

ESTONIAN JOURNAL OF ARCHAEOLOGY

Eesti Arheoloogia-
ajakiri



30/2
2026

Estonian Journal of Archaeology

Eesti Arheoloogiaajakiri

Open access journal of the Estonian Academy of Sciences published in collaboration with the Institute of History and Archaeology of the University of Tartu and the Archaeological Research Collection of Tallinn University

Eesti Teaduste Akadeemia väljaanne koostöös Tartu Ülikooli ajaloo ja arheoloogia instituudi ja Tallinna Ülikooli arheoloogia teaduskoguga

*Avaldatakse aastast 1997
Ilmub kaks korda aastas*

Published since 1997

The journal is published biannually

EDITOR-IN-CHIEF / PEATOIMETAJA

Valter Lang (University of Tartu / *Tartu Ülikool*)

EXECUTIVE EDITOR / TEGEVTOIMETAJA

Hedi Tõnso (Estonian Academy Publishers / *Eesti Teaduste Akadeemia Kirjastus*)

EDITORIAL BOARD / TOIMETUSKOLLEGIUM

Kristin Ilves (University of Helsinki / *Helsingi Ülikool*)

Giedrė Keen Motuzaitė Matuzevičiūtė (University of Vilnius / *Vilniuse Ülikool*)

Aivar Kriiska (University of Tartu / *Tartu Ülikool*)

Lembi Lõugas (Tallinn University / *Tallinna Ülikool*)

Heidi Luik (Tallinn University / *Tallinna Ülikool*)

Erki Russow (Tallinn University / *Tallinna Ülikool*)

Ragnar Saage (University of Tartu / *Tartu Ülikool*)

Uwe Sperling (University of Rostock / *Rostocki Ülikool*)

Mari Tõrv (University of Tartu / *Tartu Ülikool*)

EDITORIAL OFFICE / TOIMETUSE AADRESS

Estonian Academy Publishers / *Eesti Teaduste Akadeemia Kirjastus*

Kohtu 6, 10130 Tallinn, Estonia

hedi.tonso@eap.ee

www.eap.ee/archaeology

Subscription information is available at / *Ettetellimisinfo on leitav veebiaadressil*

www.eap.ee/subscription

Subscription orders can be sent to / *Ettetellimused palume saata:*

subscription@eap.ee

On the cover:

Human figurine made of animal bone

(AI 4118: 945) from the 4th millennium BC

found at the Tamula I settlement and burial site.

Kaanel:

Tamula I asulakoht-matmispaigast leitud

4. aastatuhandest eKr pärit loomaluust

valmistatud inimkujuke (AI 4118: 945).

Contents / *Sisukord*

- 101 People from Pskov in Estonian towns in the 13th century according to archaeological evidence
Andres Tvauri
- 130 *Pihkva päritolu asukad Eesti linnades 13. sajandil arheoloogia andmetel*
- 133 Comparing childhood and adulthood diets in a Viking Age population from the Lejasbitēni cemetery, Latvia: a pilot study
Elīna Pētersone-Gordina, Guntis Gerhards, Antonija Vilcāne, Andrew Millard, Joanna Moore and Janet Montgomery
- 157 *Lapse- ja täiskasvanuea toitumise võrdlus Läti viikingiaegse Lejasbitēni kalmistu populatsioonis: pilootuuring*
- 159 Animal exploitation over two millennia at Aukuras hill hillfort at the Kernavė archaeological complex, Lithuania: zooarchaeological evidence from birds, fish, and mammals (c. 800 cal BC–1400 cal AD)
Giedrė Piličiauskienė, Saulius Rumbutis, Karolis Minkevičius, Rokas Vengalis and Gintautas Vėlius
- 190 *Loomakasvatus ja jaht kahe aastatuhande jooksul Aukurase mäe linnamäel Kernavė arheoloogilisel alal Leedus: lindude, kalade ja imetajate zooarheoloogiline andmestik (u 800 kal eKr–1400 kal pKr)*

All articles are provided with Estonian summaries.

Full texts: www.eap.ee/archaeology; www.doaj.org

ABSTRACTED / INDEXED IN

European Reference Index for the Humanities and Social Sciences (ERIH PLUS), Web of Science Core Collection: Arts & Humanities Citation Index, EBSCO Publishing, Central and Eastern European Online Library (CEEOL), Scopus® database (Elsevier), Gale Academic OneFile Database, ProQuest LLC, Airiti Inc., Scilit, CNKI

ISSN 1406-2933 (print)

ISSN 1736-7484 (electronic)

Copyeditor / *Keeletoimetaja*: Kadri Põdra
Template design / *Maketi kujundus*: Maria Muuk
Printed by / *Trükitud trükikojas* Alfapress, Reti tee 8, 75312 Peetri, Estonia



Estonian Academy Publishers / *Eesti Teaduste Akadeemia Kirjastus*
Kohtu 6, 10130 Tallinn, Estonia
info@eap.ee
www.eap.ee
Tallinn, 2026

People from Pskov in Estonian towns in the 13th century according to archaeological evidence

Andres Tvauri

Department of Archaeology, Institute of
History and Archaeology, University of Tartu,
Ülikooli 18, 50090 Tartu, Estonia
andres.tvauri@ut.ee

Received 12 January 2026, accepted 9 April 2026, available online 10 August 2026

ABSTRACT

The earliest towns in the territory of Estonia were founded in the 13th century. Their populations were multi-ethnic: in addition to the German merchants and artisans who dominated urban life, these towns were also inhabited by people of local origin as well as Scandinavians. The results of archaeological excavations indicate that in the second and third quarters of the 13th century, settlers of Rus' origin from Pskov took up residence in the towns of Tartu, Viljandi, and Tallinn. In all of these towns, the Pskovians lived on the outskirts, in their own district. Numerous archaeological remains have been uncovered demonstrating that the Pskovians were engaged in the production of pottery in Tartu, Tallinn, and Viljandi, and in the manufacture of glass beads in Tartu and Tallinn. These settlers were permanent residents of the towns rather than temporary visitors. By the 14th century at the latest, the Pskovians had assimilated into the local urban population. In the 15th century, Tartu was home to the St George's Orthodox Church, which belonged to Novgorodian merchants, and to the Pskovians' Church of St Nicholas; Tallinn likewise had a St Nicholas Orthodox Church belonging to merchants from Novgorod. These merchant churches are not connected with the Pskovian settlements that existed in these towns in the 13th century.

KEYWORDS

archaeology, Middle Ages, medieval Livonia, Kyivan Rus', Pskov.

Introduction

The population of medieval towns was multi-ethnic everywhere, including in Livonia (present-day Estonia and Latvia), where the earliest towns were founded in the 13th century by German and Danish conquerors. Although the emerging Livonian towns were dominated by immigrants of German origin, they also included the native population (Estonians, Latvians, and Livs), whom contemporary sources referred to collectively as non-Germans (*Undeutsch*). Medieval Tallinn was also home to Danes, Swedes, and Finns. Furthermore, in the 13th-century occupation layers of three medieval

Estonian towns – Tallinn, Tartu, and Viljandi – there is clear archaeological evidence of settlers of Rus' origin (Selart 2017).

The aim of this article is to present these finds. I seek to answer the questions of why, when, and from where immigrants of Rus'ian background arrived in the emerging towns of Livonia, and what activities they engaged in there. In addition, I discuss what became of the people of Rus' origin in these towns in the following centuries.

But how can one identify particular peoples – Rus'ians in this case – within the archaeological record? Certain types of graves, dwellings, heating structures, clothing, ornaments, or specific sets of ornaments are typically employed as 'ethnic markers'. To date, however, no 13th-century buildings, heating structures, or burials have been discovered in Estonia that might be associated with a population of Rus' origin. Such an association would rest on evidence such as Orthodox pectoral crosses or ornaments of Rus' provenance placed with the deceased. For this reason, my study primarily relies on artefact finds from the 13th-century layers of Estonian towns. These objects lack analogues elsewhere in Estonia or within the Germanic cultural sphere, yet they were characteristic of and widely distributed across the territory of Kyivan Rus'. Northwest Russian style pottery – especially of the Pskov type – was in extensive use in Estonia during the 11th–15th centuries, but it cannot be attributed exclusively to groups originating from Northwest Rus' (Tvauri 2025).

The founding of towns in Estonia

A historically pivotal period in the development of modern Estonia and Latvia was the Baltic crusades, as a result of which the region came under the rule of the Livonian branch of the Teutonic Order, Catholic bishops, and the Danish king, and was Christianised. German missionaries began their activities in the 1180s in the estuary area of the River Daugava. At the end of the 12th century, regular crusades and other wars against the native peoples began, led by the Livonian bishops, military orders, and the king of Denmark. The Livs were subjugated under German rule by 1212. Northern Estonia came under Danish rule in 1219. Southern Estonia was conquered by 1224, and the nobles of Saaremaa submitted to the German crusaders in 1227. Curonia and Semgallia were conquered and subjugated by the 1290s, and southeastern Latvia was conquered in around 1310. As a result of the conquest, a conglomerate of ecclesiastic states – medieval Livonia – was established (see Selart et al. 2025).

