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Zooarchaeology of the Late Bronze Age Fortified Settlements in Lithuania

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Abstract: The economic model of the Lithuanian Late Bronze Age (1100–500 cal BC) has long been based on zooarchaeological collections from unstratified, multi-period settlements, which have provided an unreliable understanding of animal husbandry and the role of fishing and hunting. The opportunity to re-evaluate the previously proposed dietary and subsistence patterns arose after zooarcheological assemblages of Garniai 1 and Mineikiškės fortified settlements, dating only to the Late Bronze Age, were collected in 2016–2017 and 2020–2021. The new analysis revealed that the communities in these sites were mainly engaged in animal husbandry of small ungulates such as pigs, sheep/goats, which differed from western Lithuania and the rest of the Eastern Baltic. Moreover, it has been observed that hunting and fishing significantly declined after the Early Bronze Age (1700–1100 cal BC). Lastly, unusual traits for the Baltic region were identified including exceptionally highly fragmented bones and the consumption of molluscs, which could be attributed to the exploration of additional food sources in times of deprivation.

Keywords: zooarchaeology; subsistence; diet; Late Bronze Age; East Lithuania

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1. Introduction

The dietary patterns of communities excellently reflect the subsistence economy and livelihood. One of the most significant changes in the human diet was caused by the shift from a foraging to an agricultural economy in the Neolithic period. Neolithisation processes began in the Eastern Baltic region considerably later than in Central Europe and Southern and Central Scandinavia (ca. 4000–3700 BC) [1]. The earliest known domestic animal bones in Lithuanian territory have been dated to the middle of the third millennium BC, but it is likely that animal husbandry and the usage of its products began as early as 2800 BC, along with the arrival of people of the Corded Ware culture [2,3]. The latest studies suggest that the communities associated with the first Indo-Europeans in the region did not bring crop agriculture to the Eastern Baltic, as the earliest cereal grains were dated to 1409–1229 cal BC [4]. Thus, a major turning point in the region's economy occurred during the end of the Early Bronze Age (hereinafter EBA) and the beginning of the Late Bronze Age (hereinafter LBA) as a broad variety of crops and pulses were identified in fortified settlements dated to ca. 900–400 BC [5,6]. Based on the variety of cultivated plants, as well as the location of studied settlements in the nutrient–deficient soil zones, it was suggested that an intensive agricultural economy was adopted as early as the LBA (ibid.).

Up until recent archaeological investigations, only a few short-term settlements were known in Lithuania (Luokesai 1, Kukuliškiai); however; the assemblages of animal bones in these sites were scarce. For the study of this crucial period in Eastern Baltic prehistory, significantly larger zooarchaeological collections are required. Most of the LBA and Iron Age assemblages in Lithuania have been collected in multi-period sites, which has led to an unreliable understanding of the animal husbandry and the over-signified role of

hunting. Furthermore, the excavation methodology used during the acquisition of these legacy assemblages ensured the collection of only bone artefacts, complete bones, or larger fragments, which contributed to the proposal of problematic concepts [7]. From the beginning of the 20th C AD until its end, Lithuanian archaeologists rarely used dry or wet sieving methods to collect the smaller fragments, and bones highly susceptible to fragmentation were lost [8]. Before the 21st C AD, these methods were never used in the investigation of fortified settlements; therefore, the assemblages of only larger bones caused several studies to describe the hunting of large wild animals as a significant supplementary strategy in communities' subsistence during the LBA [9,10]. This has led to the understanding of the LBA economy without an important part of the archaeological data that was not collected.

The opportunity to discuss the subsistence and diet of inhabitants settled in eastern Lithuania during the LBA arose after the excavation of the single-period fortified settlements of Garniai 1 and Mineikiškės in 2016–2017 and 2020–2021 [11–15]. These assemblages, collected using meticulous methodologies, differed in their high amounts of small fragments. Thus, it is important to discuss how this information complements or challenges the previous understanding of people's nutrition and economy. By presenting the main results of the zooarchaeological analysis of assemblages collected in Garniai 1 and Mineikiškės, we seek to provide more insight into the subsistence and diet of inhabitants settled in the inland areas of the Eastern Baltic region during the Late Bronze Age.

2. Materials and Methods

Garniai 1 and Mineikiškės fortified settlements are located in north-eastern Lithuania, on isolated hills near Kriaukė and Nikajus rivers (Figure 1). These two rivers are part of different, larger river basins: Šventoji-Neris-Nemunas running southwest and Daugava running northwest, respectively. As the distance between the sites is ca. 21 km, the area could have been an important land route between these river basins. The region bordering these river basins was important for the development of early fortified settlements as at least 1/3 of all LBA fortified settlements in the Eastern Baltic region are located in this area [16]. In this particular area, there is little data on other types of LBA sites including cemeteries and unfortified settlements. From the data collected in other fortified settlements (e.g., Kereliai, Luokesai 1, Narkūnai, Sokiškės), these sites were occupied by farmers and were their main habitation areas [17–20]. These communities sometimes engaged in the bronze trade but also had to secure their goods and stock, which points to social tensions in the area [21].

In Garniai 1, an area of 107 m^2 was excavated in the southwestern and central parts of the settlement during 2016–2017, and 2021 [10,11,14]. Several features attributed to postholes of houses were identified, as well as an assemblage of 87 artefacts made of antler, bone, bronze, ceramics, flint, and stone. 1140 fragments of pottery and 2432 animal bones (2389 specimens in 2016, 2017, and 43 in 2020) were also collected. A tooth of sheep/goat, a tibia of large ungulate, and a horncore of a large bovid found in Garniai 1 was AMS-dated to 786–541 cal BC [22].

In Mineikiškės, 40 m^2 was investigated in the southern part of the settlement during 2017 and 2020 [13,14]. The assemblage consists of 99 artefact fragments made of antler, bone, ceramics, bronze, flint, and stone, supplemented by 5889 pottery fragments and 7948 specimens of animal skeletal remains (2711 pieces in 2017 and 5237 in 2020). Bones of horse and large bovid, charred organic residues in pottery, grains of *Hordeum vulgare* and *Cerealia*, and wood charcoal (altogether 19 finds) were AMS-dated to the period from 983 to 388 cal BC [22–26].

