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DIETARY PRACTICES DURING THE LATE NEOLITHIC AND THE BRONZE AGE IN THE TERRITORY OF LATVIA: A CASE STUDY OF LAKE LUBĀNS WETLAND AND THE LOWER DAUGAVA

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This paper deals with the identification and comparison of dietary practices and their changes from the Late Neolithic to the Late Bronze Age in two different ecosystems – the lower reaches of the Daugava river and Lake Lubāns wetland. Zooarchaeological, palaeobotanical, and stable isotope evidence of chemical elements were used. The obtained results show that the beginning of early farming in Latvia can be observed in the late Neolithic period, especially for the Corded Ware Culture people. However, the consumption of freshwater fish also remains significant during this period. Farming, as the main form of food provision, became established in Latvia in the Middle Bronze Age.

Key words: Eastern Baltic, Late Neolithic, Bronze Age, zooarchaeology, palaeobotany, stable isotope analysis.

Introduction

One of the most prominent research topics in contemporary archaeology is the transition from foraging to farming and its influence on different aspects of life. For example, it has been argued that it strongly changed demography through acceleration of reproductive rates, because the availability of dairy and cereal products allowed to start weaning earlier in child's life, thus enabling more frequent pregnancies and consequently higher birth rates.

During the Late Neolithic, human sustenance was still directly dependent on environmental factors. Environmental processes such as local and global climatic changes and their effects on historical processes is a topic that has been widely debated. For example, researchers have proposed different causes for transition to farming. Some explain it by searching for new subsistence strategies in situation when climatic changes had depleted natural resources that previously could sustain foraging, but others suggest that transition to farming was more likely caused by the rise in social stress and competition between societies, and the consequent search of their leaders for ways to obtain additional resources.[1] Recently, consensus have shifted towards explaining such fundamental changes as transition to farming by more complex causes, besides, they might be highly variable between different regions. Trans-regional causes should be considered as well, for example, if climatic changes caused dryer local environments in steppe regions, nomadic pastoralists had to search for new territories more suitable for their livestock, thus causing migrations.[2]

1 Sahlins 1974; Zvelebil 1993, 146–162; Lang 2007.

2 Starr 2005, 7–48.

Although more widely known as the Neolithic Revolution, the transition from foraging to farming in Northern Europe was more likely a slow and gradual process with several phases and local variabilities. For example, Estonian archaeologist Valter Lang has proposed a four-phased transition model, specific for the Eastern Baltic: 1) foraging societies start to focus more on plant-based diet; 2) first introduction of cultivated crops and domesticated animals; 3) gradual transition to farming as the leading subsistence strategy; 4) first intensification of farming.[3]

Recently, however, a more widespread application of stable isotope analysis in Scandinavian and Baltic archaeology has sparked a discussion regarding the time and process of this transition.[4] Re-evaluation and new radiocarbon dates have strongly called in question previous claims regarding crop cultivation during the Late Neolithic among the Eastern Balts.[5] Previously, research on transition to farming in Latvia has been carried out by archaeologists Harri Moora[6] (1952), Jānis Graudonis[7] (2001), Andrejs Vasks[8] (2015), Ilze Biruta Loze[9] (2001), and others.

In the territory of Latvia significant transition of dietary practices took place from the Late Neolithic (2900–1800 BC) to the Bronze Age (1800–500 BC), where hunter-fisher-gatherer communities slowly started practicing animal husbandry and farming.[10]

I. Loze has based her research mostly on Lake Lubāns wetland material, it led her to a conclusion that farming became more widespread during the Late Neolithic and became the leading subsistence strategy during or shortly after the transition to the Bronze Age.[11] Another body of discussion is related to the question of how strongly the transition to farming was connected to migrations. It has been suggested that farming and pastoralism was introduced by the Corded Ware Culture (CWC), however, in Latvia there are no direct evidence of this interpretation, and the suggestion is based on the correlation between the CWC sites and potential agricultural lands.[12]

3 Lang 1999, 361–369.

4 Eriksson et al., 2008, 520–543; Piličiauskas, Kisielienė, Piličiauskienė 2016, 183–193; Piličiauskas, Jankauskas, Piličiauskienė, Dupras 2017, 1421–1437.

5 Grikpėdis, Motuzaite Matuzeviciute 2017, 1–16.

6 Moora 1952.

7 Graudonis 2001, 116–185.

8 Vasks 2015.

9 Loze 2001, 74–112.

10 Vasks 2015, 97–99.

11 Loze 1997, 25–41.

12 Vasks 2015, 66–67.

Although the main dietary tendencies have been determined by analysing the rich osteological material as well as macroremains obtained from various settlements[13] (for example, Graudonis 1989; Loze 1979; Vasks 1994), thorough studies regarding changes and varieties of food consumption in different inhabitation regions are lacking.

The aim of this paper is to distinguish and compare dietary practices and their change from the Late Neolithic to the Late Bronze Age in two different ecosystems – coastal and inland as well as to update the data of osteological material and macroremains published before. Lake Lubāns wetland and the Lower Daugava have been chosen as regions of study based on two considerations: 1) these regions were among the most inhabited in the territory and period of study, 2) settlements in these regions have been extensively studied archaeologically. In this study seven sites are analysed in detail – Abora I settlement and cemetery and Brikuļi hillfort from Lake Lubāns wetland and Ķivutkalns hillfort and cemetery, Vīnakalns hillfort and Reznes cemetery in the Lower Daugava (Fig. 1).