In the 13th century, the towns of Tallinn (Reval), Narva (Narwa), Tartu (Dorpat), Old Pärnu (Perona, Alt-Pernau), New Pärnu (Embeck, Pernau), Viljandi (Fellin), and Haapsalu (Hapsal) were founded in the territory of

present-day Estonia (see Pärn 2004a). Since archaeological evidence of a Rus' population in the 13th century has been found only in Tallinn, Tartu, and Viljandi, I will begin by taking a closer look at the emergence of these towns. The town of Tallinn was founded beside the Danish king's castle, Tartu beside the bishop's castle, and Viljandi beside the Teutonic Order castle.

Although the existence of urban settlements prior to the conquest has repeatedly been suggested for Tallinn (e.g. Kenkmaa 1937, 83–84; Moora 1953, 172–174; Tarakanova & Saadre 1955, 11–12; Tiik 1957, 53–54; Kang-ropool & Bruns 1972, 7–8; Zobel 1980, 10–11) and Tartu (e.g. Trummal 1980, 25–26; 1996, 534–536; 1997, 346; Metsallik 1995, 28–30; Mäesalu & Vissak 2002, 153–154; 2005, 18), no written records or archaeological evidence have been found for either Tallinn (Tamm 1993; 1995; Russow 2019a, 19; 2019b; 2020, 26; 2025, 75; Mäll & Russow 2003; Russow & Tamla 2019a; 2019b, 65) or Tartu (Tvauri 2001a; Pärn 2004a, 269–271). Moreover, no evidence of the existence of urban settlements in Livonia prior to the 13th century has been found in written sources (Tarvel 1999, 293).

It has also been suggested that, already before the 13th century, there was a hillfort in Tallinn located on the Toompea cliff, and that in the area of the later medieval town there were a market square and seasonal trading factories with churches belonging to Scandinavian and Novgorodian merchants (Johansen 1951, 41–42, 66–87; 1965, 122–123; Tiik 1957, 243, 377; Kleinenberg 1962, 242; Johansen & Mühlen 1973, 39–40; Tönnisson 1996; Zobel 2008, 38). However, no archaeological evidence has been found in Tallinn for any of these, including the pre-conquest stronghold (Tamm 1993; 1995; Sokolovskij 2003, 252; Russow 2019a, 19, footnote 38; Russow & Tamla 2019b, 65; Russow 2020, 30, 33). It cannot be excluded that the Lyndanise stronghold was located not on the Toompea cliff, but rather on the Tõnismägi hill situated to its south (Mägi 2015, 113–114, fig. 2.7). Unfortunately, this hypothesis can neither be confirmed nor refuted, since during the late 17th–18th centuries the Tõnismägi hill was lowered by 6–7 m, and the excavated soil was used to construct earthen fortifications along the southern side of the Toompea cliff (Alamaa 1966, 92; Loit 2003).

In Viljandi, there was indeed a stronghold before the German conquest, but no traces of a pre-conquest settlement have been found within the area of the medieval town (see Haak & Russow 2013).

Northern Estonia came under Danish rule in 1219, when King Valdemar II's troops captured the local stronghold called Lyndanise (HCL, XXIII, 2). In 1227, Tallinn and northern Estonia were seized by the Livonian Brothers of the Sword, who in 1238 returned these territories to the king of Denmark. In 1346, the king sold northern Estonia, including the town of Tallinn, to the Teutonic Order. The founding date of the town is not known. The word *civitas*

was used to refer to Tallinn in written sources for the first time in 1238, and in 1248 King Eric IV of Denmark granted Tallinn the Lübeck town rights. A directive issued in 1265 by Queen Margareta to surround Tallinn with a town wall pertains to the territory of the later medieval town (Kala 2002, 402–404; 2019a).

The German crusaders captured the stronghold of Tartu in 1224 (HCL, XXVIII, 3–8), and in the same year Tartu also became the centre of a bishopric. The town of Tartu is mentioned in written sources for the first time in connection with a military campaign by the Novgorodians in 1262 (Selart 2009b, 35). The earliest record of the existence of the Tartu town council dates from 1263 (Mäesalu 2024, 26). It is not known when the settlement was granted town rights by the Bishop of Tartu (Tarvel 1980, 27–28).

Viljandi finally fell into the hands of the German crusaders in 1223. A written record exists showing that Willekinus de Endorpe, the Master of the Livonian branch of the Teutonic Order, confirmed the town privileges and established the boundaries of the town area in 1283 (LGU, I, 40).

Research history

Historians have primarily studied the ethnic composition of medieval Tallinn's population and the relations between different ethnic and social groups (e.g. Johansen 1934; Niitemaa 1949; Johansen & Mühlen 1973; Kaplinski 1980, 80–92; Mänd 2013; Naum 2014; Kala 2019b). The reason for this is that Tallinn's medieval archive has been preserved, whereas for other Estonian medieval towns written sources are insufficient to address this question. Historians have mainly focused on relations between Germans and non-Germans in the 14th–16th centuries, since written records from the 13th century, or concerning inhabitants of Rus' origin in the towns of the region, are extremely scarce. This limited material has been summarised by Anti Selart in his study 'Russians in the Livonian towns in the thirteenth and fourteenth centuries' (2009). Separate studies have addressed the Novgorodian trading factory in medieval Tallinn (Kleinenberg 1962) and the location of the Russian quarter and churches in medieval Tartu (Alttoa 1985; 1998; 2017).

Among Estonian archaeologists, the ethnic composition of the population of medieval towns on the basis of archaeological finds has been studied by Arvi Haak (2011; 2015; 2022). Regarding Tallinn, Magdalena Naum (2014) has analysed the representations of ethnic groups mentioned in written sources in relation to the archaeological material. Heiki Valk (2004) has identified ornaments belonging to Estonians among the grave goods in medieval urban churchyards. Anton Pärn (2004b) and Ain Lavi (2012) have used building remains to research the non-German population of the towns

of Estonia in the 13th–14th centuries. The influence of social status and ethnicity on diet in medieval Tallinn has been studied through stable isotope analysis, including samples collected from skeletons discovered at Sulevimägi Street 4/6 that are presumably of Rus' settlers origin (Lightfoot et al. 2016).

Although archaeological traces of settlers of Rus' origin in 13th-century Estonian towns have previously been mentioned or described in the context of various research topics (e.g. Mäesalu 1999, 432; Tvauri 1999; 2000a; 2000b, 24–26; 2001a; 2022, 289–290; Kadakas & Nilov 2004, 167–171; Haak & Heinloo 2007, 32–34; Selart 2009b, 44–45; Malve & Mäesalu 2014, 129–130, fig. 3; Naum 2014, 666; Lightfoot et al. 2016; Haak 2019, 38–40; 2022, 252, fig. 8: 5; Russow 2019a, 34; 2019b; 2020, 29–31, 138–143; 2025, 89, 92–93; Jegorov et al. 2023, 144), a comprehensive overview of this subject has so far been lacking.

TARTU

The richest 13th-century material related to the people of Pskov has been found in Tartu, the vast majority of it recovered from a single archaeological trench. In the area of the University of Tartu Botanical Garden (Lai Street 30 plot), an excavation of approximately 630 m² was carried out in 1988–1991 (Fig. 1: 1). The excavation site was located directly on the inner side of the medieval town wall (Fig. 2). At a depth of 3–3.4 m from the modern ground level, there was a roughly 40 cm thick deposit containing numerous finds of Rus' origin dating from ca 1230–1260 (Malve & Mäesalu 2014, 129).

Although 35 years have now passed since the excavations, the finds from this layer have scarcely entered scholarly circulation. A brief overview of these excavations is available in only two academic articles (Mäesalu 2001; Malve & Mäesalu 2014). The Pskov-type pottery discovered there has also been discussed (Tvauri 2000a), and an overview of the spatial distribution of finds of Rus' origin within the excavation area has been provided (Haak 2022, fig. 8: 5).

