis*. Many whole mussel valves were found, with damage only to the thin edges and loss of the coloured surface layer (periostracum). Signs of deliberate breakage or pounding are absent, although these may have been present on the edges. Since *Anodonta* tend to be relatively poorly preserved, their shells being naturally thinner, they may have constituted a higher proportion of the gathered assemblage. *U. tumidus* will also inhabit locations with a slow current, whereas the other mussel species are typical of plant-rich, warm water with a muddy bottom, which suggests that they were collected from the lake margins, rather than the river; mesotrophic lakes in this area typically have muddy bottoms.

In the land snail assemblage from the intact midden strata, two habitats are represented: robust pillar (*Cochlicopa nitens*) and lovely vallonia (*Vallonia pulchella*) are characteristic of calcareous wetlands, whereas moss chrysalis (*Pupilla muscorum*) and ribbed vallonia (*Vallonia costata*) are also calciphiles, but need dry, stony meadows with sunny habitats. Typical forest species are absent, even though the majority of Latvia's land snails are forest species. Snail habitat preferences suggest residence on the midden itself, which was probably not covered by trees, and in meadow-like areas close to the lakeshore.

Radiocarbon dating and stable isotopes

Twelve samples from Trench 1 of the 2011 excavation were submitted for radiocarbon dating (Table 1). Most were bones of terrestrial herbivores (aurochs, wild boar and red deer). Three charcoal samples, two human bones and one bird bone were also submitted. Two bones from the organic deposit below the midden failed, owing to a lack of collagen.

Two of the dated bones were still in articulation and must have been deposited before their soft tissues had completely decayed. The lack of mixing between fishbone-rich and shell-rich layers also suggests that these layers are intact, so we may assume that most bone and charcoal samples are contemporary with the layer in which they were found. Dating of the disarticulated human maxilla confirmed that it came from a disturbed prehistoric burial. The neonate humerus found at the interface between layer 7 and one of the older archaeological trenches dated no earlier than cal AD 1420–1480 (95% confidence).

The remaining midden samples date to the later fourth millennium, while charcoal from layer 20, the organic deposit under the midden, dates to the mid sixth millennium cal BC (Table 1). The layer 15 charcoal fragment is apparently older than the charcoal from layer 17, and must be reworked from older sediments; layer 15 also contained the redeposited maxilla. Otherwise, the results fit the stratigraphic sequence of layers 17 to 7 (Figure 12). The disarticulated aurochs bone in layer 6 is slightly older than the rest of the midden samples, but it is stratigraphically later than the medieval human bone in layer 7, and may be reworked. The undisturbed midden layers excavated in 2011 may have been deposited over only a few years: the remaining results from terrestrial samples are statistically consistent with a single date, probably within a decade or two of 3350 cal BC. The layer 6 aurochs and the stray find dated by KIA-43697 to 3090–2900 cal BC (Table 1) indicate that the site was used over a longer period.

Collagen extracted for radiocarbon dating was subsampled for stable isotope analysis. The layer 15 bird bone, from a red-necked grebe (*Podiceps grisegena*, which feeds mainly on small fish), gave isotopic values suggesting a diet based on marine or estuarine species (Figure 13 & Table 1), consistent with its radiocarbon age, which implies a dietary reservoir effect of *c*. 250–300 radiocarbon years. Data from modern mollusc and water, and mid-Holocene plant macrofossil samples indicate that the local freshwater reservoir effect was probably