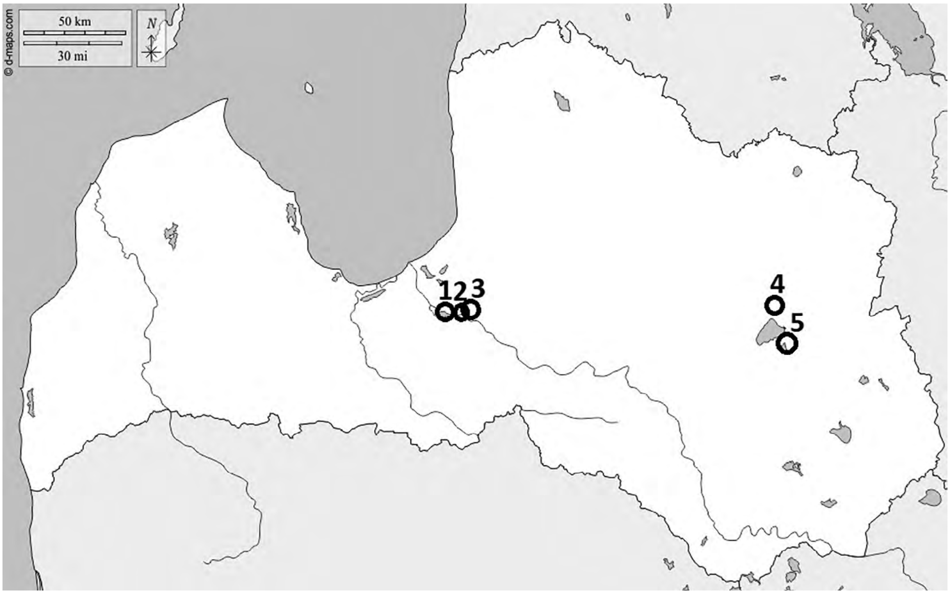

Fig. 1. Location of archaeologically studied sites: *1* – Ķivutkalns hillfort and cemetery, *2* – Reznes cemetery, *3* – Vīnakalns hillfort, *4* – Abora I settlement, *5* – Brikuļi hillfort

1. att. Arheoloģiski pētīto senvietu izvietojums. *1* – Ķivutkalna pilskalns un kapulauks, *2* – Reznu kapulauks, *3* – Vīnakalna pilskalns, *4* – Aboras I apmetne, *5* – Brikuļu pilskalns

13 Graudonis 1989; Loze 1979; Vasks 1994.

Osteological and macroremains were analysed only from settlements as the bones and botanical material found in the graves are connected to rituals and therefore do not represent species of animals and plants consumed. From Brikuļi, Ķivutkalns, and Vīnakalns hillforts seed imprints from pottery were also obtained and distinguished. Stable isotope analysis was carried out on human remains from Abora I, Ķivutkalns, and Reznes cemeteries.

Background of the settlements

Lake Lubāns is the largest lake in Latvia. A unique micro-environment that occupies an area of 480.2 km^2 – Lake Lubāns wetland – had been formed in its depression resulting from the activity of the last glacier. From the end of the last glaciation, i.e. the beginning of the Holocene ~9700 BC, the Lubāns palaeo-lake water level dropped and the climate became warmer. Therefore, at the beginning of the Mesolithic, the banks of Lake Lubāns and the shores of many rivers that had formed due to lake level lowering became an attractive ecological niche for groups of foragers. Until now, a total of 27 Stone and Bronze Age settlements have been found in Lake Lubāns wetland. During the Neolithic, this micro-region was the most densely inhabited territory throughout the entire Eastern Baltic. Lubāns wetland at the time was an important, possibly, the largest known junction of trade routes in the Eastern Baltic inland territories. The formation of this centre was influenced firstly by an advantageous location near a water route – the Aiviekste river that connects the micro-region with the largest water route – the Daugava river. Consequently, many important innovations reached this micro-region earlier than elsewhere: the earliest pottery and evidence of domesticated animals and crops, widely practiced amber craft, the earliest evidence of bronze processing.[14]

Abora I settlement and cemetery are located in Lake Lubāns plain, on the right bank of the Abora river, next to its estuary into the Abaine river.

The archaeological excavation of the site took place in 1964–1965 and in 1970–1971, led by archaeologist Ilze Loze. Of the total area of 5000 m^2 occupied by the settlement and cemetery, 1311 m^2 were studied. Altogether 3885 artefacts were found in the settlement, including fish pots, stone, bone, horn and flint tools of which 1410 were made of amber. 18,000 pottery sherds were also found. A total of 61 burials were uncovered during the excavation. Judging by

14 Vasks 2015.

the characteristics of finds as well as C^{14} dates, Abora I settlement and cemetery is dated to 3370–2025 cal BC.[15]

Brikuļi hillfort was located in Īdeņa village on the sandy promontory on the south-east side of Lake Lubāns.[16] Small test excavation in the hillfort was carried out in 1963 by I. Loze, but in 1973 two trenches were excavated by Andrejs Vasks. Due to the construction of fisheries, it was planned to take soil from Brikuļi hillfort, therefore it was fully archaeologically studied in several seasons – 1974, 1977–1979, led by A. Vasks.[17] Thus, 3410 m^2 – the entire area of the hillfort, was studied. A total of 1092 artefacts and ca. 33,000 pottery sherds were found. By the characteristics of the finds as well as C^{14} analysis, two inhabitation periods were distinguished: 1) 9^{th} century BC – 2^{nd} century AD, and 2) 7^{th}–11^{th} century AD.[18]

Ķivutkalns hillfort and cemetery was located on a promontory in Dole island, next to the Daugava river and was surrounded by the small Pižaga river and its old distributary. Archaeological excavation led by Jānis Graudonis and Jolanta Daiga took place there in 1966–1967. Due to the construction of the Rīga Hydroelectric Power Plant in the flooding area of which Ķivutkalns was situated, the site had been fully excavated, researching an area of 2276 m^2.[19] Under the Ķivutkalns hillfort, a cemetery with 247 inhumation and 21 cremation burials was discovered.[20] During the excavation, 2700 artefacts, ca. 38,000 pottery fragments and 11,600 animal bones were found.[21] Based on the artefacts and C^{14} dates, the chronology of the cemetery is ca. 800–680 cal BC, but the hillfort was established approximately at 650 cal BC, and periodically inhabited until the first half of the second century AD.[22]

Reznes cemetery was located on the right shore of the Daugava river in present-day Salaspils civil parish on a small peninsula that was separated from the mainland by the Jurupīte rivulet. Altogether, eight barrows have been identified there, they were located in a row along the north edge of the shore. Excavations in Reznes were conducted in 1933 and 1935 by Eduards Šturms and in 1958 and 1969 by J. Graudonis. During the excavations, 404 graves, 44 artefacts and a few pottery sherds were found. Based on the finds and C^{14} dates,

15 Loze, Eberhards 2012, 26–38.

16 Vasks 1994, 4.

17 Ibid., 7.

18 Ibid., 55–56.

19 Graudonis 1989, 11–12.

20 Denisova, Graudonis, Grāvere 1985, 10.

21 Graudonis 1989, 11, 20.

22 Graudonis 1989, 49; Oinonen, Vasks, Zarina, Lavento 2013, 1252–1264.

the chronology of Reznes cemetery is the middle of the 14^{th} century BC–6^{th} century BC.[23]

Vīnakalns hillfort was located around two km to the west of railway station Ikšķile, on the moraine promontory, to its south was the Daugava river, but to the east – a small river. The hillfort was archaeologically studied in 1967 by J. Graudonis. Due to the plans to construct Rīga–Ogre highway over the hillfort, it was completely excavated, the reached area covering 1550 m^2. During the excavation, 280 artefacts and 3057 pottery sherds were found.[24] By the characteristics of the finds and C^{14} dates, the hillfort was inhabited from ca. 789–476 cal BC[25] (Table 1).