The assemblage from this layer (TM A 43: A683–A2475) comprises 1792 catalogued finds. In addition, numerous finds of Rus' origin have also been recovered from the deposits immediately overlying the layer under examination. The majority of the finds recovered from the examined layer consist of pottery sherds, most of which originate from vessels that have close parallels in the 13th-century layers of the town of Pskov and of the Izborsk castle located in the Pskov Land (Tvauri 2000a, fig. 4). These vessels predominantly belong to the subtypes 3:2 and 3:3 of the Pskov-style ceramics as classified in Estonia (see Tvauri 2000b, 100–102, 104–105). Only a very small number of sherds from near-stoneware jugs of German origin were recovered from the 'Pskovian' layer of the University of Tartu Botanical

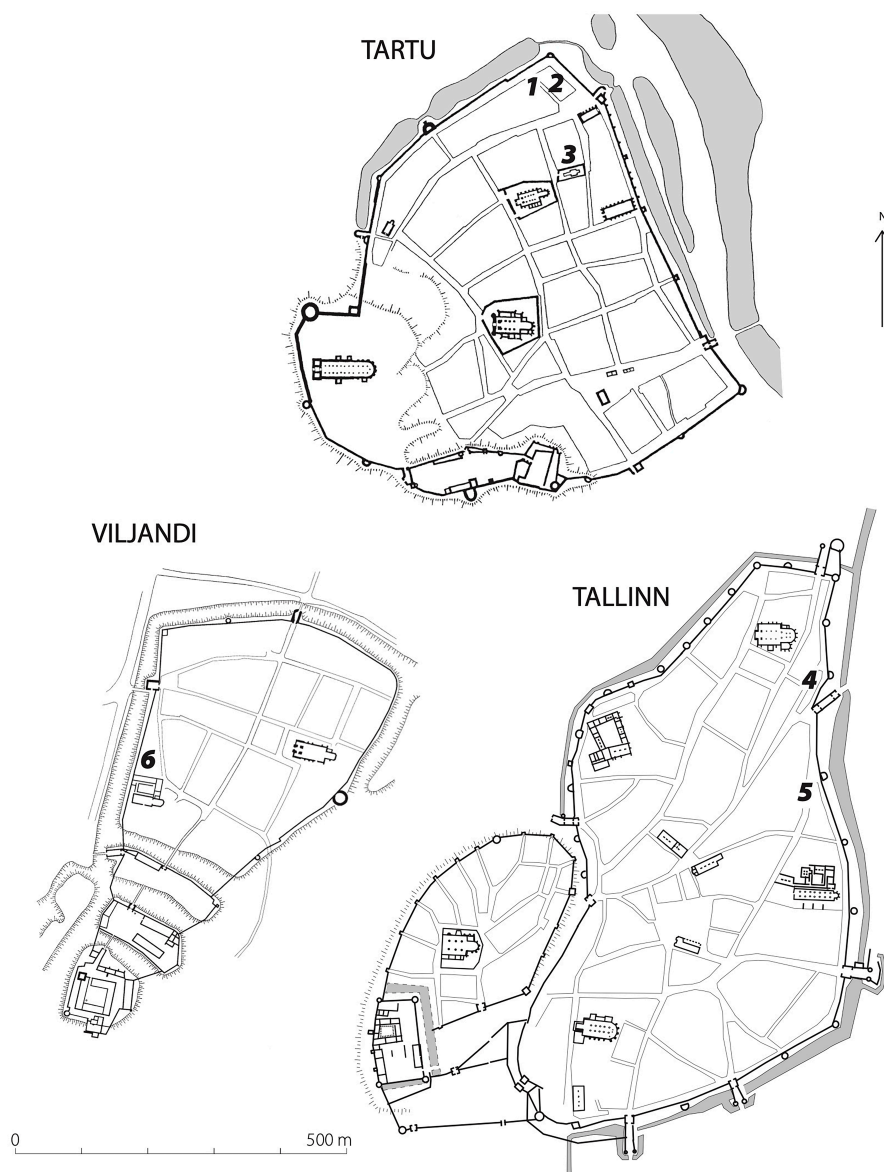


FIG. 1. The location of the settlement of Pskovians in the 13th century and the location of Novgorodian merchants' churches in the 15th century in Estonian towns: 1 – excavations conducted in the University of Tartu Botanical Garden in 1988–1991; 2 – remains of the St George's Orthodox Church, discovered in 1981–1982; 3 – remains of the St Nicholas Orthodox Church, discovered in 2025; 4 – archaeological excavation carried out in 2003 on the plot at Sulevimägi Street 4/6; 5 – St Nicholas Orthodox Church; 6 – archaeologically investigated pottery workshop area. Draft by Jaana Ratas.

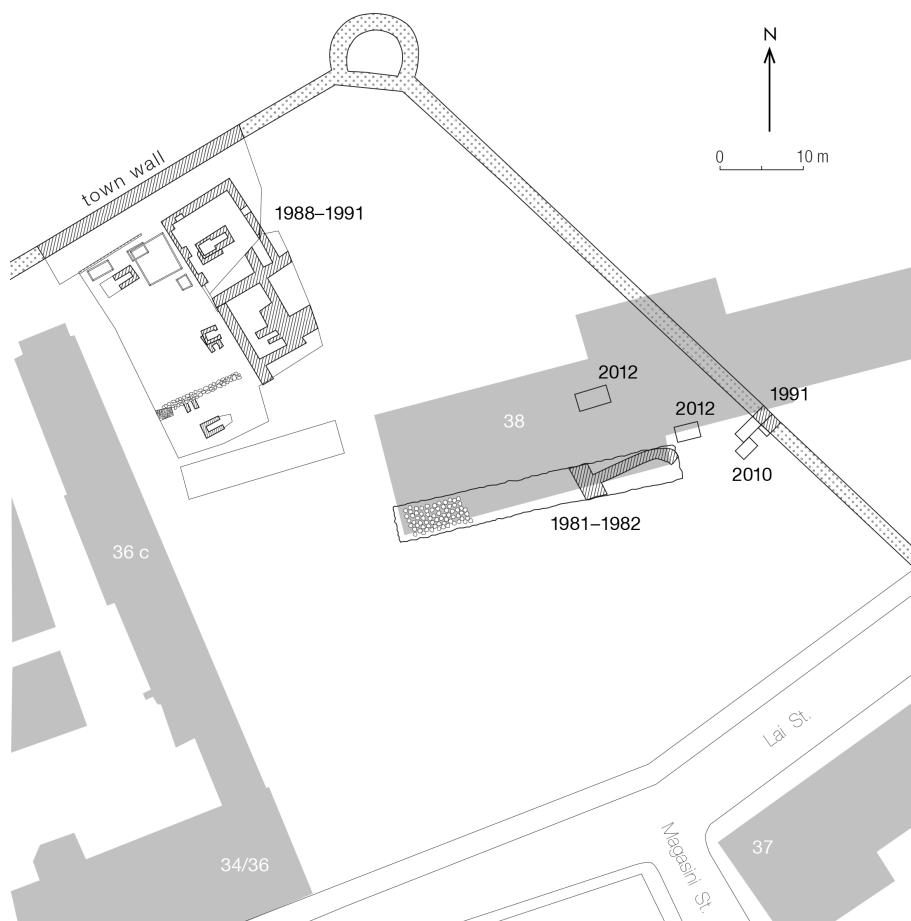


FIG. 2. Archaeological investigations conducted in the area of the University of Tartu Botanical Garden. Draft by Jaana Ratas.

Garden. Among the sherds of Pskov-style earthenware are fragments deformed by heat (e.g. TM A 43: A797, A816), which may represent production waste and thus constitute evidence of pottery manufacture in the immediate vicinity of the excavated area.

The most intriguing find from this context is a clay fragment inscribed with the first four Cyrillic letters, АБВГ (Fig. 3: 1). The letters appear to have been scratched into dried clay, which was later, most likely under accidental circumstances, subjected to burning. This flat clay piece, measuring 68×55 mm, had probably been placed between timber logs in a wall (Malve & Mäesalu 2014, 129). Several alphabets inscribed on birch bark have been recovered from the 11th–13th-century layers in Novgorod (Artsikhovskij & Borkovskij 1963, 20–21; Yanin et al. 2004, 15–16). One such alphabet was incised onto birch bark in the second third of the 13th century by a boy named Onfim, who is also the author of several other birch bark letters and

drawings discovered there (Artsikhovskij & Borkovskij 1963, 22–23; Yanin 1998, 55–63).

Objects characteristic of the material culture of Old Rus'ian towns include glass bracelets, of which at least 4000 fragments have been found in the Kyivan Rus' territories located within the present-day Russian Federation. Although the earliest glass bracelets found in the Kyivan Rus' date from the late 10th century, their widest distribution occurred in the 12th century and the first half of the 13th century (Stolyarova 2021, 507–508). From the Pskovian occupation layer of the excavation at the University of Tartu Botanical Garden, ten fragments of such bracelets were recovered (Fig. 3: 2). From elsewhere in Estonia, only a single fragment of a glass bracelet (Valk 1995, 64, pl. 24: 2) has so far been found, namely from the southern side of the medieval Tartu Cathedral, in a layer dated to approximately 1030–1061, when Tartu was under the control of Prince Yaroslav Vladimirovich of Kyiv (see Tvauri 2001b).