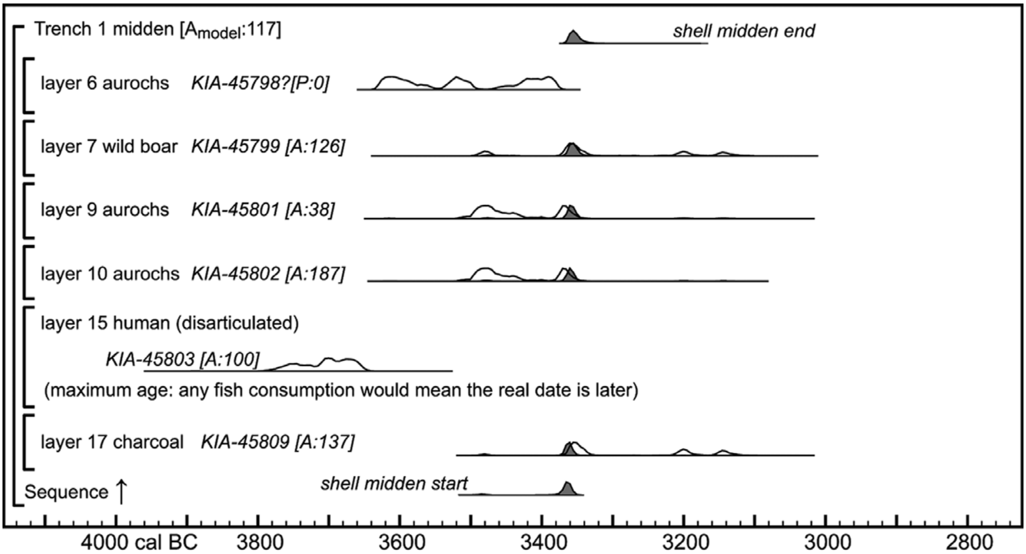

Figure 12. Bayesian chronological model of the midden sequence excavated in 2011, using OxCal v4.2 (Bronk Ramsey 2009). Probability distributions of the calibrated dates are shown in outline. The solid distributions are posterior density estimates of the dates of samples included in the OxCal Sequence model, and of the beginning and end of midden deposition (OxCal Boundary). The low probability index for KIA-45798 shows that this aurochs bone must be older than layer 6. The human bone result, KIA-45803, is treated as a terminus post quem *(OxCal After).*

c. 800–900 radiocarbon years (Meadows *et al.* 2014). This bird therefore died before it could acquire a more local isotopic signature.

Isotope results (enriched δ^{15}N, depleted δ^{13}C; Table 1) from the prehistoric maxilla suggest that this individual consumed a good deal of freshwater fish and shellfish; the values are at the aquatic end of the range of human bone isotope results from Zvejnieki (cf. Eriksson 2006). The medieval neonate had a more terrestrial diet; the high δ^{15}N value is probably a nursing effect, not the result of fish consumption. The δ^{13}C results do not indicate significant consumption of plants using the C4 photosynthetic pathway (e.g. millet), or of marine resources. Results from herbivore bones are consistent with expectations for wild animals from a mid-Holocene forest habitat.

Riņņukalns and its significance in eastern Baltic prehistory

Geophysical survey and test excavation have shown that parts of the Riņņukalns shell midden are still preserved *in situ*, with an undisturbed stratigraphy at least 0.8m thick. The newly excavated area of the midden represents a short phase of the eastern Baltic late Middle Neolithic. An early Middle Neolithic (Typical Comb Ware) layer exists under the shell midden, and the radiocarbon date from layer 20 and some typical bone tools from the nineteenth-century excavation indicate Mesolithic occupation as well. Small assemblages of pottery, lithics, bone artefacts and tooth ornaments have been recovered from secure contexts, as well as the first confirmed prehistoric human remains at this site.