Table 1 / 1. tabula

Evaluated material / Analizētais materiāls

Site name	Character of the site	Archaeologist	Excavation time	Dating
Abora I	Settlement and cemetery	Ilze-Biruta Loze	1964–1965, 1970–1971	3484–3102 cal BC to 2137–1925 cal BC
Brikuļi	Hillfort	Andrejs Vasks	1974, 1977–1979	9^{th} cal BC – 2^{nd} centuries AD and 2) 7^{th}–11^{th} centuries AD
Ķivutkalns	Hillfort	Jānis Graudonis, Jolanta Daiga	1966–1967	800–680 cal BC
Reznes cemetery	Cemetery	Eduards Šturms, Jānis Graudonis	1933–1935, 1958–1969	1400–600 cal BC
Vīnakalns	Hillfort	Jānis Graudonis	1967	789–476 cal BC

Animal bones

During the excavations of the settlements of Abora I, Brikuļi, Ķivutkalns, and Vīnakalns, a massive amount of animal bones were obtained.[26] Basic statistical comparison of three animal groups – domesticated and wild animals and fish identified at the settlements shows that Abora I settlement is a classical Late Neolithic site with dominant hunter-fisher-gatherer model, where hunted animal

23 Vasks, Zariņa, Legzdiņa, Plankajs 2021, 3–31.

24 Graudonis 1968, 57–59.

25 Visocka, in print.

26 Graudonis 1989; Loze 1979; Vasks 1994.

bones make up 60.0%, but fish – 37% of all bones found on the site.[27] Late Bronze Age hillforts, on the other hand, were inhabited by farmers, where domesticated animal bones make up for more than 75–94% of the bones.[28] Notably, in Brikuļi fishing still played a great role in the subsistence strategies compared to other hillforts, possibly due to accessibility of fish: they make up 18% of all bones. Notably, for some reason there is no comparable data about fish bones in Vīnakalns hillfort material.

Table 2 / 2. tabula

Domesticated and wild animal bones (in %) in the Late Neolithic and Bronze Age sites in the territory of Latvia/Mājdzīvnieku un meža dzīvnieku kaulu īpatsvars (%) vēlā neolīta un bronzas laikmeta senvietās Latvijā

Animals	Abora I (Loze 1979)	Brikuļi (Vasks 1994)	Ķivutkalns (Graudonis 1989)	Vīnakalns (Graudonis 1989)
Domesticated animal bones	**2.7**	**86.7**	**93.9**	**75.9**
Cattle (*Bos primigenius taurus*)	0.7	34.1	35.9	35.9
Sheep/goat (*Ovis aries/ Capra aegagrus h.*)	0.2	19.1	17.2	9.3
Pig (*Sus scrofa dom.*)	–	16.7	24.95	16.3
Horse (*Equus ferus caballus*)	0.4	16.15	15.4	14.1
Dog (*Canis familiaris*)	1.4	0.65	0.4	0.2
Wild animal bones	**97.3**	**13.3**	**6.1**	**24.1**
Elk (*Alces alces*)	39.1	5.5	0.9	5.5
Roe deer (*Capreolus capreolus*)	1.0	0.05	0.1	0.2
Beaver (*Castor fiber*)	12.5	1.7	3.4	15.6
Wild boar (*Sus scrofa*)	32.5	4.5	0.7	1.5
Red deer (*Cervus elaphus*)	3.3	0.02	0.7	0.9
Aurochs (*Bos primigenius sin Bison bonasus*)	6.3	–	0.05	–
Other wild animals	2.6	1.48	0.25	0.4

27 Loze 1979, 126.

28 Graudonis 1989, 74–79; Vasks 1994, 59–60.

Domesticated animals (Table 2). The comparison of tendencies regarding domesticated animals in all settlements reveals quite notable differences. First of all, there are no domesticated pigs in Abora I settlement, however cattle, sheep, and goat bones have been uncovered during excavations, but the largest proportion of bones is constituted by dog bones (1.4%).[29] We must note that residents of Abora I settlement most likely did not use dogs for meat consumption (because no traces of cut-marks have been found on the surface of dog bones). However, some of dog bones have chewing marks possibly left by other dogs. Unfortunately, the archaeological context of the chewed dog bones (humerus dex. dist. and mandibula dex.) is unclear, as the notes attached to them have vanished. The reason why so relatively many dog bones were found is that people buried dogs (or separate parts of their body) in the settlement area. This indicates that the dog had an important utilitarian role in the Abora community as a guard and hunting mate and possibly it also had a special semiotic/symbolic meaning that finds expression in the tradition of wearing dog fang pendants as amulets or ornaments. In hillforts the most common domesticated animal is cattle; with regard to other animals, regional differences are seen – Brikuļi inhabitants preferred sheep/goat, but inhabitants of the Lower Daugava region – pigs. Although without DNA and radiocarbon analyses it is impossible to determine whether wild or domesticated horse meat was used in the diet, it is assumed that data from Abora I indicate the consumption of wild horses, while a relatively high proportion of horse bones from Bronze Age settlements represents domesticated individuals.