During all excavation seasons in both sites, soil dry-screening with 5 × 5 mm sieves was applied; thus, the smallest bone fragments were collected. The typochronology of the artefacts is consistent with the AMS dates acquired for both sites, as the assemblages are inherent to the Late Bronze Age, with no finds indicating later periods.

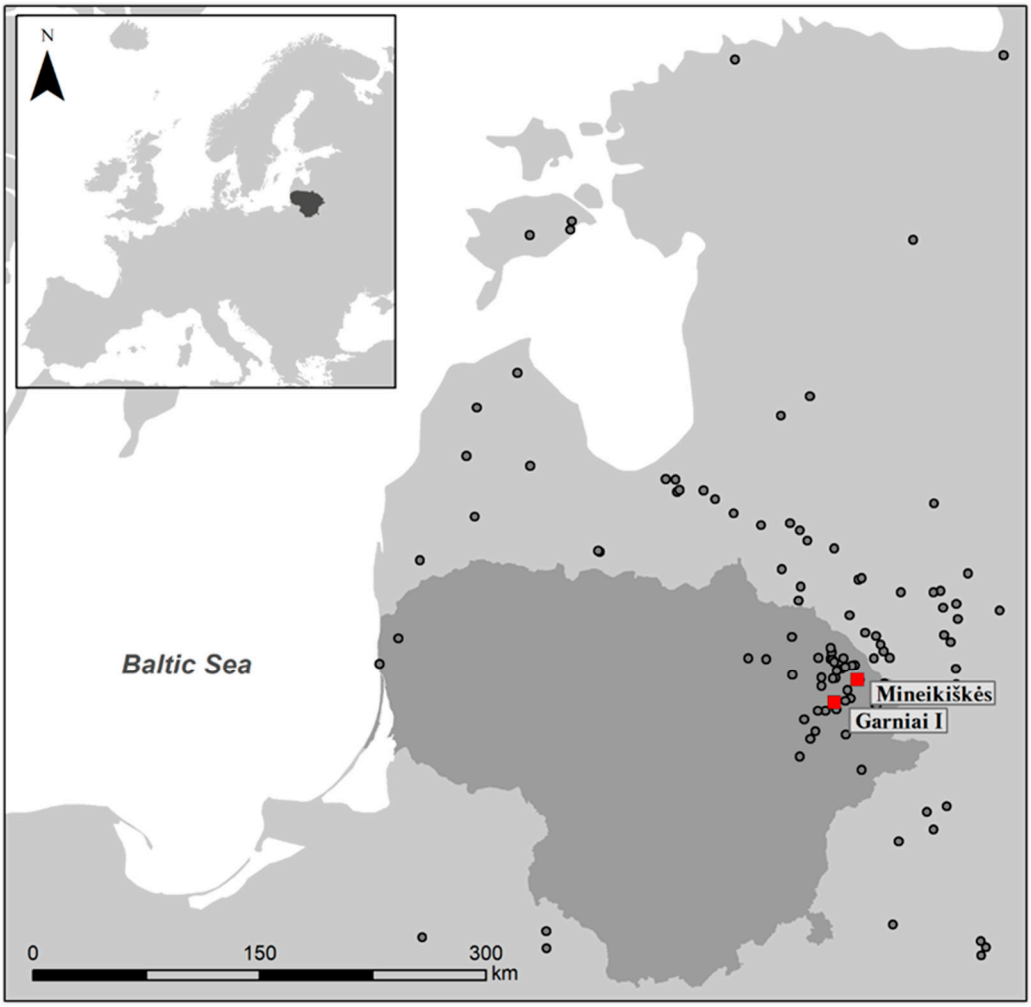

Figure 1. The locations of Garniai 1 and Mineikiškės fortified settlements. Grey dots indicate locations of other LBA fortified settlements in the region [23].

The research was carried out in the Zooarchaeology Laboratory of Vilnius University using a comparative collection of mammal and fish bones. Sheep and goat bones were identified according to the characteristics described by Boessneck et al. [27], Schramm [28], and Prummel and Frisch [29]. When representative features of bone fragments to distinguish between sheep and goats were lacking, the fragments were classified as sheep/goat. The unidentified bones were divided into three groups: small ungulates, large ungulates, and small fragments. The minimum number of individuals (MNI) was calculated using White's [30] methodology. The epiphyseal fusion and teeth eruption time were defined on the basis of schemes developed by Silver [31]. The age of sheep/goats in terms of tooth wear was assessed according to Payne's method [32]. The age of cattle and pigs in terms of tooth wear was assessed according to Grant [33]. The age of the cattle was determined by the height of the first lower molar tooth (M_1) according to the methodology (the third model) suggested by Sten [34]: age = 18.13 − 0.25xH. The age of the horses was estimated by the wear of the incisors, and height of the premolars and molars [35]. Bones and bone fragments were measured with a caliper to an accuracy of 0.1 mm according to the methodology of Von den Driesch [36]. The mollusc remains were identified visually, and the reliability of the identification was checked using malacofauna atlases (descriptions, drawings, photographs, and online data sources) [37–40]. The size of the fish was determined by the fish of a known length in a reference collection. The Latin names of the mentioned species are given in the tables below. Mammal remains were identified by Micelicaitė (material from 2016 and 2017 excavation) and Piličiauskienė (material from 2020

excavation); fish remains were analysed by Piličiauskienė and an analysis of molluscs was provided by Damušytė.

3. Results

The analysed material consisted of 7948 (12.7 kg) bones and bone fragments from Mineikiškės and 2432 (2.4 kg) from Garniai 1. In both fortified settlements, terrestrial mammal remains were the most abundant (89.8–99.8%). These finds were complemented by bones of domestic and wild mammals, fish bones and scales, as well as mollusc shells. The remains of birds were not identified to the exact species (Table 1). The assemblages of the Mineikiškės and Garniai 1 settlements are presented separately below (for general results, see Tables 2 and 3).

Table 1. Amount and composition of studied zooarchaeological material in Mineikiškės and Garniai 1 sites.