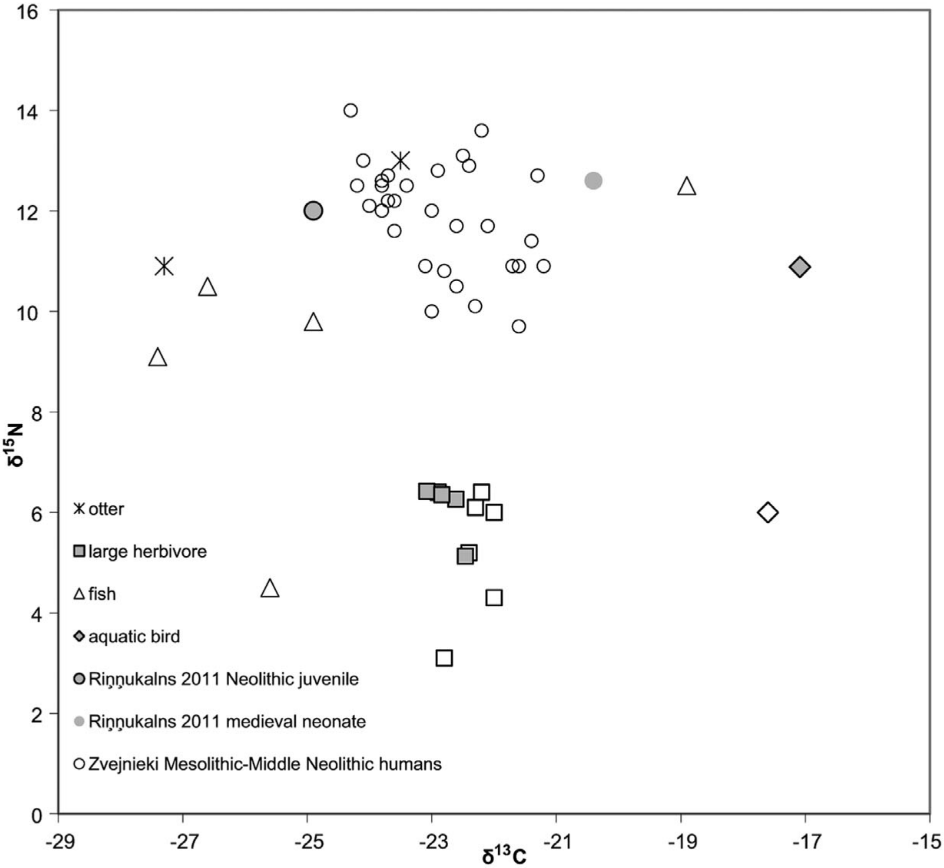

Figure 13. Stable isotope data from Lake Burtnieks sites. Solid symbols: data from Riņņukalns 2011 excavation; open symbols: data from Zvejnieki (Eriksson 2006).

Preservation of mollusc shells and fish bones is exceptional. This site currently represents the best source of information on the prehistoric use of freshwater mussels in the Baltic region. A wide range of fish species has also been identified, and there are indications that the species composition and even the dimensions of fish vary between midden layers, although cyprinids, eel and perch predominate in all the sampled contexts.

In the eastern Baltic, as in neighbouring areas, the term 'Neolithic' has generally been retained as a designation for the ceramic final stage of the Stone Age. Thus, the Mesolithic and Neolithic simply correspond to 'aceramic' and 'ceramic', respectively. Currently, various lines of evidence point to the Middle Neolithic as the period of incipient agriculture in the eastern Baltic (for more details see Bērziņš 2008: 371–73, 403–404). This period may be viewed, following Zvelebil (1996: 329), as representing a prolonged 'substitution phase', during which wild food resources continued to provide the main subsistence basis.

The settlement of this period at Riņņukalns maintains the focus on rich concentrations of aquatic resources associated with the major lake basins. The finds from the old excavations, the artefactual evidence pointing to a range of domestic activities, as well as the burials, indicate that Riņņukalns was much more than a specialised fishing/mollusc-gathering station. Rather, it may be classed along with the settlement complex at Zvejnieki and similar sites in other lake basins in the region as a multi-purpose residential site in a location offering excellent access to a range of wild food resources—with the difference that during the Middle Neolithic this particular spot came to be used for the mass dumping of mussel shells.