Wild animals. Regional and periodical differences are also seen regarding the preferences of hunting animals: in Lake Lubāns plain, wild boar and elk were preferred, and also, small fur mammals (martens, otters, rabbits etc.) were hunted more than in the Lower Daugava. Notably, the most hunted animal in the Lower Daugava was beaver, who is relatively easy to capture and its entire body – meat, fur, fat and bones (*astragalus*) is usable.[30]

Fish (Table 3). Altogether 19 fish species were obtained from all three settlements. The greatest variety of fish is seen in Abora settlement, where 14 fish species, such as European perch, Northern pike, silver perch, Crucian carp, tench, pikeperch etc. are distinguished. A wide variety of fish is seen in Ķivutkalns as well, but not in Brikuļi. In Abora, the most common fish is European perch, whereas in both hillforts it is pikeperch. In all three settlements Northern pike was also favoured. Ķivutkalns inhabitants in quite large amounts consumed sturgeon and bream as well. Although no remains of fish have been found in

29 Loze 1979, 125.

30 Graudonis 1989.

Vīnakalns, there is no reason to believe that the inhabitants of this site did not use fish in their diet, even more so, considering that in the surroundings of every other settlement fish remains have been found.

Table 3 / 3. tabula

Fish bones (%) in the Late Neolithic and the Bronze Age sites in the territory of Latvia/Zivju kaulu īpatsvars (%) vēlā neolīta un bronzas laikmeta senvietās Latvijā

Fish species	**Abora I (Loze 1979)**	**Brikuļi (Vasks 1994)**	**Ķivutkalns (Graudonis 1989)**
Pikeperch (*Sander lucioperca*)	7.0	79.8	39.2
Northern pike (*Esox lucius*)	7.4	10.0	9.7
European perch (*Perca fluviatilis*)	63.6	4.5	3.0
Wels catfish (*Silurus glanis*)	4.8	4.4	1.8
Ide (*Leuciscus idus*)		0.5	0.2
Common roach (*Rutilus rutilus*)	1.7	0.35	1.7
Burbot (*Lota lota*)	–	0.35	–
Chub (*Squalius cephalus*)	–	0.1	0.8
European sturgeon (*Acipenser sturio*)	–	–	23.2
Common bream (*Abramis brama*)	0.6	–	17.3
Crucian Carp (*Carassius Carassius*)	6.7	–	–
Tench (*Tinca tinca*)	1.6	–	–

Plant macroremains

In Abora settlement, the analysis of plant macroremains has been performed for only two samples, the volume of each sample was 5 litres. These remains show different complexes of plant residues at a depth of 1.6 m and 0.5 m. At a depth of 1.6 m from the earth's surface, the sediments are dominated by the remains of lake shore plants (common club-rush (*Schoenoplectus lacustris*), flowering-rush (*Butomus umbellatus*), arrowhead (*Sagittaria sagittifolia*), fine-leaved water-dropwort (*Oenanthe aquatica*) etc.), aquatic plants (water lilies and various-leaved pondweeds (*Potamogeton*)), and ruderal plants (common nettle (*Urtica dioica*), goosefoots (*Chenopodium rubrum, Ch. album, Ch. polyspermum)*, pale Persicaria (*Polygonum lapathifolium*)), also in quite large amounts charred hazelnut shells.[31] Hazelnuts were definitely used for consumption. At a depth of 0.5 m, only 10 plant taxon residues have been found in the sediments, mostly small amounts of coastal plant seeds. Only carbonated fruit fragments of the water chestnut (*Trapa natans*) were found in large numbers, which indicates their usage for consumption.[32]

Ķivutkalns plant macroremains were analysed from 14 samples by Rasiņš and Tauriņa (1983), additionally analysed were cereal grain imprint positives from pottery fabric, where 13 imprints were distinguished. The latter analysis was carried out in Vīnakalns as well, where seven grain imprints were discovered. Except cereal grains and seeds of other food plants in Ķivutkalns, soil weeds of winter and summer annuals were found as well as perennial weeds.[33] In Ķivutkalns, on 69 occasions, crops were found, the most common were barley (*Hordeum vulgare*) and emmer wheat (*Triticum dicoccum*), large proportion is made also by garden pea (*Pisum sativum*), yellow millet (*Panicum miliaceum*), and wild oat (*Avena fatua*).[34] Notable is camelina *(Camelina sativa)*, which although being an oil plant, according to J. Graudonis, was most likely used for consumption.[35] The only data regarding crops in Vīnakalns, as previously mentioned, is from imprints. Out of seven imprints, six were identified as barley (*Hordeum vulgare*), one as wild oat (*Avena fatua*). Unfortunately, it is impossible to compare these data as they are not of the same kind. Although in Brikuļi layer 3–4 no grains were found, it does not mean that food crops were not cultivated and used for consumption. It is notable that quite many grinding stones have been found in Brikuļi, indicating that the inhabitants possibly cultivated food crops.[36]

Stable isotope analysis: material, method, and results

Carbon and nitrogen stable isotope analysis (C and N SI analysis) were carried out by Dardega Legzdiņa for human bones from three sites: the Late Neolithic Abora I settlement, the Early/Late Bronze Age Reznes barrow cemetery, and the Late Bronze Age Ķivutkalns cemetery. Part of the samples were analysed at the Research Laboratory for Archaeology and the History of Art, Oxford

31 Loze, Iakubovskaia 1984, 85–94.
32 Ibid.
33 Rasiņš, Tauriņa 1983, 152–176.
34 Ibid., 166–167.
35 Graudonis 1989, 72.
36 Vasks 1994.

University (RLAHA, OU), and the other part – at the Analytical Chemistry department, Chemistry Faculty, University of Latvia (CF, UL). All the bones were analysed by applying a relatively mild collagen extraction method, given the old age of the bones. In all cases, a laboratory protocol established by Longin[37] with some modifications[38] was followed. Bone chunks were demineralised in 0.5M HCl solution over a course of days, depending on each individual sample. Repeated rinsing in a deionised H_2O followed. 'Collagen' gelatinisation was done in a pH = 3 solution at ~72 °C for approximately 48 hours. The gelatine was filtered with 60–90 μm Ezee filters and freeze dried. The collagen samples were then analysed for $\delta^{13}C$ and $\delta^{15}N$ with SerCon Callisto CFIRMS system at the RLAHA, OU and with Nu Instruments Nu Horizon IRMS and EuroVector Euro EA3024 at the CF, UL. Delta notation (δ) expresses ratios of $^{13}C/^{12}C$ and $^{15}N/^{14}N$ relative to the international standards VBDP for carbon and AIR for nitrogen in parts per mill (‰). Standard deviations are <0.2‰ for $\delta^{13}C$ and <0.3‰ for $\delta^{15}N$. More detailed analysis of stable isotope content results is presented in several publications.[39] This paper deals only with main tendencies in Neolithic and Bronze Age diets.