Different Groups of Assemblages/Settlement		Mineikiškės	Garniai 1
Identified mammals	n	1965	531
	%	24.7%	21.8%
Unidentified mammals	n	334	74
	%	4.2%	3.0%
Small unidentified ungulates	n	4565	1788
	%	57.4%	73.5%
Large unidentified ungulates	n	282	36
	%	3.5%	1.4%
Birds	n	12	-
	%	0.1%	-
Fish	n	287	3
	%	3.6%	0.1%
Molluscs	n	500	-
	%	6.2%	-
Total	n	7948	2432
	%	100%	100%
Weight	kg	12.7 kg	2.4 kg

Animal remains in both settlements were highly fragmentary. The average weight of mammal bone was around 1–1.7 g; therefore, a large proportion of specimens could not be identified at the species level. Bone fragments of small ungulates, most of which seem to have belonged to pigs and sheep/goat, predominated among the unidentified material, while fragments of unidentified bones of large ungulates accounted for only a small proportion of the total zooarchaeological collection. In both sites, some of the bones were also burned, amounting to 420 (5.2% of the total material) in Mineikiškės and 171 (7.0%) in Garniai 1. Burnt bones were scattered throughout the excavation area and were not concentrated in one place. Numerous bones also had marks of dog or pig gnawing. Osteometric bone measurements were only possible in a few cases due to severe material fragmentation. The best-preserved material for osteometric analysis was pig teeth, but these are too few in number to provide broader insight.

Table 2. Species and anatomical distribution of the examined animal bones in the zooarchaeological material of the Mineikiškės fortified settlement. NISP: number of identified specimens; MNI: minimum number of individuals. Data from this study and forthcoming paper of Minkevičius et al. [26].

Animal/Bone	Horn Core	Cranium	Maxilla	Mandible	Dentes	Vertebrae	Scapula	Humerus	Radius	Ulna	Carpal Bones	Metacarpus	Pelvis	Femur	Patella	Tibia	Fibula	Calcaneus	Talus	Tarsal Bones	Metatarsus	Phalanges	Metapodia	NISP	NISP, %	MNI	MNI, %
Cattle *Bos taurus*	1	16	2	9	46	10	1	7	6	12	2	7	1	17		10		3			5	6	4	**165**	**8.4**	**7**	**9.2**
Sheep *Ovis aries*		1		2	2			3				4						1				2	2	**17**	**0.9**		
Goat *Capra hircus*																						4		**4**	**0.2**	**22**	28.9
Sheep/goat *Ovis aries/Capra hircus*		51	3	23	112	102	8	26	49	7	20	15	2	86		55		2	3	3	35	39	11	**652**	**33.2**		
Pig *Sus scrofa domesticus*		94	28	29	227	69	10	47	14	12	26	10	7	50	2	32	29	3	3	19	6	132	41	**890**	**45.3**	**21**	**27.6**
Horse *Equus ferus caballus*		9	2	14	44	9		4	2	1	2	3	1	1		7		1	1		1	2		**104**	**5.3**	**8**	**10.5**
Elk *Alces alces*					1	1																		**2**	**0.1**	**1**	**1.3**
Red deer *Cervus elaphus*									1			1		2										**4**	**0.2**	**1**	**1.3**
Roe deer *Capreolus capreolus*					2		1							2										**5**	**0.3**	**1**	**1.3**
Wild boar *Sus scrofa*		1			2												1							**4**	**0.2**	**1**	**1.3**
Pig/wild boar *Sus scrofa domesticus/Sus scrofa*				3	6									1			1							**11**	**0.6**	**1**	**1.3**
Beaver *Castor fiber*					1	1																		**2**	**0.1**	**1**	**1.3**
Otter *Lutra lutra*		1																1				1		**3**	**0.2**	**1**	**1.3**
Red fox *Vulpes vulpes*			1	6	4	3			1	2		1				1		2	2		2	2	2	**29**	**1.5**	**3**	**3.9**
Hare *Lepus timidus/Lepus europaeus*		1		1		4	1	7	7	4		2	1	3		16		2			1	1	3	**54**	**2.7**	**3**	**3.9**
European marten *Martes martes*				2		1			1													1		**5**	**0.3**	**1**	**1.3**
Mustelidae									1				1			2								**4**	**0.2**	**1**	**1.3**
Red squirrel *Sciurius vulgaris*		1		1									1	1										**4**	**0.2**	**1**	**1.3**
Small rodents		2	2	2																				**6**	**0.3**	**2**	**2.6**
In total	**1**	**177**	**38**	**92**	**447**	**200**	**21**	**94**	**82**	**38**	**50**	**43**	**14**	**163**	**2**	**123**	**31**	**15**	**9**	**22**	**50**	**190**	**63**	**1965**		**76**	
%	**0.1**	**9.0**	**1.9**	**4.7**	**22.7**	**10.2**	**1.1**	**4.8**	**4.2**	**1.9**	**2.5**	**2.2**	**0.7**	**8.3**	**0.1**	**6.3**	**1.6**	**0.8**	**0.5**	**1.1**	**2.5**	**9.7**	**3.2**		**100.0**		**100.0**

Table 3. Species and anatomical distribution of the examined animal bones in the zooarchaeological material of the Garniai 1 fortified settlement. NISP: number of identified specimens; MNI: minimum number of individuals. Data from this study and forthcoming paper of Minkevičius et al. [26].