One of the most remarkable finds from the excavation at the University of Tartu Botanical Garden is the bottom part of a glass vessel (Fig. 3: 3), originating from a conical, thick-walled vessel. Of this artefact type, only one more fragment has been found in Estonia (see p 114). Fragments of such vessels have been discovered in 11th–13th-century sites of Kyivan Rus' (Shchapova 1972, fig. 2: 1, 5: 8, 8: 5–6, 9: 4, 10: 3). They were produced at least in Kyiv (Sergeeva & Zhurukhina 2018, fig. 1: 6; Khamaiko et al. 2022, 54–55). This is likely the earliest archaeological glass vessel fragment identified in Estonia.

A characteristic object of Kyivan Rus' material culture is the spindle whorl made of pink slate (Fig. 3: 4); nine such items were recovered from the excavation at the University of Tartu Botanical Garden. This excavation site is, in fact, the richest find spot for such artefacts in Estonia. A spindle whorl of this type (TM A 23: 50), which may also date to the 13th century, has been unearthed from the plot at Magasini Street 12a, within the area of the medieval town. Thirteen items have likewise been recovered from the occupational layers of the Jurjev stronghold and its adjacent settlement in Tartu, dating to approximately 1030–1061. From elsewhere in Estonia, only three spindle whorls of this type are known: one from the Maidla II stone cemetery in western Estonia (AM A 580: 2053), another as a stray find from Risti village in northwestern Estonia (Trummal 1964, 69), and the third from the settlement site at Pedajasaare in Setomaa, near the southeastern border of Estonia (Aun 2001, fig. 3: 1). Among other medieval towns in Estonia, a fragment of such a spindle whorl has been found only in Tallinn, in a refuse deposit from the last quarter of the 15th century uncovered in the Kalamaja suburb (AI 7909: 3195). The stone used for their production occurs in the vicinity of Ovruch, northwest of Kyiv, Ukraine. Spindle whorls made of pink



FIG. 3. Finds of Kyivan Rus' origin from the excavation at the University of Tartu Botanical Garden: 1 – clay fragment inscribed with the first four Cyrillic letters (TM A 43: A824); 2 – fragments of glass bracelets (TM A 43: A695, A1438, A1490); 3 – bottom part of a glass vessel (TM A 43: A1053); 4 – spindle whorl made of pink slate (TM A 43: A738); 5 – spindle whorl made of lead (TM A 43: A396); 6 – round brooch (TM A 43: A831); 7 – pendant cross made of mother-of-pearl (TM A 43: A1036); 8 – clay cupel-crucible (TM A 43: A897); 9 – fragment of a casting mould used for making a finger ring (TM A 43: A769). Photos by Arvi Haak.

slate appeared in northern Rus' towns at the end of the 10th century and remained widely used until around 1240, when their production came to an end owing to the destructive Mongol invasion (Kolchin 1958, 111; Rybakov 1965, 189–190, 194–196).

A spindle whorl made of lead (Fig. 3: 5) is a rare find in Estonia. One such artefact has been found in the southern part of medieval Tartu (Aun 1998, pl. II: 2), one in the southern suburb of medieval Tartu (TM A 126: 1731), two at Tarvastu castle in Viljandimaa (Valk et al. 2022, fig. 14: 7, 8), and one at the medieval settlement site of Olustvere (Tvauri 2025, fig. 3: 2). No parallels for this object have been found in western Europe. However, similar examples have been found in Russia, for instance, in layers dating from the 10th to the 15th century in Novgorod (Sedova 1981, 156–157) and Pskov (Sergina 1983, fig. 18: 6–12).

A round brooch made of tin (Fig. 3: 6) also has an almost identical counterpart known from the town of Novgorod (Sedova 1981, fig. 32: 4), where such brooches were in use from the mid-12th century until the late 14th century (Sedova 1981, 89). Another such brooch has been recovered from the area of the southern suburb of Tartu (Aun 2004, fig. 6: 3).

A find unique in Estonia to date is a pendant cross made of mother-of-pearl (Fig. 3: 7). Similar crosses have been discovered in Israel and Turkey, as well as in the territories of Kyivan Rus', including Pskov (Spirģis 2015, fig. 3: 3, 6). An object closely comparable to the Tartu pendant cross has also been found in Riga (Spirģis 2015, fig. 1: 1). The arms of the Tartu cross pendant resemble the dome of the chapel tower located above the Tomb of Christ in the Church of the Resurrection in Jerusalem. It has been suggested that mother-of-pearl crosses of this type represent pilgrim badges originating from the Church of the Resurrection in Jerusalem and dating to the 12th–13th centuries (Musin 1999, 96–97; Spirģis 2015; 2018; Mäesalu 2023).

Another noteworthy find from the 13th-century layer of the University of Tartu Botanical Garden is a clay cupel-crucible (Fig. 3: 8). Fragments of similar cupels have been found in the fill soil of the medieval moat at the Munga Street 18 plot. To determine the function of these cupels, elemental analysis was performed on the residues. Elemental analysis confirms the use of such cupels for local glass bead production in Tartu (Jegorov et al. 2023, 140–141, 144). Since the moat was filled in during the 19th century, these objects may have reached their findspot within soil excavated from the foundation pit of a building erected at that time.

In addition, it is necessary to mention the finds recovered from the 'Pskovian' layer, which, although not 'ethnic markers', nevertheless provide evidence of the activities and everyday life of the people who lived here. Four limestone casting moulds were found. One of them (Fig. 3: 9) originates from a mould used for casting finger rings, while in the case of the three others it remains unclear what was cast with them. In addition to the round brooch mentioned above, the jewellery finds include a copper-alloy penannular brooch, copper-alloy finger rings, fragments of copper-alloy bracelets, glass beads, and cowrie shells. Among the items related to production discovered there are also fragments of cylindrical clay crucibles, an iron awl, bone spindle whorls, spindle whorls made of limestone, and fragments of iron scissors. Among the household implements, one may mention knives, whetstones, padlock keys made of iron, fire-steels, and small pieces of dark-grey flint used for striking fire. Among the horse equipment, the finds include iron bridle bits, spurs, an iron curry comb, a fragment of a horseshoe, and ice nails fastened under the horse hoof. Other objects worth mentioning are an iron fishhook and bone combs.

TALLINN

The first reference to Rus'ians staying in Tallinn dates from the 1230s. It remains unclear, however, whether they were visitors or residents (Selart 2009b, 41). The Russian church located in the area of present-day Sulevimägi Street in Tallinn is first mentioned in written sources in 1371. References to this church appear repeatedly in Tallinn's municipal records up until 1413 (Tiik 1957, 243, 384–385). A record from that year describes the church as old or former (*olde*) (Tiik 1957, 383). Furthermore, a document dating to 1437 still refers to the former Russian cemetery situated at this site (Tiik 1957, 385).

Evidence for a Rus' settlement in the area of Sulevimägi Street is provided by the archaeological investigations carried out in 2003 on the plot at Sulevimägi Street 4/6 (Figs 1: 4 and 4), covering an area of approximately 600 m² (Kadakas & Nilov 2004, 167–171). Although no walls of an Orthodox church were uncovered, twelve burials (Fig. 4), oriented with their heads towards the west and without grave goods, presumably from the 13th century, were discovered, suggesting that a church had been located here (Kadakas & Nilov 2004, 170–171; Russow 2020, 30–31). The discovered burials were preserved only beneath one later building, most likely because its cellar had not been dug into the ground. The cellars of the surrounding buildings extended deeper than the level of the uncovered graves. During the construction of those buildings, both the church walls and the burials were presumably destroyed (Villu Kadakas, pers. comm., 25.02.2026).

Above the natural subsoil, in the northern and southern parts of the excavation trench, patches of an intense occupation layer were preserved (Fig. 4). From this layer, numerous earthenware sherds were collected, among which two vessel styles can be distinguished. A smaller portion of the sherds derives from pots of the Pskov style, belonging to types 3:2 (Fig. 5: 1; 6: 1) and 3:3 (Fig. 5: 2, 3; 6: 2), which closely resemble corresponding vessels recovered from the University of Tartu Botanical Garden excavation (see Tvauri 2000a, fig. 7). The majority of the sherds, however, belong to earthenware vessels imitating tripod pots, Paffrath-type globular pots, and stoneware jugs originating from northern Germany and southern Scandinavia (Fig. 6: 3, 4). Since the sherds of these German-type imitations also include fragments of vessels that were overburnt in the potter's kiln and broken during the process of production (e.g. AI 6648: 7/107, 7/110, 7/114), it can be assumed that such vessels were produced in the Sulevimägi Street area itself. In Tallinn's 13th-century layers, sherds of this type of earthenware are widely distributed (Mäll & Russow 2000, 123; 2003, figs 7–8, 13, 14: B–H; Russow & Haak 2018, fig. 6; Russow 2020, 160–165).