The local isotope ecology of Lake Lubāns wetland is well established and based on 43 Stone Age animal bones from five sites and provides a solid baseline for human data interpretation. Most of the samples used for Lake Lubāns wetland region isotope ecology clarification were taken from Abora and Osa settlements animal bone collections. Abora material was of a special interest due to the nearby Stone Age burial site, while Osa provided rich bone material of fish and a great variety of other animal species. Zvidze settlement collection contained rich fish bone material. Additionally, few samples, from both Eiņi and Iča settlements, were selected to provide reference material from a wider area. Altogether, the selected sites cover a long period of Lubāns wetland habitation, spanning from the Late Mesolithic (6690–6339 cal BC) up to the Late Neolithic (2137–1925 cal BC).[40]

A total of 14 results from fish bones were obtained: four pikes and one pikeperch from Zvidze; two pikes, one pikeperch, and four unidentified fish from Abora; one pike from Eiņi and one bream from Osa. All but one sample form a rather tight cluster (with $\delta^{13}C$ ranging –26‰ – –23.55‰ and $\delta^{15}N$ ranging 7.9‰ – 10.24‰). The only outlier with $\delta^{13}C$ value of –27.53‰ and $\delta^{15}N$ of 5.69‰ is bream. Breams, contrary to pikes and pikeperches, are bottom feeders, which

37 Longin 1971, 241–242.

38 Chisholmet et al. 1983, 335–360.

39 Vasks et al. 2021, 23; Legzdiņa, Zariņa 2023, 20–30.

40 Liiva, Loze 1993, 503–506; Liiva, Loze 1994, 153–158; Legzdiņa, Zariņa 2023, 20–30.

can accordingly be seen by the stable isotope values. In summary, the fish bone results from the four sites indicate homogenous local isotope ecology.

Similar conclusions can be drawn from the herbivore results from four settlements (Abora – two beavers, two elks; Zvidze – one elk; Iča – one elk, one auroch; Osa – two roe deer, two elks, one wild horse, one auroch). All results fall within $\delta^{13}C$ range of –24.56‰ – –21.95‰ and $\delta^{15}N$ range of 3.65‰ – 7.70‰.

The two omnivore results are from wild boar ($\delta^{13}C$ = –23.08‰; $\delta^{15}N$ = 4.50‰) and brown bear ($\delta^{13}C$ = –24.52‰; $\delta^{15}N$ = 5.26‰), placing them accordingly in the range of an omnivorous terrestrial diet.

Regarding bird bones, they show a high variability in both $\delta^{13}C$ and $\delta^{15}N$ values, reflecting the feeding habits of different bird species (terrestrial and freshwater; herbivore, omnivore, and carnivore). Three marten results differ minimally with $\delta^{13}C$ varying for 1‰ (–19.8–20.8), and $\delta^{15}N$ – for only 0.4‰ (8.8–9.2), also two dog samples from Abora and Osa values were very similar ($\delta^{13}C$ –22.6 and – 23.2‰; $\delta^{15}N$ 9.2 and 9.0‰).

Based on comparisons between the five sites, we conclude that the animal bone C and N stable isotope results can be used as a dietary baseline for other sites in the micro-region, paving the way for future human diet research. Moreover, the wide chronology of the sites used in this research shows that the local stable isotope ecology can be considered invariable during the Stone Age. We therefore propose these results as an animal bone C and N stable isotope dataset with a significant number of data points (43) and a high variety of species from different dietary groups, characterising the Lubāns valley C and N isotope ecology to be one with notably depleted $\delta^{13}C$ (–27‰ – –20‰) and with regular $\delta^{15}N$ (4‰–12‰) values (Fig. 2).

The results of the stable isotope content for residents of the Abora I settlement have been published and analysed in a separate publication.[41] The data show that the Abora human diets during more than 1000-year time span, from ~3200–3100 cal BC till ~2000–1900 cal BC, were definitely not what would be expected from early farmers, i.e. less depleted $\delta^{13}C$ and lower $\delta^{15}N$ values. The majority of human isotope content values, when viewed in context with the Stone Age animal data, group in a cluster with one end reflecting a freshwater diet and the other end – a mixed freshwater/terrestrial diet (Fig. 3). In general, the population of Abora I had diets that were still heavily based on freshwater resources, with only a few individuals having more mixed freshwater/terrestrial diet with lower protein intake that could be explained by some amount of farming produce in their diet. Application of locally applicable FRUITS model estimated that 23 of the 29 adults

41 Legzdiņa, Zariņa 2023, 20–30.

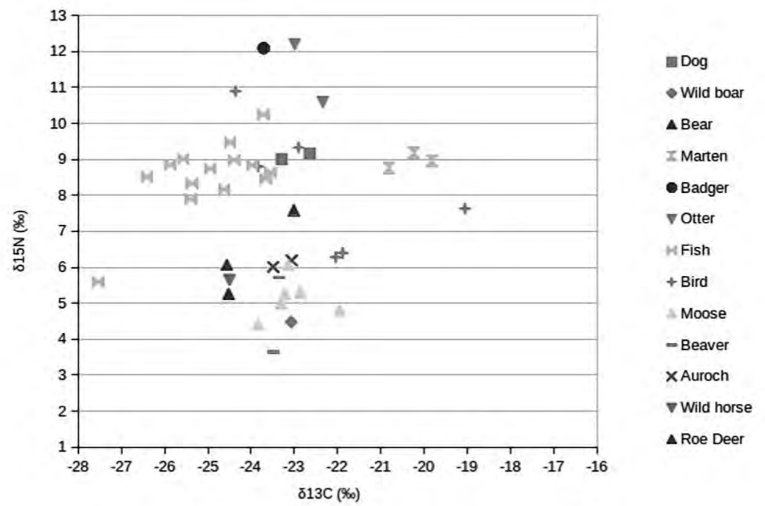

Fig. 2. Stable isotope plot (‰) of Lake Lubāns wetland region fauna remains

2. att. Lubāna ezera mitrāja faunas ķīmisko elementu stabilo izotopu dati (‰)