Animal/Bone	***Horn Core***	***Cranium***	***Maxilla***	***Mandible***	***Dentes***	***Vertebrea***	***Sacrum***	***Scapula***	***Humerus***	***Radius***	***Ulna***	***Metacarpus***	***Carpal Bones***	***Pelvis***	***Femur***	***Tibia***	***Fibula***	***Calcaneus***	***Talus***	***Metatarsus***	***Phalanges***	***Metapodium***	**NISP**	**NISP,%**	**MNI**	**MNI, %**
Cattle Bos taurus	2	1	1	1	8				4	2	2	2	1		3	3					1	1	**32**	**1.3**	**2**	**5.9**
Sheep *Ovis aries*																		1		1			**2**	**0.1**	**4**	11.8
Sheep/goat *Ovis/Capra*		13		3	29	12			1	17		3	3	2	15	10		2	1	7	7	2	**127**	**5.2**		
Pig *Sus scrofa domesticus*		35	5	6	94	19		2	14	7	2	5	10	1	24	7	8	1	1	1	50	15	**307**	**12.6**	**16**	**47.1**
Horse *Equus ferus caballus*					3	3				1													**7**	**0.3**	**2**	**5.9**
Dog *Canis familiaris*					1																		**1**	**0.04**	**1**	**2.9**
Brown bear *Ursus arctus*																		1					**1**	**0.04**	**1**	**2.9**
Wild boar *Sus scrofa*																	2						**2**	**0.1**	**1**	**2.9**
Pig/wild boar Sus scrofa domesticus/Sus scrofa					2																		**2**	**0.1**	**1**	**2.9**
White hare *Lepus timidus*					1	1	1	1	4	3	1	1		1	3	11		1	1			1	**31**	**1.3**	**1**	**2.9**
Red fox *Vulpes vulpes*				1		3								2	1					1			**8**	**0.3**	**1**	**2.9**
European marten *Martes martes*						1																	**1**	**0.04**	**1**	**2.9**
European polecat *Mustela putorius*					1	1																	**2**	**0.1**	**1**	**2.9**
Red squirrel *Sciurus vulgaris*									2														**2**	**0.1**	**1**	**2.9**
Small rodents *Rodentia*		2		2	1									1									**6**	**0.2**	**1**	**2.9**
Total	**2**	**51**	**6**	**13**	**140**	**40**	**1**	**3**	**25**	**30**	**5**	**11**	**14**	**7**	**46**	**31**	**10**	**6**	**3**	**10**	**58**	**19**	**531**		**34**	
%	**0.4**	**9.9**	**1.2**	**2.5**	**27.2**	**7.8**	**0.2**	**0.6**	**4.9**	**5.8**	**1.0**	**2.1**	**2.7**	**1.4**	**8.9**	**6.0**	**1.9**	**1.2**	**0.6**	**1.9**	**11.3**	**3.7**		**21.8**		**100.0**

3.1. Mammal Remains

Mineikiškės. A total of 1965 (24.7%) fragments of domestic and wild animal bones were identified. Most of the unidentified fragments (88.1%) belong to small ungulates (pigs, sheep, goats), and only 5.4% belong to large animals (cattle, horses, red deer, and elk). The identified material was dominated by the remains of domestic animals, which comprised 93.2% of the bones in total, while 6.7% belonged to wild animals in the assemblage. Additionally, 11 bones could only be identified to the family level, i.e., to pigs or wild boars.

A total of 890 bones were attributed to pigs. Their age mostly varied from 4–6 months to 4 years (Table 4). Furthermore, parts of the skeletons of at least one newborn were found. Based on tooth eruption, two larger age groups of 6–12 months and 1.5–2 yr individuals were distinguished.

Table 4. Pig age according to tooth eruption and wear.

Age	4–6 Months	6–12 Months	1.5–2 Years	2–3 Years	>3–4 Years
Individuals	3	5	8	3	1

There was also a large number of sheep/goat bones–673. Based on identification features, 15 specimens belonged to at least three different aged sheep. According to the lower M_1 tooth eruption time, one individual was about three months old. Based on tooth wear, one sheep was less than two years old and another one was 2–3.5 years old. The material also contained four phalanges, which appear to have belonged to two goats. The remaining bones could not be identified to the exact species and were, therefore, attributed to the general sheep/goat group. The individuals were of different ages (Table 5), but several age groups stood out in terms of tooth eruption and wear, namely 1.5–2 years (MNI 8) and 2–4 years (MNI 9). Skeletal fragments of at least one newborn sheep/goat were also found.

Table 5. Sheep/goat age based on tooth eruption and wear.

Age	3 Months	6 Months	8–10 Months	1.5–2 Years	2–4 Years	>4 Years
Individuals	1	1	1	8	9	1

There were 168 cattle bones, from at least seven different aged individuals (Table 6). Based on the lower M_1 teeth eruption and the skeletal remains, it seems that at least one individual was about half a year old. Based on tooth wear, two young animals of about 1–3 years old were identified and one of about 5–6 years old. Another three individuals were about 8–9 years or older according to tooth wear.

Table 6. Cattle age based on tooth eruption, wear and M_1 tooth height.

Age	6 Months	1–3 Years	5–6 Years	>8–9 Years
Individuals	1	2	1	3

A total of 104 bones and teeth belonged to at least eight horses of different ages (Table 7). Based on tooth eruption, one foal and one young horse (2.5–3.5 years) were found. Based on tooth wear, four individuals were middle-aged and slightly older; their ages ranged from 8 to 15 years. Two more individuals were over 20 years.

Table 7. Horse age, based on tooth eruption and tooth height.

Age	<1 Year	2.5–3.5 Years	5–7 Years	8–9 Years	11–13 Years	13–15 Years	>20 Years
Individuals	1	1	1	1	1	1	2

Of the small number of wild animals' bones, the diversity of identified species is high. Bone fragments of large animals were determined, belonging to elk (0.1%), red deer (0.2%), wild boar (0.2%), and roe deer (0.3%), but the majority of the finds were small game remains. These were mainly small fragments of hare (2.7%) and fox (1.5%) bones. There were also a few beaver (0.1%), otter (0.2%), marten (0.3%), and red squirrel (0.2%) bones. Ten bones could not be identified to species level; four of them belonged to animals of the Mustelidae family and six to small rodents.

Garniai 1: 531 (21.8%) bones, teeth, and fragments of domestic and wild animals were identified to the species and family (eight specimens) level. The majority of the unidentified fragments belonged to small ungulates. Most of the skeletal remains (89.6%) were attributed to domestic animals, while 9.9% of the bone fragments belonged to wild animals. Two teeth were assigned to a domestic pig or a wild boar.

In total, 307 bone and teeth fragments belonged to pigs. The age of the animals varied (Table 8). As in Mineikiškės, two of the same age groups stood out: 6–12 months (MNI 7) and 1.5–2 years of age.

Table 8. Pigs age based on tooth eruption and wear.