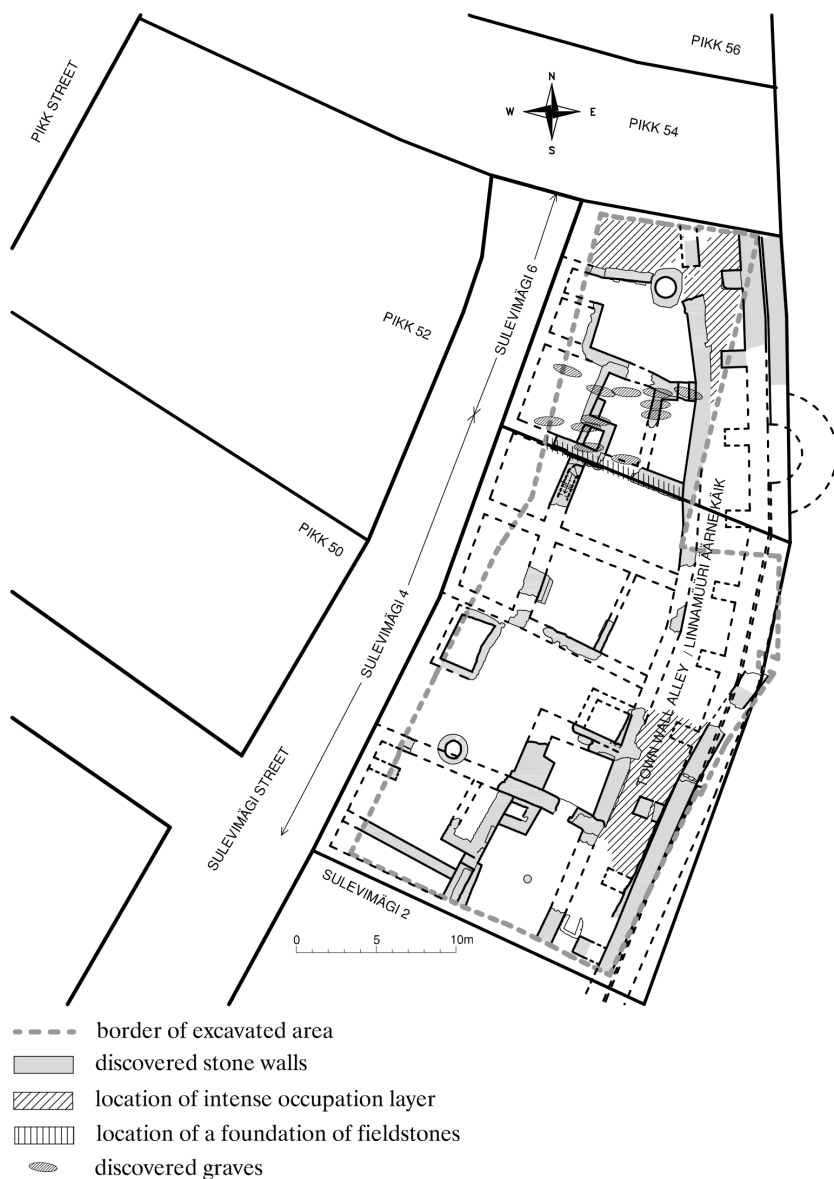


FIG. 4. Archaeological investigations conducted in Tallinn in the area of Sulevimägi Street 4/6. Draft by Villu Kadakas.

The finds also included evidence of glass bead production, namely flat melting cupel-crucibles (Fig. 7: 1), glass waste (Fig. 7: 2), and tiny beads, among which there are specimens of yellow opaque glass, green transparent glass, and blue glass (Fig. 7: 3; Russow 2020, 138). Glass beads likely produced here have been recovered from the oldest layers of the town of Tallinn, for example during archaeological excavations in the Town Hall Square and on Sauna and Aida streets (Russow 2020, 141). It is possible that

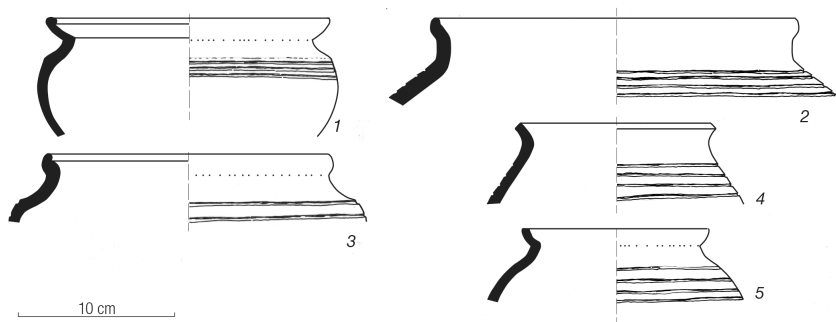


FIG. 5. Earthenware from the excavation at Sulevimägi Street 4/6: 1 – Pskov style 3:2 (AI 6648: 14/39); 2 – Pskov style 3:3 (AI 6648: 22/93); 3–5 – earthenware vessels imitating ware originating from northern Germany and southern Scandinavia (AI 6648: 6/94, 6/95, 6/97). Draft by Andres Tvauri.



FIG. 6. Earthenware from the excavation at Sulevimägi Street 4/6 (AI 6648: 14/39, 4/3, 23/505, 8/522). Photos by Andres Tvauri.

the yellow and also blue glass beads found on the neck of a woman buried in the 13th century in St Nicholas churchyard are also of local origin (Russow 2020, 38, 141).



FIG. 7. Finds of Kyivan Rus' origin from the excavation at Sulevimägi Street 4/6: 1 – clay cupel-crucible (AI 6648: 13/37); 2 – glass waste (AI 6648: 8/964); 3 – glass beads (AI 6648: 9/480–488). Photos by Andres Tvauri.

In addition, a variety of other finds were recovered from the 13th-century layer of the excavation at Sulevimägi Street 4/6. Among the jewellery and clothing accessories made of bronze alloy, fragments of two penannular brooches, a fragment of a cruciform-headed dress pin with connected terminals, fragments of a double spiral finger ring, a buckle, and a fragment of a tinker bell were found. Tools were represented by an iron auger bit and a bone spindle whorl. The household implements include a copper-alloy spoon, fragments of a padlock key, and pieces of dark grey flint. Among the horse equipment, there were an iron spur and an ice nail. An iron needle with a ring was also recovered (Russow 2020, 28). From the 13th-century find context of the excavation at Sulevimägi Street 4/6, fragments of window glass and a fragment of a limestone mortar were likewise uncovered. In addition, a particularly noteworthy find is a fragment of the foot of a glass beaker of Kyivan Rus' origin (AI 6648: 22/202). It derives from a vessel of the same type as a fragment recovered from the 13th-century layer of the University of Tartu Botanical Garden excavation (Fig. 3: 3).

During the 2003 excavations at the Sulevimägi Street 4/6 plot, twelve skeletons were uncovered. Stable isotope analyses of carbon, nitrogen, and oxygen from bone collagen were conducted on four of these skeletons in order to reconstruct aspects of the individuals' diet (Lightfoot et al. 2016). The results indicate that their dietary patterns were comparable to those of other medieval inhabitants of Tallinn previously studied. The findings suggest

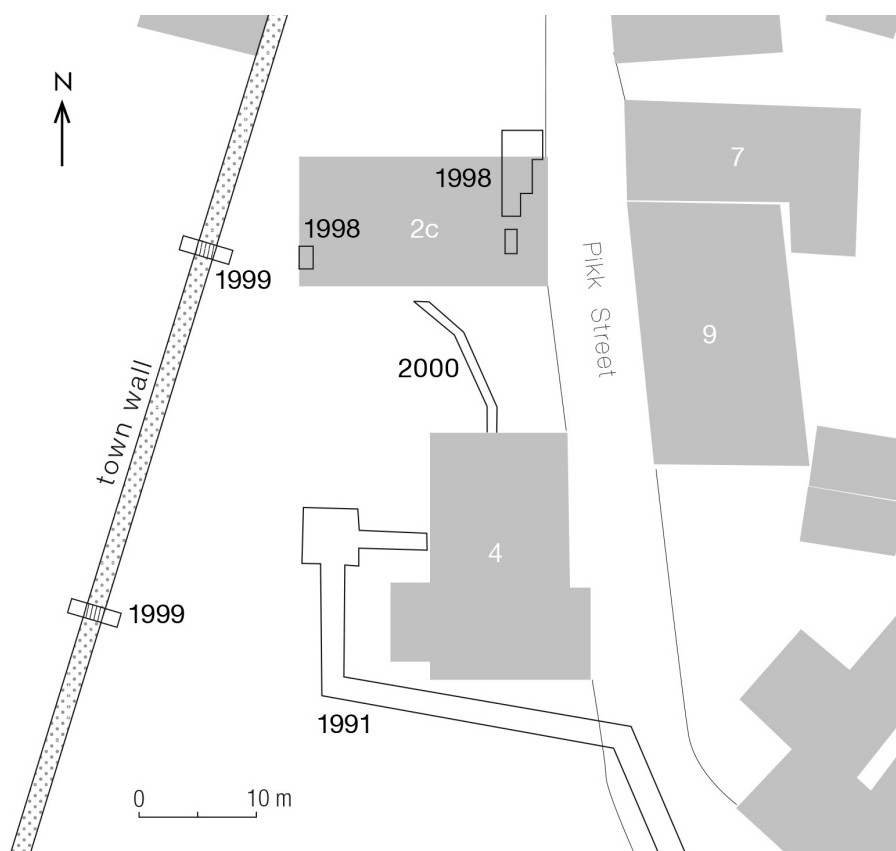


FIG. 8. Archaeological investigations conducted in Viljandi in the area of Pikk Street 4. Draft by Jaana Ratas.