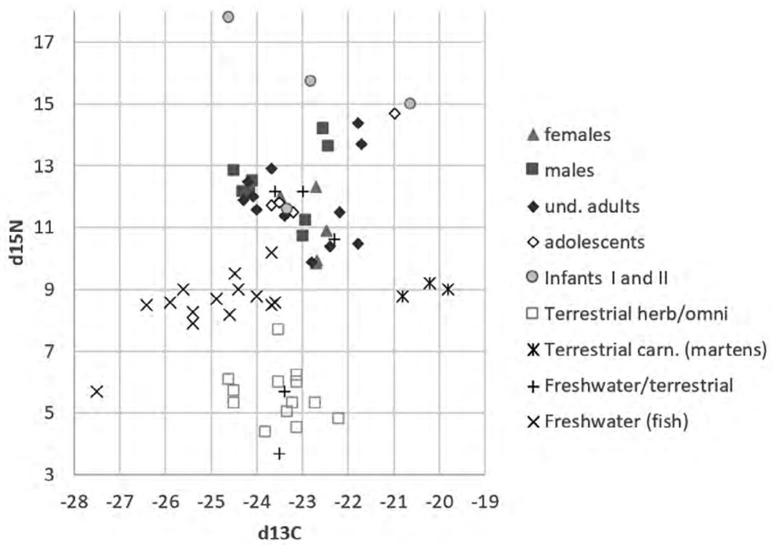

Fig. 3. Stable isotope plot (‰) of Abora I human remains

3. att. Aboras I apmetnes cilvēku apbedījumu ķīmisko elementu stabilo izotopu dati (‰)

analysed had 40–60% fish intake in their diets, with most of them falling closer to the 60% mark. In general, the same individuals then had 20–40% plant intake, and only 5–20% terrestrial animal intake. On the other hand, the other six adults had 50–60% animal intake and 20–40% fish intake. Plant intake, however, is more similar to that of the larger group: 20–30%. Evidently, these six individuals relied heavily on terrestrial animals in their diet, which could be explained either by hunting, or by animal husbandry.

However, moderate reliance on plants, even if they might have been domesticated plants, does not put these individuals in a dietary pattern that would be typical for early agriculturalists, more likely – pastoralists, that still incorporated fishing in their diet. Interestingly, three of them are recorded as having been interred in crouched burials – the burial position that is archaeologically associated with the Corded Ware Culture (of other three individuals only stray bones were found, and the burial position could not be determined).[42]

Previous publications on the human bone ^{14}C dates from Ķivutkalns also include some stable isotope data as well. The moderate $\delta^{13}C$ and $\delta^{15}N$ values (~ –21 – –18‰ and 9–11‰, respectively) led researchers to conclude that the diet there was generally terrestrial. The $\delta^{15}N$ values were explained in terms of a large proportion of meat and dairy products, and the occasionally elevated $\delta^{13}C$ as due to an addition of millet in the diet.[43]

We now report stable isotope data of three more humans from Ķivutkalns and seven from Reznes, and isotope data for two more horse teeth from Reznes (Fig. 4). Our Ķivutkalns human stable isotope analysis results correspond very well to the findings of the previous studies, and actually, so do the results for the Reznes humans. We therefore agree with the previous interpretation, which excluded the marine factor from the Bronze Age diet. However, we are more cautious when it comes to disregarding freshwater resources. So far, we do not have a comprehensive isotopic dataset of Bronze Age fish from the Daugava. However, a study of the Late Iron Age local and migratory fish of the Lower Daugava shows unusually low $\delta^{15}N$ values (~7–11‰) and a high variability in $\delta^{13}C$ values (~ –25 – –17‰).[44]

Therefore, we are not confident in disregarding the presence of fish in the Bronze Age diet. Also, animal stable isotope baseline for the Lower Daugava river region for the time being is not well established. Some data are available from previous research. For example, there are three unspecified animal data

42 Legzdiņa, Zariņa 2023, 20–30.

43 Oinonen et al. 2013, 1252–1264; Vasks, Zariņa 2014, 5–36.

44 Gunnarssone et al. 2020, 45–69.

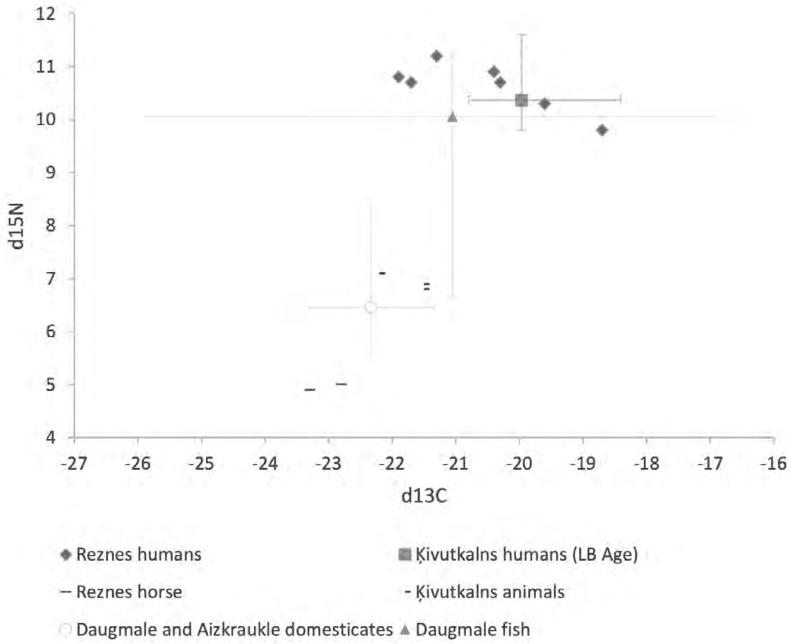

Fig. 4. Stable isotope plot (‰) of Ķivutkalns and Reznes human remains

4. att. Ķivutkalna un Reznu kapulauku cilvēku apbedījumu ķīmisko elementu stabilo izotopu dati (‰)

from the Late Bronze Age hillfort Ķivutkalns. As the sampled material are finely worked bone artefacts, the species are impossible to determine. However, the C and N δ values place them in the terrestrial herbivore/omnivore area as well.[45]