Age	6–12 Months	1.5–2 Years	2–3 Years	>3.5 Years
Individuals	7	7	1	1

Sheep/goat skeletal fragments were the second most abundant (24.3%). These are the remains of at least four different aged individuals (Table 9). At least one bone calcaneus belonged to a sheep.

Table 9. Sheep/goat age, based on tooth eruption and wear.

Age	10–12 Months	2–4 Years	>4 Years
Individuals	2	1	1

A total of 31 bone fragments were attributed to cattle. Based on tooth eruption, one individual was around 1.5–2 years old; the other one was about 8–9 years old (based on M_1 height).

Only seven bone fragments belonged to horse. One individual was about 6–8 years, while the other horse based on lower P_3 tooth height, was about 17–18 years old.

The proportion of wild animal bones, compared with domesticated animals, is small. As in Mineikiškės, species diversity is quite high. Bone fragments of large mammals such as wild boar (0.4%) and bear (0.2%) were also uncovered; however, most bone fragments were from small fur-bearing animals. Those identified in the highest numbers were hare (5.6%) and fox (1.6%), as well as red squirrel (0.4%), marten (0.2%), European polecat (0.4%), and small rodent remains (1.2%).

3.2. Fish Remains

Fish remains were found in both Mineikiškės and Garniai 1 sites (Table 10). However, only three small and unidentified fish bone fragments were found in the latter. Meanwhile, 287 fish bones and about 240 scales were found at Mineikiškės. We did not include scales in the general osteological analysis. The largest number of scales and their fragments, about 150 pieces, belonged to cyprinids, 88 to perch and eight to pike.

Of the 287 fish bones, 169 (58.9%) specimens were identified to the species or family level. They belonged to at least six freshwater fish species (Table 10), with the most numerous remains from cyprinids–110 (65.1%) pieces. Among the cyprinids, the most abundant were roach (13.6%), bream (10.7), and rudd (4.1%) Additionally, a few bones of ide and European chub were found. Another 57 pieces of cyprinid bones remained unidentified. However, for one species, pike remains were the most abundant, with 48 (28.4%, MNI 14) bone fragments. In addition to pike, for predatory fish, 11 (5.6%) perch bone fragments were found.

Table 10. Species and anatomical distribution of fish bones in Mineikiškės fortified settlement. NISP-number of identified specimens, MNI-minimum number of individuals.

Species/Bone		Parasphenoid	Premaxilla	Maxilla	Palatinum	Frontal	Quadrate	Articular	Dentary	Ectopterygoid	Hyomandibular	Keratohyal	Urohyal	Praeoperculum	Operculum	Interoperculum	Pharyngeal	Vertebrae	Supracleithrum	Cleithrum	Basipterygium	NISP	%, NISP	MNI	%, MNI
Northern pike	*Esox lucius*	2		6	1		2	7	5	2	1	2		2				4	2	11	1	**48**	**28.4**	**14**	**29.2**
Perch	*Perca fluviatilis*						1	1	2					2	4	1						**11**	**6.5**	**7**	**14.6**
Cyprinid	*Cyprinidae*					12			2					4			1	28		10		**57**	**33.7**	**-**	**-**
Bream	*Abramis brama*		1	3			2		3		2		3		1			2			1	**18**	**10.7**	**6**	**12.5**
Roach	*Rutilus rutilus*								1					2			17	1		2		**23**	**13.6**	**12**	**25.0**
Common rudd	*Scardinius erythrophthalmus*																7					**7**	**4.1**	**6**	**12.5**
Ide	*Leuciscus idus*																2					**2**	**1.2**	**2**	**4.2**
European chub	*Leuciscus cephalus*													2			1					**3**	**1.8**	**1**	**2.1**
In total		**2**	**1**	**9**	**1**	**12**	**5**	**8**	**13**	**2**	**3**	**2**	**3**	**12**	**5**	**1**	**28**	**35**	**2**	**23**	**2**	**169**		**48**	
In total, %		**1.2**	**0.6**	**5.3**	**0.6**	**7.1**	**3.0**	**4.7**	**7.7**	**1.2**	**1.8**	**1.2**	**1.8**	**7.1**	**3.0**	**0.6**	**16.6**	**20.1**	**1.2**	**13.6**	**1.2**		**100.0**		**100.0**

The size of the fish varied, with pike ranging from 20–30 cm to 80–90 cm, and the largest number of fish being 50–60 cm long. Bream size varied from quite small fish of 25–30 cm to 45–50 cm. Perch also varied in length, from 15–20 cm to 35–40 cm. Among the roach and rudd, the predominant length was from 20 to 25 cm, although there were some smaller fish, and at least one rudd was from 35 to 40 cm long. Ide and European chub are also variable in size, ranging from 20–25 cm to 35–40 cm in length.

3.3. Mollusc Remains

Almost all of the mollusc remains were found during the 2020 excavations of the Mineikiškės site, while only a few shells were retrieved during older excavations. A large part of the mollusc shells could not be collected during the excavations due to their extremely poor preservation, as the shells simply disintegrated during the attempt to remove them from the cultural layer or during preparation. Shell fragments were also found during the archaeological excavations of the Garniai 1 fortified settlement, but only small fragments remained and were not subjected to further analysis.

Due to the fragmentation and poor preservation, out of 500 mollusc remains, only 57 were identified to the species level. In total, two mollusc species were distinguished (Figure 2). A total of 49 specimens were thick-shelled river mussels (*Unio crassus*) and the remaining eight were swollen river mussels (*Unio tumidus*). Both of these species live in freshwater, mostly in slow-flowing rivers and old riverbeds, and sometimes in overflowing lakes. It is likely that these mussels were collected from the Nikajus river, located near the Mineikiškės fortified settlement.