a diet primarily based on C_3 plants (e.g. wheat, barley, rye, and rice) as well as on animals that had themselves consumed C_3 plants. The isotope values from two individuals interred in the Sulevimägi churchyard further indicate a possible minor C_4 component in the diet (most likely millet). It has been proposed that in medieval Estonia, millet was particularly consumed by members of the urban middle classes (Sillasoo & Hiie 2007, 89).

VILJANDI

Archaeological rescue investigations in the area of the medieval town of Viljandi, at the plot of Pikk Street 4 and its surroundings (Fig. 1: 6), were carried out in 1991 in connection with the construction of a heating pipeline, covering an area of approximately 175 m² (Fig. 8). On the natural subsoil, a 5–12 cm thick layer was identified, containing numerous sherds of earthenware vessels that had melted and bloated in the heat of a potter's kiln (Valk 1992, 2–13, 26–36; 1993, 7–8, 16–17, 20).

In 1998, excavations at the Pikk Street 4 plot uncovered the subterranean part of a potter's kiln, namely the stokehole and firing chamber (Fig. 8), which contained sherds from 20–30 vessels broken during firing (Tvauri 1999; 2000a). Test pits excavated during the same investigation revealed the remains of two additional firing chambers of potter's kilns dug into the natural subsoil (Tvauri 1999, 92). Another subterranean firing chamber of a potter's kiln was uncovered here in 2000 (Fig. 8; Tvauri 2001a). The pottery workshop had been established on former arable land, as directly evidenced by plough marks exposed in the virgin soil beneath this layer (Tvauri 1998, fig. 4; 2001a, fig. 3).

The earthenware pots and lids produced in the Viljandi pottery workshop are virtually indistinguishable from 13th-century ceramics of Pskov and from vessels of the same type found in the University of Tartu Botanical Garden excavation (see Tvauri 2000a, fig. 7). In addition to earthenware, only a few sherds of German stoneware were recovered (e.g. VM Pikk 4 1991¹: 9/2, 12/2, 16/2). Excluding the clearly Pskov-style earthenware, the other finds from the occupational layer resulting from the activity of the workshop cannot be associated with any particular place of origin or ethnic background. An exceptional discovery is a bone template used in shaping ceramic vessels (Tvauri 2000a, figs 2–4). Other finds include, for example, a circular lead pendant with an indeterminate image (Tvauri 2000a, fig. 5), a small penannular brooch of copper alloy (Tvauri 1999, fig. 3), a spiral tube made of brass wire, a tiny yellow glass bead identical to that depicted in Fig. 5: 3, a knife, and two iron padlock keys. Since no artefacts characteristically associated with the material culture of Kyivan Rus' (such as spindle whorls made of pink slate or glass bracelets) were recovered from the 13th-century occupational layer at Viljandi's Pikk Street area, it may be assumed that the Pskovians active here had not come directly from Pskov, but rather via Tartu.

The Pskovians in Tartu and Tallinn in the 13th century versus the Russian churches and merchant yards of the 15th–16th centuries

While finds of Germanic and Estonian origin in Tartu are distributed evenly across the 13th–14th-century urban space (see Haak 2022, fig. 8: 4), the material associated with Pskovian settlers from the 13th century is concentrated in specific locations (Fig. 1).

1 The finds do not have main numbers. They are housed in the Archaeological Collection of the University of Tartu.

All the 13th-century Pskovian settlement clusters under consideration existed at a time when these towns had not yet been surrounded by town walls. In Tallinn, the earliest phase of the town wall was erected in the second half of the 13th century, after 1265; however, the Sulevimägi Street area was incorporated into the walled zone only around 1310, when the fortified area was expanded northwards (Russow 2019, 32, fig. 9). On the basis of observations made during the excavations at the site of the University of Tartu Botanical Garden in 1988–1991, it has been concluded that the construction of the town wall, at least in this location, was begun in the final third of the 13th century (Malve & Mäesalu 2014, 130). The town wall of Viljandi was most likely built sometime around the year 1300 (Tvauri 2001c, 106; Haak & Russow 2013, 75). Archaeological investigation of the section of the town wall adjoining a pottery workshop located on Pikk Street revealed that the workshop was already located there before the erection of the wall (Tvauri 2001c, 106–107).

What became of the Pskovian settlement clusters in Tallinn, Tartu, and Viljandi after the 13th century? In Viljandi, the pottery workshop appears to have operated only for a relatively short period. Despite the tens of thousands of sherds resulting from pottery firing recovered here, the occupational layer associated with the workshop is only 5–20 cm thick, depending on the location (Valk 1993, 7, 18; Tvauri 1998, fig. 7; 2001a, fig. 2). The layer deposited above the workshop stratum contained finds dating from the second half of the 13th century and the first half of the 14th century (Valk 1993, 20).

In the excavations at the site of the University of Tartu Botanical Garden, no finds of Rus' origin were recovered from layers dating later than the 13th century. In the final third of the 13th century, two residential buildings were erected in the investigated area. One of them was constructed of brick, while the other was a half-timbered building. As evidenced by the preserved fire layer and a coin hoard dating from the 1320s found therein, these buildings were destroyed in the conflagration of 1329, which is known from written sources (Malve & Mäesalu 2014, 130). Both the timber-framed construction and the furnace of a heat-storage hypocaust discovered in the brick house are, in any case, characteristic features of distinctly German urban culture (see Tvauri 2009). It is likely that the Pskovian settlement there was destroyed in the course of the looting raid carried out by the Novgorodians in 1262 (Selart 2009b, 44–45), after which this area was incorporated within the town wall. Archaeological evidence does not permit the dating of the end of the Pskovian settlement with annual precision; however, no material later than the 13th century has been recovered from the 'Pskovian' layer.

The earliest written record concerning the Russian churches of St Nicholas and St George in Tartu dates from 1438 (Selart 2009a, 283; Alttoa 2017, 204). The Russian quarter of Tartu (*русских конецъ*) is mentioned for

the first time in 1474 (Alttoa 2017, 204). A description from 1498 provides information about the character of this Russian quarter (*Ruske ende*). It is said to have consisted of buildings surrounding the Russian church, which belonged to the townspeople. Previously, Russians had lived there, renting houses from Tartu citizens (Alttoa 2017, 203). On the basis of later written sources, it can be inferred that the reference concerned the St George's Orthodox Church. According to written sources, this church was situated next to the Russian Gate, between Lai Street and the town wall, and appears to have belonged to the Novgorodians (Alttoa 2017, 205–206).

Thus, the medieval church of the Novgorod merchants was situated near the area investigated in 1988–1991, likewise within the grounds of the present-day University of Tartu Botanical Garden. By 1555, the church had already been completely destroyed. According to written records, there were still two Russian churches in Tartu in 1481, but only one in 1498. Kaur Alttoa has suggested that the church of the Novgorodians was demolished by the authorities of Tartu after Tsar Ivan III of Moscow closed the Hanseatic kontor (St Peter's Yard) in Novgorod in 1494 and deported its merchants to Moscow (Alttoa 2017, 207).

The remains of the Novgorodians' St George's Church are most likely preserved beneath the greenhouse of the University of Tartu Botanical Garden. During archaeological rescue excavations in the winter of 1981–1982, an area measuring 33×4 m was partially investigated (Fig. 1: 2). A medieval wall built of bricks and fieldstones was uncovered, running approximately east–west. The eastern end of the wall, 143 cm thick, curved gently towards the south. At the western end of this wall, another stone wall was found, about 245 cm thick and oriented roughly north–south (Fig. 2). Within the construction debris surrounding the walls, human bones were present, and fifteen skeletons were uncovered along the northern side of the wall. The bodies lay on their backs, with their heads towards the west or northwest and their hands on the chest. Two burials contained traces of wooden coffins and iron nails originating from them. No grave goods were associated with the deceased (Aun 1982; Aun et al. 1983; Malve & Mäesalu 2014, 131). The rounded eastern termination of the wall is most likely the apse of a church (Alttoa 1998, 38). The excavations did not provide an answer to the question of when this stone church building was erected. It was established only that the stone church was not the earliest structure on the site – the remains of wooden buildings were discovered beneath its walls (Aun et al. 1983).