The thick shell accumulation sets Riņņukalns apart from other Middle Neolithic sites in the eastern Baltic. On the other hand, in terms of site location, economic basis and artefact typology, it fits the regional pattern. In all of these respects, we may identify particularly close parallels with the approximately contemporaneous settlement of Tamula in south-eastern Estonia (Jaanits 1984). Similarly situated by a lake outlet, Tamula has produced very similar bone tools and ceramics, and a faunal assemblage consisting primarily of wild mammal, bird and fish bone, supplemented with a small quantity of remains from domestic livestock. A further parallel is the occurrence of burials within the settlement area (Jaanits 1957). Especially significant is grave XIX, which not only gave an uncalibrated radiocarbon date and a δ^{13}C value (Kriiska *et al.* 2007: tab. 1: lab. no. Hela-1337; ^{14}C-year: 4925±25 BP; δ^{13}C: –25.0) almost identical to that of the human maxilla from layer 15, but also contained some bird figurines of bone (Kriiska *et al.* 2007: fig. 10, AI 4118: 2501, 2502) comparable to finds from Riņņukalns (Ebert 1927–1928: pl. 25n).

The widespread use of mussel shell as temper in ceramics suggests that freshwater mussels were in fact a significant element of diet across the eastern Baltic region. Sites with mussel shells are quite exceptional, however. Apart from Riņņukalns, evidence for large-scale consumption of shellfish has only been found at Narva Riigikülä I in north-eastern Estonia (Indreko 1964: 68–79; Gurina 1967: 22, 159, figs. 10, 12 & 14). Mussel shells are also reported from Neolithic layers at other sites along the River Narva (Indreko 1964: 66; Kriiska 1996: fig. 3).

The general absence of shell layers at Neolithic sites might be explained by a combination of factors: the re-use of shell for pottery temper, non-preservation due to soil acidity, and/or destruction in historical times as a source of agricultural lime. On the other hand, it is questionable whether the shell from freshwater mussels collected primarily for food could have completely disappeared as tempering material; and post-depositional factors do not satisfactorily account for the absence of shell layers at stratified sites with well-preserved antler and bone.

In the neighbouring southern Baltic, *Unio* sp. freshwater mussels were used not only as food but also for the production of ornaments in the Brześć Kujawski group of the Lengyel culture, which represents the northernmost tradition of the Central European Early Neolithic. At Brześć Kujawski sites, freshwater mollusc shells have been found as production or consumption waste in various kinds of pits, including a special type of pit with a regular bell-shaped profile that could have been used for the live storage of shellfish (Grygiel & Bogucki 1981: 17; 1986: 130). Similarly, pits with large quantities of *Unio* sp. shells (Krysiak & Lasota 1973) are known from the settlement of Zawichost-Podgórze in south-eastern Poland.

In the north German lowlands and Denmark, freshwater molluscs are very sparsely represented at sites of the fifth and fourth millennia BC, contrasting with the plentiful evidence of marine mollusc consumption. From late Ertebølle contexts there are only scattered examples of freshwater mollusc shells used as beads or pendants (e.g. Lübke 2009: 560). So far, the only evidence for actual consumption of freshwater mussels comes from the small inland sites within the extensive Åmose bog area on Sjælland, Denmark. Small heaps or middens of the shells are reported from several sites, generally belonging to the Funnel Beaker culture (Noe-Nygaard 1983, 1995: 64; Koch 1998: 147, 2003; Fischer & Heinemeier 2003). They occur in definite connection with traces of food preparation involving fire, namely charcoal concentrations and burnt shell or fish remains (Noe-Nygaard 1983: 137)—very similar to Riņņukalns.

The sporadic evidence for freshwater mollusc consumption across the Baltic region presents an enigma. On current evidence it is difficult to say whether mussels represented a secondary resource that obtained dietary importance only in certain periods when the exploitation of primary resources was in some way restricted, or whether shellfish consumption was actually a more widespread dietary practice than is indicated by the preserved evidence. Certainly, a much clearer understanding of freshwater shellfish as a component in the annual cycle of food acquisition is required, and in this regard Riņņukalns offers exciting possibilities. Already at the time of the 2011 excavation, it was thought that the sequence of distinct layers of fish bone, unburnt shell and burnt shell might represent a recurring seasonal pattern. The radiocarbon results, demonstrating that this sequence probably accumulated over only a few years, appear to fit this interpretation and suggest that each of the midden layers is a seasonal deposit reflecting intensive exploitation of particular resources. Thus the Riņņukalns midden offers a very fine-grained picture of seasonality in resource exploitation, which will be a focus of future research.