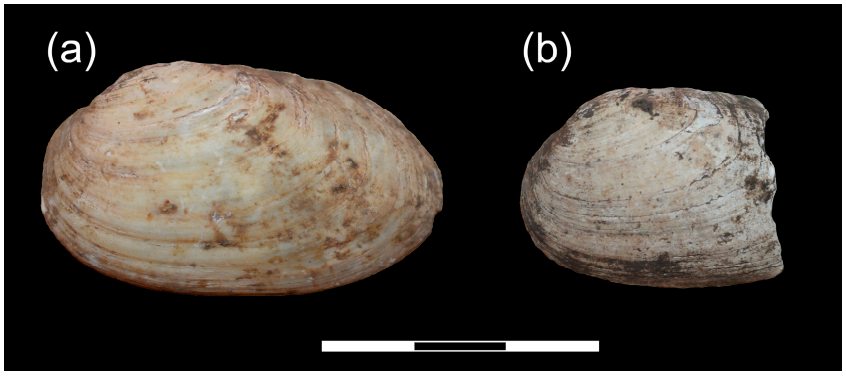

Figure 2. Mollusc shell remains discovered at the fortified settlement of Mineikiškės. (**a**) Thick-shelled river mussel (*Unio crassus*); (**b**) swollen river mussels (*Unio tumidus*) (photo by V. Micelicaitė).

4. Discussion

4.1. Animal Husbandry

Meat from domestic animals seems to have been one of the main sources of proteins for the discussed communities. Both assemblages are dominated by the remains of small ungulates, i.e., pigs and sheep/goats, while large ungulates such as cattle and horses made up a small percentage of the identified species.

The amount of pig bone fragments was the highest in both settlements; therefore, it can be inferred that pork might be the main source of meat for the discussed communities. However, this proportion may change when considering how much meat could have been produced by slaughtering larger and smaller ungulates. For example, Lyman's [41] calculation of the meat from slaughtered pigs (MNI 21) would yield about 580–620 kg, while the meat from cattle alone could have yielded 1400–2000 kg. However, it is likely that Lyman's weight for Lithuania animals is too high. Using other estimates [42–44], pigs could be expected to yield as little as 1400 kg and cattle about 1050 kg. However, further consideration of this issue requires more detailed osteometric and taphonomic studies. In Garniai 1 and Mineikiškės, two same-pig-age groups appeared; animals aged from 6 to 12 months and 1.5 to 2 year old animals. These appear to be spring-born individuals that

were slaughtered before the first and second winters. As pigs were mainly kept for the meat, the majority of them were slaughtered as soon as they reached their maximum body weight. If these animals were kept over the winter, the lack of food would cause them to lose all the weight they had obtained [45].

Pigs are dominant not only in Garniai 1 and Mineikiškės but also in multi-period sites in Eastern Lithuania. Most of the investigated material from Antilgė, Narkūnai, Nevieriškė, and Sokiškės fortified settlements was dated from LBA toRoman Iron Age; thus, it seems that pigs were important in the economy of communities living in this area over a long time. Looking at the higher frequencies of pig bones, Eastern Lithuania is distinctive from the rest of the areas in the Eastern Baltic region (Table 11). In all investigated cases, the bones of these animals were not found in higher amounts than 25% of all identified species [7,46–51].

Sheep/goats were the second most abundant group of domestic animals in the Garniai 1 and Mineikiškės fortified settlements. As the communities in these sites obtained most of their meat from pigs, it is possible that the role of sheep/goats in the household was more diverse. Secondary products in the community may have been used, but it is not possible to determine for what specific purpose, milk or wool, the sheep/goats were kept. Only four animals were identified at the Garniai 1 site, with an age ranging from 10–12 months to more than four years, so it is impossible to say whether sheep/goats were bred in this site for particular specific activities. In Mineikiškės, two general age groups were distinguished (1.5–2 yrs and 2–4 yrs). It is likely that individuals aged 1.5–2 years may have been reared for meat production. Some researchers suggest that this is the most optimal time to slaughter sheep/goats because, at this age, individuals, especially males, reach their weight gain peak; therefore, if no other functions in the household were required, there was no need to keep them for a longer time [52–54]. Older animals, such as those of 2–4 years and over four years of age, may have been kept for breeding and for secondary products.

In Estonia, Saaremaa Island, the pig and sheep/goat abundance is ca. vice versa that of the assemblages from Eastern Lithuania. In the Asva and Ridala fortified settlements, sheep/goats were the most frequently (25.6–37.1%) reared animal, while the second most abundant group was pigs [50]. Meanwhile, in other LBA settlements in the eastern Baltic, sheep/goat numbers were distributed differently (Table 11). In several sites, they accounted for only 6.7–7.6% of all identified specimens, in others 17.1–19.1% [46–49,51].

The number of cattle bone fragments found in the analysed sites was significantly lower; it is possible that cattle were very important, just not kept in large numbers, as they were so expensive to keep. Some researchers point out that cattle may have been an important exchange commodity between nearby or distant communities. Rare cattle may have been valued for their large quantities of meat production and functionality, as they had several uses in the household, including ploughing, and the production of dairy products [54–56].

The age of cattle found in the settlements varies, and they appear to have been reared and kept both for meat production, secondary products, manure, and as draught power. Three individuals aged 2–3 years were found in both sites; it is likely that they were traditionally slaughtered at this age for meat. This practice is also prevalent in medieval societies when young cattle of 8–18 and 18–30 months of age were slaughtered [57–59]. A few skeletal remains of older adult individuals of 5–6 and 8–9 years old were also found in Garniai 1 and Mineikiškės. It is more likely that older animals were used for dairy products and work. The indication that cattle from Mineikiškės could be used as draught animals is the metacarpal bone with exostoses on the distal part (Figure 3). This type of pathology often occurs when the animal is exposed to heavy loads [60,61]. However, exostoses on the lower limb of cattle can occur not only as a result of high stress during work but also due to the age of the animal, soil characteristics, genetics, and other reasons [60]. The demand for dairy products in the community would be indicated by the increased number of bones of older females [62]; however, due to the fragmented zooarchaeological material in these settlements, it is hardly possible to observe such trends at present.

Table 11. Zooarchaeological material from LBA-dated settlements in the Eastern Baltic Region.