The other Orthodox church in medieval Tartu, the St Nicholas Church, was located about 140 m south of the St George's Church, in the area between present-day Rütli and Magasini streets (Fig. 1: 3). The location of this church was first identified by the historian Richard Otto, who placed it on the

site plan appended to his study on medieval monasteries in Tartu (Otto 1910, pl. III). The site of the church is evidenced in written sources. Specifically, Bartholomäus Wybers's revision book (1582–1658) (EAA.995.1.21865, fol. 92) and the 1616 revision compiled by the Polish authorities within the *Metrica* of the Grand Duchy of Lithuania (RGADA, ф. 389, оп. 578, л. 7) indicate that it was located on the eastern side of Rütli Street near Lai Street (Altoa 2017, 205). During the period of Polish rule, the church was used by the Jesuits, and by 1613 it had been completely destroyed by the Swedes (Protocoll, 34), during the years 1600–1603, when Tartu was occupied by the Swedish army. The date of its construction is unknown. Scholars have suggested that this church may have belonged to merchants from Pskov (Otto 1918; Altoa 2017); however, definitive written sources to substantiate this assumption are lacking. Thus far, three human skeletons have been recovered from a pipeline trench on Magasini Street (Tvauri 2005, 4) and two additional skeletons from preliminary archaeological investigations in the courtyard of Magasini Street 10 (Bernotas & Liivak 2024, 9). These burials are presumed to have been associated with this church or its churchyard. During rescue excavations conducted in 2025, the preserved remains of the church walls were uncovered. The building was constructed of brick, and its plastered and whitewashed interior walls were decorated with wall paintings. As part of these investigations, more than 300 burials found within and around the church were examined (Malve 2025; Malve & Valk 2025). In situ burials and disarticulated human remains have also previously been discovered in the subsoil beneath the building at Rütli Street 21, which borders the plot at Magasini Street 10 (Piirits 1998, 7).

In the Sulevimägi Street area of Tallinn (Fig. 1: 4), the Rus'ian church and cemetery were abolished between 1397 and 1413 (Tiik 1957, 384–385). Leo Tiik has suggested that the church at Sulevimägi stood in the way of the construction of the town wall and was therefore removed (Tiik 1957, 387). In reality, however, the written sources do not reveal the reason for the abolition of this church and cemetery. From 1422 onwards, the sources begin to mention the stone St Nicholas Orthodox Church belonging to merchants from Novgorod. It was located about 180 m south of the excavation site at Sulevimägi Street 4/6, in the area between Vene (Russian) Street and the town wall (Fig. 1: 5). Under the same roof as the church there was a house where goods were stored and where Novgorodian merchants visiting Tallinn held their meetings. The church had no door opening directly onto the street, and at the demand of the Tallinn town council, the building complex contained no stoves. This regulation had been established to ensure that Russian merchants lodged in rooms rented from townspeople. The medieval church was demolished between 1822 and 1827, and in its place the present St Nicholas Orthodox Church was built (Kleinenberg 1962, 242; Selart 2009a,

281). No archaeological investigations have been carried out on the later Novgorodian church and merchants' buildings located on Vene Street in Tallinn.

The earliest reports of Rus'ian merchants in Livonia's largest city, Riga, date back to 1209 (Selart 2009b, 38). A Rus' quarter, later known as the 'Russian village' (*Russche dorp*), may have been established sometime after the 1212 treaty between the Prince of Polotsk and the Archbishop of Riga, and was possibly enclosed within the town walls during the 1220s or around 1230. The earliest written sources concerning the Rus' quarter in Riga date only from the late 13th century (Selart 2009b, 40). In addition to Rus'ian merchants, written sources from Riga in the 13th century also mention Rus'ian artisans (Caune 1994). Notably, some of the Rus'ian inhabitants referred to in Riga's 13th–14th-century sources were citizens of the town and property owners (Angermann 2003, 266; Selart 2009b, 39; Gonsovska 2018).

Archaeological evidence demonstrates that, similar to Tallinn and Tartu, glass beads were also produced in the Rus' quarter of Riga during the 13th century. Specifically, along the town wall at Trokšņu Street on the northern edge of the medieval town, a 20 cm thick occupational layer dating from the late 13th to the early 14th century was uncovered. This layer yielded remains and tools associated with glass bead production – faulty glass beads and their fragments, metal rods coated with glass, and cupel-crucibles (Caune 2004; Caune & Ose 2006, 459–460). In addition, stone moulds intended for the manufacture of ornaments in the Rus' style have been recovered from 13th-century layers of Riga. Andris Caune (1994, 204) has suggested that the Rus'ian craftsmen active in Riga during the 13th century were refugees originating from Rus' towns destroyed by the Mongols. From 1297 onwards, references appear to the St Nicholas Orthodox Church located in the 'Russian village' (Selart 2009b, 40). Unlike in Tallinn and Tartu, the Russian quarter in Riga remained in the same location from the 13th century until the Livonian War (1558–1583) (Caune 1994; Šterns 1996; Selart 2009a, 288–289).

In Tallinn and Tartu, the 13th-century Pskovian settlements were situated in locations different from those of the later Russian churches or quarters (Fig. 1). Although in Tartu the 13th-century Rus' settlement was located adjacent to the later Novgorodian St George's Church, the two were nevertheless separated by a street.

The numerous pottery sherds recovered from the excavation at the University of Tartu Botanical Garden and from Pikk Street in Viljandi unquestionably derive from ceramic vessels representing the Pskov manufacturing tradition. Although it has been suggested that the Novgorodians' St George's Church in Tartu may have been established already in the 13th century (Malve & Mäesalu 2014, 129), there is no evidence to support this. The fact that people of Pskov origin resided in the

northern corner of Tartu in the 13th century rules out the possibility that the Novgorodians could have built a church there. In the mid-13th century, Novgorod and Pskov were rivals, with part of the Pskov elite allied with the rulers of Livonia. In 1240, the Bishopric of Tartu supported the attempt of the Pskov nobleman Yaroslav Vladimirovich to become Prince of Pskov. That same year, at the invitation of Bishop Hermann of Tartu, the forces of the bishopric, the Livonian branch of the Teutonic Order, and the king of Denmark conducted a military campaign that resulted in the conquest of Pskov and the installation of Yaroslav Vladimirovich as ruler. Already in 1242, however, Novgorod's prince Alexander Yaroslavich (later known as Alexander Nevsky) reconquered Pskov and deposed Yaroslav Vladimirovich (Maasing & Mäesalu 2024, 15–16). Written sources record that Yaroslav Vladimirovich, together with his relatives and supporters, spent a period of exile at the bishop's castle in Otepää after 1232 (Mäesalu 1993, 147; Selart 2001, 114–115; 2015, 133–134; Maasing & Mäesalu 2024, 14). Although written records of their presence in Tartu and Viljandi are lacking after the years 1232 and 1242, respectively, the archaeological material discussed above provides grounds to assume that refugees from Pskov also reached these towns.

The inhabitants of Pskovian origin in the towns of 13th-century Livonia were engaged in crafts, specifically in the production of pottery, glass beads, and copper-alloy ornaments. Later Russian centres, by contrast, primarily functioned as merchants' churches and warehouses. In Tartu, Orthodox churches may also have been used by fishermen and shoemakers of Russian origin, whose presence is attested in written sources from the first half of the 16th century (Tarvel 1980, 47, 52). Glass bracelets and spindle whorls made of pink Ovruch slate, discovered in the layer of the University of Tartu Botanical Garden, are artefacts that were used by women. This fact indicates that the people arriving from Pskov resided here in family groups. In later sources, by contrast, the Russian quarters of Livonian towns are associated primarily with merchants, who stayed only seasonally and did not own property in the towns.

In the case of Tallinn, scholars have previously assumed continuity between the hypothetical Russian trading yard that operated in the Sulevimägi area and those situated along Vene Street (see Tiik 1957, 383–385; Kleinenberg 1962, 254). However, in the light of the available evidence, it appears more likely that the Pskovian community at Sulevimägi assimilated and converted to Catholicism, so that by the late 14th century there were no longer Orthodox inhabitants in the city to make use of the own church and cemetery. The new church and trading yard on Vene Street were established for merchants from Novgorod. In Tartu as well, there may not have been a direct continuity between the settlement of refugees from

Pskov in the 13th century and the later communities that made use of St George's Church and cemetery, associated with Novgorodian merchants, and St Nicholas Church and cemetery, associated with Pskovian merchants.