Geographically close, but chronologically more distant are the Late Iron Age domesticated animals from Daugmale (two domesticated pigs) and Aizkraukle (horse, cattle, chicken, goose) hillforts. The horse sample from Aizkraukle: 5.6–22.73, i.e. very close to Reznes horses. The other domesticates from Alise Gunnarssone's research can provide a baseline distribution for the domesticated animal data.[46]

Unfortunately, there are no isotopic data available for different plants, which complicates addressing the issue of possible manuring of domesticated plants, crops, etc. However, the impact of plant isotopes on the bone collagen is less prominent due to carbon and nitrogen coming mostly from protein sources (100%

45 Oinonen et al. 2013, 1252–1264.

46 Gunnarssone et al. 2020, 45–69.

for N and ~74% for C), whereas in plants protein is in much smaller amounts than carbohydrates.[47] Ongoing discussion is that of C4 and C3 plants in the Bronze Age palaeodiets[48] (Oinonen et al. 2013; Vasks & Zariņa 2014). As the territory of Latvia is located in Northern Europe, there are actually no indigenous C4 plants, as they require more warm and arid climates. Same goes for imported domesticate crops. One such exception is millet which has actually been recorded in Latvian archaeological material.[49] Millet as C4 plants, have much higher δ13C values. If an individual consumes large amounts of millet for a prolonged period of time, it should be recorded in their isotopic data as elevated $\delta^{13}C$ and depleted $\delta^{15}N$ value. Geographically the closest millet isotopic data is from Lithuania: −9.1 $\delta^{13}C$ and 6.4 $\delta^{15}N$.[50] Further, we adopt this data when the consumption of millet is discussed. In the case of bone collagen, it is estimated that ~20% of dietary protein (not to be mistaken for the overall calorie intake) must come from a non C3 source in order for it to be distinguishable isotopically.[51] In literature, a cautious application of a $\delta^{13}C$ cut off usually use value of −18‰ or greater, combined with relatively low $\delta^{15}N$ values as an indication of C4 consumption.[52] From the analysed Reznes humans, none have $\delta^{13}C$ values higher than −18‰. Two of them have somewhat elevated $\delta^{13}C$: −18.7‰ and −19.6‰; however, they both still have high $\delta^{15}N$ values: 9.8‰ and 10.3‰, respectively. When applying the Bayesian statistical probability programme FRUITS[53], it becomes clear that the millet consumption could be low to non-existent to all Reznes individuals, including the ones with higher $\delta^{13}C$ values.

Therefore, another way to look at the data is to see if there is any correlation between the $\delta^{13}C$ values and the cal BC dates. Interestingly, there indeed seems to be some correlation, as the five older dates (~1200–900 cal BC) all have lower $\delta^{13}C$, while the two most recent – 804–552 cal BC and 798–546 cal BC – fall more closely not with other Reznes individuals, but with the Late Bronze Age Ķivutkalns individuals: both regarding the $\delta^{13}C$ and the ^{14}C dates, and even regarding the $\delta^{15}N$ values (Fig. 5). Although the sample size is still too small for a more certain interpretation, this seems to indicate a slight dietary shift from the Early to the Late Bronze Age.[54]

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47 Fernandes et al. 2012, 291–301.

48 Oinonen et al. 2013, 1252–1264; Vasks, Zariņa 2014, 5–36.

49 LA 1974, 88.

50 Antanaitis, Ogrinc 2000, 3–12.

51 Hedges 2003, 66–79.

52 Pearson et al. 2007, 2170–2179.

53 Fernandes et al. 2014.

54 Vasks et al. 2021, 23.

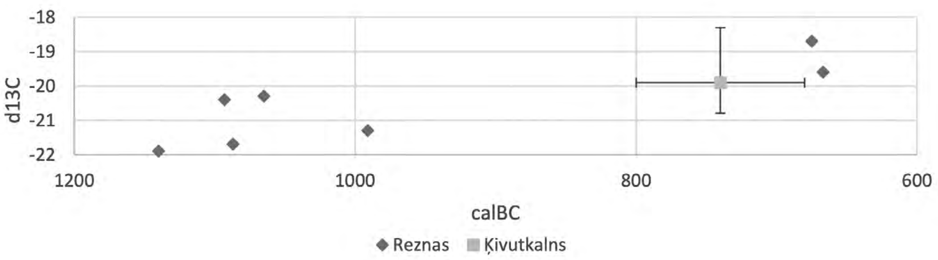

Fig. 5. Comparing Early and Late Bronze Age human isotopes (‰)

5. att. Agrā un vēlā bronzas laikmeta iedzīvotāju ķīmisko elementu stabilo izotopu datu salīdzinājums (‰)

Conclusions

Lake Lubāns wetland and the Lower Daugava was the most inhabited regions during the Neolithic and Bronze Age, and also have been extensively archaeologically studied.

In this study seven sites are analysed – Abora I settlement and burials and Brikuļi hillfort from Lake Lubāns wetland and Ķivutkalns hillfort and cemetery, Vīnakalns hillfort and Reznes cemetery in the Lower Daugava.

Stable isotope data of Abora humans show that most of the population relied heavily on freshwater fish with complementary terrestrial plant resources, while having a low contribution from terrestrial animal resources. Several individuals, however, had a different subsistence strategy that relied heavily on terrestrial animal sources, with complementing freshwater and plant sources. None of the individuals have isotope data that would indicate agriculture as a significant subsistence strategy. In Abora I settlement plant macroremains dominated the remains of lake shore plants (common club-rush, flowering-rush, arrowhead, fine-leaved water-dropwort etc.), aquatic plants (perfoliate and various-leaved pondweed, water lilies) and ruderal plants (common nettle, goosefoots, pale Persicaria), also in quite large amounts charred hazelnut shells and fragments of water chestnut fruits. Regional tendencies are seen in hunted animals – in the Lower Daugava beaver and elk dominates, but in Lubāns plane – elk and wild boar. Local farming preferences are seen regarding inland and coastal hillforts (sheep and goats in Brikuļi, domesticated pigs in the Lower Daugava). In Ķivutkalns a noticeable amount of cereals was found, the most common are barley and emmer wheat, a large proportion is made also by garden pea, yellow millet and wild oat. Grinding stones have been found in Brikuļi, indicating that the inhabitants of this site cultivated food crops. Analysis of Reznes humans isotopes shows that freshwater resources could be slightly more dominant than terrestrial; notably, significant millet intake cannot be detected. Overall, archaeozoological and palaeobotanical data correspond to stable isotope data, however, some methodical problems are present. Carbon and nitrogen stable isotope analyses were carried out, utilising collagen extracted for radiocarbon dating purposes. Therefore, the skeletal elements sampled are variable, also the number of analysed individuals from Reznes and Ķivutkalns is small. However, for the purposes of this study, even the limited data provides a valuable insight. For example, none of the seven Reznes individuals had significant millet contribution to their diet. Distinction between terrestrial and aquatic protein sources is complicated due to the isotopic ecology in the Daugava river. In the lower reaches of the Daugava, three groups of fish can be encountered – freshwater, marine, and migratory. Consequently, there is a high variability in fish isotopic values. Due to possible fish consumption, freshwater reservoir effect needs to be addressed in future research.