Animal/Settlement	Brikuli [51]		Kivutkalns [46]		Vinakalns [46]		Krievu kalns [48]		Ridala [49,51]		Asva [47,49]	
	n	%	n	%	n	%	n	%	n	%	n	%
Cattle (*Bos taurus*)	1518	28.7	3510	32.8	323	29.4	65	17.3	282	7.6	330	18.1
Sheep/goat (*Ovis aries/Capra hircus*)	850	16.0	1684	15.7	84	7.7	25	6.7	749	20.1	468	25.6
Pig (*Sus scrofa domesticus*)	743	14.0	2439	22.8	147	13.4	22	5.9	431	11.6	158	8.6
Horse (*Equus ferus caballus?*)	719	13.6	1505	14.1	127	11.6	113	30.1	92	2.5	95	5.2
Dog (*Canis familiaris*)	29	0.5	38	0.4	2	0.2	-	-	33	0.9	10	0.5
Total domestic animals:	**3859**	**72.9**	**9176**	**85.8**	**683**	**62.3**	**225**	**60.0**	**1587**	**42.6**	**1061**	**58.0**
European bison/auroch(*Bison Bonasus/Bos primigenius*)	-	-	5	0.05	-	-	15	4.0	-	-	-	-
Elk (*Alces alces*)	238	4.5	96	0.9	94	8.6	34	9.1	40	1.1	23	1.3
Red deer (*Cervus elaphus*)	1	0.02	67	0.6	16	1.5	61	16.3	-	-	-	-
Roe deer (*Capreolus capreolus*)	2	0.04	15	0.1	3	0.3	8	2.1	-	-	-	-
Wild boar (*Sus scrofa*)	194	3.7	68	0.6	26	2.4	21	5.6	3	0.1	6	0.3
Brown bear (*Ursus arctos*)	3	0.1	15	0.1	3	0.3	-	-	-	-	3	0.2
Wolf (*Canis lupus*)	4	0.1	-	-	-	-	-	-	-	-	-	-
Beaver (*Castor fiber*)	77	1.5	345	3.2	268	24.4	9	2.4	8	0.2	5	0.3
Otter (*Lutra lutra*)	27	0.5	4	0.04	2	0.2	-	-	-	-	-	-
Seal (*Phocidae*)	-	-	-	-	-	-	-	-	377	10.1	721	39.4
Red fox (*Vulpes vulpes*)	6	0.1	1	0.01	-	-	-	-	-	-	2	0.1
Hare (*Lepus timidus*)	6	0.1	2	0.02	-	-	-	-	-	-	1	0.1
European badger (*Meles meles*)	3	0.1	3	0.03	2	0.2	-	-	-	-	-	-
European marten (*Martes martes*)	15	0.3	-	-	-	-	-	-	-	-	4	0.2
European polecat (*Mustela putorius*)	-	-	-	-	-	-	-	-	-	-	-	-
Red squirrel (*Sciurus vulgaris*)	-	-	-	-	-	-	-	-	1	0.03	-	-
Small rodents (*Rodentia*)	-	-	-	-	-	-	-	-	-	-	1	0.1
Hedgehog (*Erinaceus europaeus*)	-	-	-	-	-	-	-	-	-	-	1	0.1
Total wild animals:	**576**	**10.9**	**621**	**5.8**	**414**	**37.7**	**148**	**39.5**	**429**	**11.5**	**767**	**42.0**
Fish	862	16.3	897	8.4	-	-	1	0.3	1705	45.8	-	-
Birds	-	-	-	-	-	-	1	0.3	-	-	-	-
Total:	**5297**	**100**	**10,694**	**100**	**1097**	**100**	**375**	**100**	**3721**	**100**	**1828**	**100**

Figure 3. Distal part of the cattle metacarpal bone with signs of inflammation (photo by V. Micelicaitė).

In the neighbouring countries of the Eastern Baltic region, the number of cattle is considerably higher than in northeastern Lithuanian sites (Table 11). For example, the ratio of cattle is below 20% of all identifiable species in Ridala, Asva, and Krievu kalns, while in other fortified settlements it ranges from 29.4–35.8% [46–51]. Moreover, cattle were the most prevalent domestic animal in the western Lithuanian sites, which probably indicates that cattle breeding played a significant role in local agricultural communities, possibly due to their role as draught power and a source of manure. This could also suggest the relatively increased importance of agriculture in western than in eastern Lithuania [7].

Horse bone fragments are the least frequent domestic mammal in the analysed zooarchaeological material; therefore, it seems that the meat of these animals was not of high importance to human nutrition. However, in neighbouring regions, it seems likely that horse meat may have formed a larger part of the diet of these communities (Table 11). In Asva and Ridala, the number of horses was very low, but in other settlements, it varied significantly at higher ratios, i.e., from 11.5 to 30.2% [46–51]. However, horse bones comprised the second largest or even the largest portion of the recovered zooarchaeological material in western Lithuania and Latvia during the LBA, Roman Iron Age, and Migration period [7].

Unsurprisingly, horse remains contained butchering marks, suggesting their meat was used for food. Due to the limited and fragmentary nature of the Mineikiškės and Garniai 1 assemblages, it is difficult to assess whether the horse skeletal remains belonged to wild or domestic animals. Some researchers believe that domestic horses were present in Lithuanian territory from the Late Neolithic to the Early Bronze Age [63]. However, it should be noted that wild horses were still hunted by the local population from as late as 16 to 17 C AD in the territory of Lithuania, Prussia, and possibly western Latvia [64,65]. The small number of bones and the age structure suggest that horses were not used as an important source of food for these communities. The skeletal remains of horses found in both fortified settlements belonged mainly to individuals ranging from young adults to the elderly. It is likely that they first functioned as a workhorse and were only slaughtered when they were no longer able to function in that way. A few exceptions are one yearling and one 2–3 year old horse, found in the Mineikiškės hillfort. The reason for slaughtering these animals might be due to illness or food shortages, or they might have been hunted wild animals.

4.2. Hunting, Fishing and Gathering

Bone fragments of small fur-bearing animals (e.g., hares, foxes) predominate among the wildlife remains, accounting for 87.0–96.1% of all identified game animals. Bones of

large game were rare in both settlements. Foxes were mainly represented by the lower limb bones and mandibles, the latter usually bearing cutting marks. Meanwhile, among the bones of hares, the tibia, femur, humerus, and radius were the most common. Therefore, hares, as expected, were mainly hunted for meat, while foxes seem to have been hunted only for their fur. Very few bones from other furbearers (mustelids, otter, red squirrel) were used to draw more reliable conclusions about their use.