Moreover, research will address the place of Riņņukalns in the Lake Burtnieks regional settlement system. The relationship between Riņņukalns and Zvejnieki is still unclear, but several indicators suggest that Riņņukalns was not simply a fishing station for the Zvejnieki settlement. The Zvejnieki graveyard demonstrates that Lake Burtnieks was a preferred occupation area throughout the Stone Age. Further research on both sites may clarify which resources were used at what time in the area, when Riņņukalns became an important component of the settlement system, and why freshwater mussels became extraordinarily significant at the end of the eastern Baltic Middle Neolithic.

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References

ÁLVAREZ, M., I.B. GODINO, A. BALBO & M. MADELLA. 2011. Shell middens as archives of past environments, human dispersal and specialized resource management. *Quaternary International* 239: 1–7. http://dx.doi.org/10.1016/j.quaint.2010.10.025

ANDERSEN, S.H. 2007. Shell middens ('Køkkenmøddinger') in Danish prehistory as a reflection of the marine environment, in N. Milner, O.E. Craig & G.N. Bailey (ed.) *Shell middens in Atlantic Europe*: 31–45. Oxford: Oxbow.

BĒRZIŅŠ, V. 2008. *Sārnate*: *living by a coastal lake during the East Baltic Neolithic* (Acta Universitatis Ouluensis B Humaniora 86). Oulu: Oulu University Press. Available at: http://herkules.oulu.fi/isbn9789514289415/isbn9789514289415.pdf (accessed 26 June 2013).

BĒRZIŅŠ, V., U. BRINKER, H. LÜBKE, J. MEADOWS & I. ZAGORSKA. Forthcoming. New research on the human burials of Riņņukalns, Latvia, in *Mesolithic burials—rites, symbols and social organization of early postglacial communities*. Halle: Congresses of the State Museum for Prehistory Halle.

BIRZĀKS, J., Ē. ALEKSEJEVS & M. STRŪĢIS. 2011. Occurrence and distribution of fish in rivers of Latvia. *Proceedings of the Latvian Academy of Sciences Section B* 65: 57–66.

BRONK RAMSEY, C. 2009. Bayesian analysis of radiocarbon dates. *Radiocarbon* 51: 337–60.

EBERT, M. 1913. Die baltischen Provinzen Kurland, Livland, Estland. *Prähistorische Zeitschrift* 5: 498–559.

– 1927–1928. Rinnekalns, in M. Ebert (ed.) *Reallexikon der Vorgeschichte* 11: 145–47. Berlin: Walter de Gruyter.

ERIKSSON, G. 2006. Stable isotope analysis of human and faunal remains from Zvejnieki, in L. Larsson & I. Zagorska (ed.) *Back to the origin. New research in the Mesolithic-Neolithic Zvejnieki cemetery and environment, northern Latvia* (Acta Archaeologica Lundensia series in 8° 52): 183–215. Stockholm: Almqvist & Wiksell.

FISCHER, A. & J. HEINEMEIER. 2003. Freshwater reservoir effect in ^{14}C dates of food residue on pottery. *Radiocarbon* 45: 449–66.

GREWINGK, C. 1876. Der Kauler- und der Rinne-Kaln am Burtnecksee in Livland. *Sitzungsberichte Dorpater Naturforscher-Gesellschaft* 4: 206–25.

– 1877. Zur Abwehr. *Sitzungsberichte Dorpater Naturforscher-Gesellschaft* 4: 534–39.