The results possibly indicate that farming as the main form of food provision became established in Latvia in the Middle Bronze Age.

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VĒLĀ NEOLĪTA UN BRONZAS LAIKMETA IZTIKAS STRATĒĢIJAS LATVIJAS TERITORIJĀ LUBĀNA MITRĀJĀ UN DAUGAVAS LEJTECĒ

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Rakstā tiek izvērtētas un salīdzinātas uztura nodrošināšanas prakses no vēlā neolīta līdz vēlajam bronzas laikmetam divās dažādās ekosistēmās – Daugavas lejtecē un Lubāna mitrājā. Darbā tika izmantoti zooarheoloģiskie, paleobotāniskie un kaula materiāla stabilo izotopu dati. Iegūtie rezultāti liecina, ka Latvijā ražojošās saimniecības aizsākumi vērojami vēlā neolīta periodā, īpaši auklas keramikas kultūras iedzīvotājiem. Tomēr šajā periodā saglabājas arī nozīmīga saldūdens zivju izmantošana uzturā. Ražotājsaimniecība kā galvenā uztura nodrošināšanas forma nostiprinās Latvijā bronzas laikmeta vidū.

Atslēgas vārdi: Austrumbaltija, vēlais neolīts, bronzas laikmets, zooarheoloģija, paleobotānika, stabilo izotopu analīze.

Kopsavilkums

Lubāna mitrājs un Daugavas lejtece neolītā un bronzas laikmetā bija visblīvāk apdzīvotie reģioni Austrumbaltijā. Tie ir arī plaši arheoloģiski pētīti.

Šajā pētījumā tiek analizēta Lubāna ezera mitrāja Aboras I apmetne un apbedījumi un Brikuļu pilskalns, kā arī Ķivutkalna pilskalns un kapulauks, Vīnakalna pilskalns un Reznu uzkalniņu kapulauks Daugavas lejtecē.

Aboras I apmetnes iedzīvotāju stabilo izotopu dati liecina, ka ievērojama loma pārtikā bija saldūdens zivīm, papildus sauszemes augu resursiem, bet sauszemes dzīvnieku resursu patēriņš bija zems. Tomēr vairākiem indivīdiem bija atšķirīga iztikas stratēģija, kas lielā mērā balstījās uz sauszemes dzīvnieku resursiem, papildinot tos ar saldūdens zivīm un augiem. Neviens no pētītajiem indivīdiem nav piekopis lauksaimniecību kā nozīmīgu iztikas nodrošinājuma veidu. Aboras I apmetnē augu makroatliekās dominēja ezera piekrastes augi (ezera meldrs, čemurainais puķumeldrs u. c.), ūdensaugi (bultenes, ūdensrozes) un nezāles (parastā nātre, balandas, skābeņlapu sūrene), kā arī konstatēts ievērojams daudzums pārogļotu lazdu riekstu čaumalu.

Medījumiem vērojamas reģionālas tendences – Daugavas lejtecē dominē bebrs un alnis, bet Lubāna mitrājā – alnis un meža cūka. Vērojamas atšķirības mājlopu sastāvā. Brikuļu pilskalnā ir vairāk liecību par aitu un kazu audzēšanu, Daugavas lejtecē – par pieradinātām cūkām. Ķivutkalnā konstatēts ievērojams labības daudzums. Nozīmīgs ir miežu un kviešu īpatsvars, pārstāvēti arī dārza zirņi, prosa (sējas sāre), sējas idra un vēja auzas. Brikuļos ir atrasti beržamakmeņi, kas norāda uz graudaugu audzēšanu. Reznu kapulaukā apbedīto cilvēku izotopu analīzes liecina, ka saldūdens resursi varētu būt nedaudz dominējošāki nekā sauszemes.

Kopumā zooarheoloģiskie un paleobotāniskie dati atbilst stabilo izotopu rezultātiem, tomēr pastāv dažas metodiskas problēmas. Oglekļa un slāpekļa stabilo izotopu analīzes tika veiktas, izmantojot radioaktīvā oglekļa noteikšanas nolūkos ekstrahētu kolagēnu. Līdz ar to paraugiem izmantotas dažādas skeleta daļas, kā arī neliels ir no Reznu un Ķivutkalna kapulaukiem analizēto indivīdu skaits. Tomēr šī pētījuma ierobežotie dati sniedz vērtīgu ieskatu ražotājsaimniecības attīstības procesos Latvijā. Piemēram, nevienam no septiņiem Reznu indivīdiem nebija vērojama prosas lietošana uzturā. Sauszemes un ūdens olbaltumvielu avotu nošķiršana ir sarežģīta Daugavas izotopu ekoloģijas dēļ. Daugavā sastopamas trīs zivju grupas – saldūdens, jūras un migrējošās. Līdz ar to zivju izotopu vērtības ir ļoti mainīgas. Iespējamā zivju patēriņa dēļ turpmāk būtu jāpievērš uzmanība saldūdens rezervuāra ietekmes izpētei Daugavas baseinā. Reznu kapulauka atsevišķiem indivīdiem novērotās tendences uzturā lietot pamatā sauszemes produktus 800–550 gadus pirms Kristus, iespējams, liecina, ka lauksaimniecība kā galvenais pārtikas nodrošinājuma veids Latvijā nostiprinājās šajā periodā.

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