Large game accounted for only 3.9–13.0% of all the analysed wild animals. The diversity of species is slightly wider in Mineikiškės while, in Garniai 1, only two bones were found, belonging to a wild boar and bear. The lower number of large wild animals in Garniai 1 seems to be due to the size of the assemblage. The low quantity of large wild animal bones in both settlements and their anatomical distribution could be due to the fact that the large game was butchered in the kill sites instead of the habitation area, and the hide of the animal was used as a container to transport the meat back to the settlement. The meat appears to have been removed from the forequarters and hindquarters and the bones discarded, while feet were left attached to the hide and used as handles to drag the meat-filled skin [66].

Hunting significantly declined in this area from Neolithic to LBA as the community became more involved in other sectors of the economy, such as animal husbandry and crop agriculture. Livestock became the main source of meat. The bones of domestic animals were one of the most available resources for the production of tools, weapons, and parts of garments. Wild animals were more likely to be hunted in case of food shortages and for secondary products such as fur. Although wild animal remains make up a very small proportion of the total number of bones identified in the Garniai 1 and Mineikiškės, the situation was different in some other areas of the Eastern Baltic region (Table 11). While in Brikuļi and Ķivutkalnis (Latvia), wild animals made up a small percentage of the material identified [46,48], in other settlements such as Asva, Ridala (Estonia, Saaremaa Island), Krievu kalns and Vīnakalns (Latvia), the skeletal remains of game ranged between 21.2 and 41.9% of the total number of identifiable species [46,48–51]. Thus, the subsistence strategies varied in the Eastern Baltic region, as some communities practiced more active hunting during the LBA.

Mollusc remains account for 6.2% of the total analysed material. Molluscs, like wild animals, could have provided an additional source of protein for the communities in times of food shortage [67]. These are the first settlements in Lithuania where mollusc remains were found in such large quantities. A few mollusc shells were also found in the Narkūnai hillfort (identified recently in the National Museum of Lithuania), but due to the position of the finds from LBA–medieval periods in the same strata of this site, it is not possible to determine the specific time period of the mollusc remains. In addition, sieving was not used in Narkūnai, so in most cases, the fine shells may simply not have been collected. In fact, mollusc remains are very rare in zooarchaeological assemblages from all periods not only in the territory of Lithuania but also in the whole Eastern Baltic region. A large number of molluscs was found in northern Latvia, in the Subneolithic settlement of Riņņukalns [68]. Large quantities of mollusc remains were also found in several Neolithic settlements in Estonia (Narva Riigiküla and several settlements along the Narva River) [68].

All the fish species found in the settlement, except for the chub, like to live in lakes or slow-moving rivers. Only the chub prefers more flowing rivers. It can, therefore, be assumed that the local community mainly fished in the slow-moving river near the site or in nearby lakes. Among fish remains, 63.3% of the fish bones were cranial elements, with the remaining 16.0% of shoulder grids and 20.1% of vertebrae and, as mentioned above, a significant number of scales were found. This anatomical composition of the fish bones, with a particularly high proportion of cranial bones, suggests that both small and large fish were likely to have been filleted locally, and the bones that were found may be both fish processing and eating waste. The quite abundant fish remains also can be related to food shortage. However, this can be linked to the excavation technique or small excavated areas.

Only a few fragments of bird bones were found, all of which were not identified. However, the importance of wild poultry in the human diet was likely minimal.

4.3. Butchering

As mentioned above, animal remains in both sites were very fragmented (Figure 4). Several factors may have contributed to this: the zooarchaeological assemblages were collected from the area of habitation, where the accumulated waste was often trampled by humans and animals. Until the second half of 20th C AD., the sites were ploughed for a long time. At Mineikiškės, only the top layer was ploughed, while at Garniai 1, the plough furrows reached sterile soil, which contributed to the poorer survival of archaeological material. The trampling, ploughing, and gnawing contributed to the condition of the collected material; however, this situation is typical of many archaeological sites. Meanwhile, the situation in the discussed sites was somewhat different. As was pointed out by Luik et al. [69], the bones of the animals in Mineikiškės and Garniai 1 were merely smashed, crushed, and then probably cooked during the preparation of food, thus obtaining the maximum possible extraction of the fat and marrow in the bones. Animal bones butchered in this way are quite exceptional in Lithuanian zooarchaeological material; the faunal remains from other periods in Lithuania are generally less fragmentary. This may be related to a particular shortage of protein food during the Late Bronze Age as well as the non-traditional consumption of mussels [69].

Figure 4. Typical zooarchaeological material from Mineikiškės fortified settlement (photo by V. Micelicaitė).

5. Conclusions

The zooarchaeological assemblages from Garniai 1 and Mineikiškės fortified settlements indicate that the communities there practiced a subsistence strategy, mostly based on the herding of pigs and ovicaprines that differed from western Lithuania and the rest of the eastern Baltic where cattle and, in some areas, horses were more abundant. That allows us to hypothesise that the higher consumption of pig and sheep rather than of cattle and horse meat was one of the characteristic features of eastern Lithuania during the Late Bronze Age. The animal husbandry strategy, which mostly focused on the herding of small ungulates, prevailed in eastern Lithuania, at least in the Roman period.

During the Late Bronze Age, the role of fishing and hunting was very similar and insignificant in northeasters in western Lithuania. However, the inhabitants of Garniai 1 and Mineikiškės spent less time fishing and hunting than contemporary communities living in eastern and western Latvia, and the lower reaches of the Daugava River and Saaremaa Island. In contrast to previous periods, small animals were mainly hunted in northwestern Lithuania during the Late Bronze Age, again indicating the changing role of hunting in the economy and, presumably, in the means and aims of hunting.

However, the likely decline in big game hunting is probably not due to the abundant food resources available to local populations. Their risky and probably very poor subsistence is evidenced by the untypical, extremely fragmentary nature of zooarchaeological material and by the consumption of molluscs, an atypical food for the East Baltic. However, further research is needed to understand the reasons that may have led to these unusual choices.

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