– 1884. *Die Neolithischen Bewohner von Kunda in Estland und deren Nachbarn.* Dorpat (Tartu): C. Mattiesen.

GRYGIEL, R. & P.I. BOGUCKI. 1981. Early Neolithic sites at Brześć Kujawski, Poland: preliminary report on the 1976–1979 excavations. *Journal of Field Archaeology* 8: 9–27. http://dx.doi.org/10.1179/009346981791505201

– 1986. Early Neolithic sites at Brześć Kujawski, Poland: preliminary report on the 1980–1984 excavations. *Journal of Field Archaeology* 13: 121–37. http://dx.doi.org/10.1179/009346986791535762

GURINA, N.N. 1967. *Iz istorii drevnih plemen zapadnyh oblastej SSSR (po materialam narvskoj ekspedicii) [On the history of ancient tribes of the western regions of the USSR (based on the material of the Narva expedition)].* Leningrad: Nauka.

GUTIÉRREZ-ZUGASTI, I., S.H. ANDERSEN, A.C. ARAÚJO, C. DUPON, N. MILNER & A.M. MONGE-SOARES. 2011. Shell midden research in Atlantic Europe: state of the art, research problems and perspectives for the future. *Quaternary International* 239: 70–85. http://dx.doi.org/10.1016/j.quaint.2011.02.031

INDREKO, R. 1964. *Mesolithische und Frühneolithische Kulturen in Osteuropa und Westsibirien* (Antikvariska Serien 13). Stockholm: Almqvist & Wiksell.

JAANITS, L. 1957. Neue Gräberfunde auf dem spätneolitischen Wohnplatz Tamula in Estland, in C.F. Meinander (ed.) *Studia neolitica in honorem Aarne Äyräpää*: 80–100. Helsinki: Suomen muinaismuistoyhdistys.

– 1984. Die kennzeichnenden Züge der Siedlung Tamula. *Iskos* 4: 183–93.

KOCH, E. 1998. *Neolithic bog pots from Zealand, Møn, Lolland and Falster* (Nordiske Fortidsminder Serie B 16). Copenhagen: Det Kongelige Nordiske Oldskriftselskab.

– 2003. Stenalderbønder på sommerjagt. *Nationalmuseets Arbejdsmark* 2003: 209–29.

KRIISKA, A. 1996. Archaeological excavations on the Neolithic site of Riigiküla IV. *Proceedings of the Estonian Academy of Sciences. Humanities and Social Sciences* 45(4): 410–19.

KRIISKA, A., L. LÕUGAS, M. LÕHMUS, K. MANNERMAA & K. JOHANSON. 2007. New AMS dates from Estonian Stone Age burial sites. *Estonian Journal of Archaeology* 11(2): 83–121.

KRYSIAK, K. & A. LASOTA. 1973. Szczątki zwierzęce z wykopu IV na neolitycznym stanowisku w Zawichoście. *Wiadomości Archeologiczne* 38: 83–89.

LARSSON, L. & I. ZAGORSKA (ed.). 2006. *Back to the origin. New research in the Mesolithic-Neolithic Zvejnieki cemetery and environment, northern Latvia* (Acta Archaeologica Lundensia series in 8° 52). Stockholm: Almqvist & Wiksell.

LÕUGAS, L. 1996. Stone Age fishing strategies in Estonia. What did they depend on? *Archaeofauna* 5: 101–109.

Löwis of Menar, K. von. 1895. Bericht über Ausgrabungen am Burtneckschen See und am Rinnekaln. *Sitzungsberichte Gesellschaft für Geschichte und Alterthumskunde der Ostseeprovinzen Russlands* 1895: 77–84.

Lübke, H. 2009. Hunter and fisher in a changing world. Investigations on submerged Stone Age sites off the Baltic coast of Mecklenburg-Vorpommern, Germany, in S. McCartan, R. Schulting, G. Warren & P. Woodman (ed.) *Mesolithic horizons. Papers presented at the Seventh International Conference on the Mesolithic in Europe, Belfast 2005*: 556–63. Oxford: Oxbow.

Meadows, J., H. Lübke, I. Zagorska, V. Bērziņš, A. Ceriņa & I. Ozola. 2014. Potential freshwater reservoir effects in a Neolithic shell midden at Riņņukalns, Latvia. *Radiocarbon* 56: 823–32. http://dx.doi.org/10.2458/56.16950

Milner, N., O.E. Craig & G.N. Bailey. 2007. *Shell middens in Atlantic Europe*. Oxford: Oxbow.

Noe-Nygaard, N. 1983. The importance of aquatic resources to Mesolithic man in inland sites in Denmark, in C. Grigson & J. Clutton-Brock (ed.) *Animals and archaeology 2: shell middens, fishes and birds* (British Archaeological Reports international series 183): 125–42. Oxford: Archaeopress.

– 1995. *Ecological, sedimentary and geochemical evolution of the late-glacial to postglacial Åmose lacustrine basin, Denmark* (Fossils & Strata 37). Copenhagen, Oslo & Stockholm: Scandinavian University Press.

Reimer, P.J., M.G.L. Baillie, E. Bard, A. Bayliss, J.W. Beck, P.G. Blackwell, C. Bronk Ramsey, C.E. Buck, G.S. Burr, R.L. Edwards, M. Friedrich, P.M. Grootes, T.P. Guilderson, I. Hajdas, T.J. Heaton, A.G. Hogg, K.A. Hughen, K.F. Kaiser, B. Kromer, G. McCormac, S. Manning, R.W. Reimer, S. Remmele, D.A. Richards, J.R. Southon, S. Talamo, F.W. Taylor, C.S.M. Turney, J. van der Plicht & C.E. Weyhenmeyer. 2009. IntCal09 and Marine09 radiocarbon age calibration curves, 0–50,000 years cal BP. *Radiocarbon* 51: 1111–50.

Rudzīte, M., I. Zagorska, H. Lübke & V. Bērziņš. 2012. Molluscs from a new archaeological excavation at Riņņukalns, Latvia. *Schriften zur Malakozoologie* 27: 49–56.

Rütimeyer, L. 1877. Ueber die Thierreste des Rinnekalns. *Sitzungsberichte Dorpater Naturforscher-Gesellschaft* 4: 534–39.

Sievers, C.G. 1875. Ein normannisches Schiffsgrab bei Ronneburg und die Ausgrabung des Rinnehügels. *Verhandlungen der Berliner Gesellschaft für Anthropologie, Ethnologie und Urgeschichte* 1875 *(Zeitschrift für Ethnologie 7)*: 214–25.

– 1877. Ueber die wahrscheinliche Entstehung des Rinnehügels. *Sitzungsberichte Dorpater Naturforscher-Gesellschaft* 4: 406–17.

Sommer, A. 1884. Der Rinne-Kalns und seine Bedeutung fur die Anthropologie Livlands. *Archiv für die Naturkunde Liv-, Ehst- und Kurlands. Serie II* IX: 345–99.

Virchow, R. 1877. Bericht über eine archäologische Reise nach Livland. *Verhandlungen der Berliner Gesellschaft für Anthropologie, Ethnologie und Urgeschichte* 1877 *(Zeitschrift für Ethnologie 9)*: 365–437.

Zagorska, I. 2006. Radiocarbon chronology of the Zvejnieki burials, in L. Larsson & I. Zagorska (ed.) *Back to the origin. New research in the Mesolithic-Neolithic Zvejnieki cemetery and environment, northern Latvia* (Acta Archaeologica Lundensia series in 8° 52): 91–113. Stockholm: Almqvist & Wiksell.

Zvelebil, M. 1996. The agricultural frontier and the transition to farming in the circum-Baltic region, in D.R. Harris (ed.) *The origins and spread of agriculture and pastoralism in Eurasia*: 323–45. London: University College London Press.

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