In the 13th century, in addition to people of German origin and the local population, immigrants from Pskov also arrived in Tartu, Tallinn, and Viljandi, who by the following century at the latest appear to have adopted the Catholic faith and assimilated into the broader urban population. Similarly, the Rus' immigrants who settled in Riga during the 13th century assimilated by the following century at the latest, depending on their social standing, either into the higher-status German or the lower-status non-German segments of the population (Selart 2009b, 49–50).

At the earliest stage of urban development in Livonia during the 13th century, towns were socially and ethnically far more open than in the 15th–16th centuries, when nearly all trade and the majority of crafts came to be concentrated in the hands of German burghers. In the 15th–16th centuries, the Russian merchants present in the towns of Livonia were no longer residents of these towns but rather visitors.

Conclusions

The earliest towns in Estonia were founded in the 13th century following the German–Danish conquest and the Christianisation of the region. In addition to the German merchants and craftsmen who dominated urban administration, substantial numbers of Estonians and Scandinavians also resided in these towns. Archaeological evidence indicates that in the mid-13th century, settlers of Rus' origin arrived in Tartu, Viljandi, and Tallinn from Pskov.

In all of these towns, the settlement centres of the Pskovians were located on the periphery of the contemporary urban area: in Tartu in the area of the present-day University of Tartu Botanical Garden, in Viljandi on the plot at Pikk Street 4, and in Tallinn on the property at Sulevimägi Street 4/6. The Pskovian origin of these inhabitants is demonstrated primarily by the large quantity of pottery sherds characteristic of Pskov recovered from the aforementioned sites.

The substantial assemblage of finds indicates that craftsmen originating from Pskov lived in these locations as family groups and were engaged in pottery production (in Tartu, Viljandi, and Tallinn), the manufacture of glass beads (in Tartu and Tallinn), and the casting of small metal ornaments (in Tartu). From a mid-13th-century layer in the excavation area of the University of Tartu Botanical Garden, fragments of glass bracelets, spindle whorls made of pink slate originating from the region of Ovruch near Kyiv, a lead spindle whorl, and a tin penannular brooch decorated with vegetal ornamentation were recovered – artefacts characteristic primarily of the

material culture of Kyivan Rus'. From the same layer, as well as from a 13th-century layer at the plot at Sulevimägi Street 4/6 in Tallinn, fragments of glass vessels manufactured in Kyiv were discovered. These represent the earliest glass vessel fragments found in Estonia. The assemblage demonstrates that people of Pskovian origin were permanent residents of Tartu, Viljandi, and Tallinn in the 13th century rather than temporary visitors. At Sulevimägi Street in Tallinn, an Orthodox church and cemetery belonging to the Pskovian community were also present. The Pskovians were assimilated into the urban population of these towns by the end of the 14th century at the latest.

In the 15th century, the St Nicholas Orthodox Church belonging to the Novgorodians was constructed along Vene Street in Tallinn. Probably in the same century, the St George's Church of the Novgorodians and the St Nicholas Church of the Pskovians were built in Tartu; both have also been investigated archaeologically. These were churches of Russian merchants, and the associated trading courts were not connected to the Pskovian settlement that had existed in the area in the 13th century.

DATA AVAILABILITY STATEMENT

All data supporting the findings of this study are included within the article.

ACKNOWLEDGEMENTS

I would like to thank Arvi Haak, Villu Kadakas, Irita Kallis, Erki Russow, Anti Selart, and Heiki Valk for their valuable data, comments, and corrections. This paper was prepared as part of the Estonian Research Council project PRG1931 'Estonia in 1100–1400: native society, traditions and culture in the time of changes' and the Centre of Excellence 'Estonian Roots' (TK215), funded by the Ministry of Education and Research. The publication costs of this article were partially covered by the Estonian Academy of Sciences.

References

- Alamaa, E.** 1966. Toompea eeslinn. – Tallinn. Linna asustus- ja ehitusajaloolisi materjale seitsmes köites, III. Eds E. Alamaa & A. Kivi. Eesti NSV Riiklik Ehituskomitee, RPI Eesti Projekt, Tallinn, 80–136.
- Alttoa, K.** 1985. „Vene ots“ keskaegses Tartus. – Tartu. Minevik, tänapäev. Tallinn, 87–96.
- Alttoa, K.** 1998. Das Russische Ende im mittelalterlichen Dorpat (Tartu). – Steinbrücke. Estnische Historische Zeitschrift, 1, 31–42.
- Alttoa, K.** 2017. „Vene ots“ keskaegses Tartus. – Tartu: piiskopi- ja hansalinnast Emajõe Ateenaks. Kirjutisi Tartu vanemast ehitusloost. Ed. U. Tõnisson. Ilmamaa, Tartu, 199–209.
- Angermann, N.** 2003 = **Ангерманн Н.** Русские и белорусские купцы в средневековой Ливонии. – От Древней Руси к России нового времени: сборник статей к 70-летию Анны Леонидовны Хорошкевич. Ed. В. Л. Янин. Наука, Москва, 264–271.
- Artsikhovskij, A. V. & Borkovskij, V. I.** 1963 = **Арциховский А. В. & Борковский В. И.** Новгородские грамоты на бересте (из раскопок 1956–1957 гг.). Издательство Академии наук СССР, Москва.

- Aun, M.** 1982. Aruane avariikaevamistest Tartu Riikliku Ülikooli Botaanikaiaia territooriumil 9. detsembrist 1981. a. kuni 30. jaanuarini 1982. a. Tartu. (Manuscript in the Archaeological Research Collection of Tallinn University.)
- Aun, M.** 1998. Tartu vanalinna arheoloogilise uurimise tulemusi (VII kvartali IV kaevandi kesk- ja idaosa põhjal). – *Estonian Journal of Archaeology*, 2: 1, 94–144. <https://doi.org/10.3176/arch.1998.1.05>
- Aun, M.** 2001. Rescue excavations on the island of Sosna, Setumaa. – *Archaeological Field Works in Estonia* 2000, 91–102.
- Aun, M.** 2004. Ehteide keskaegse Tartu lõunapoolse eeslinna alalt. – Linnusest ja linnast. Uurimusi Vilma Trummali auks. Eds A. Haak, E. Russow & A. Tvauri. (Muinasaja teadus, 14.) Tallinn, Tartu, 35–56.
- Aun, M., Lang, V. & Ligi, P.** 1983 = **Аун М., Ланг В. & Лиги П.** Об археологических памятниках на территории ботанического сада Тартуского Государственного Университета. – *Eesti NSV Teaduste Akadeemia toimetised. Ühiskonnateadused*, 32: 4, 324–328.
- Bernotas, R. & Liivak, R.** 2024. Aruane arheoloogilistest eeluuringutest Tartus Magasini tn 10 kinnistul 2024. aastal. Tartu. (Manuscript in the National Heritage Board.)
- Caune, A.** 1994 = **Цауне А.** Русский двор в Риге XIII–XVI вв. – Новгородские археологические чтения. Материалы научной конференции, посвященной 60-летию археологического изучения Новгорода и 90-летию со дня рождения основателя Новгородской археологической экспедиции А. В. Арциховского, Новгород, 28 сентября–2 октября 1992 г. Eds B. Л. Янин & П. Г. Гайдуков. Новгородский государственный объединенный музей-заповедник, Новгородская археологическая экспедиция, Центр по организации археологических исследований Новгорода, Новгород, 204–205.
- Caune, A.** 2004. Archäologische Zeugnisse von der Bearbeitung des Glases in Riga im 13. und 14. Jahrhundert. – *Archaeologia et historia urbana. Pamięci Tadeusza Nawrołskiego*. Eds R. Czaja, G. Nawrołska, M. Rębkowski & J. Tandecki. Muzeum w Elblągu, Elbląg, 457–464.
- Caune, A. & Ose, I.** 2006. Archäologische Erkenntnisse zum Handwerk in Riga. Unter besonderer Berücksichtigung des 13./14. Jahrhunderts mit einem Ausblick auf das 17. Jahrhundert. – *Das Handwerk*. Ed. M. Gläser. (Lübecker Kolloquium zur Stadtarchäologie im Hanseraum Band, V.) Schmidt-Römhild, Lübeck, 459–472.
- EAA = National Archives of Estonia, EAA.995.1.21865, fol. 92: Wyberssches Revisionsbuch.
- Gonsovskaja, M.** 2018 = **Гонсовска М.** Русская среда в средневековой Риге. – Страны Балтики и северо-запад: исторический опыт взаимодействия. Материалы международной научно-практической конференции Великий Новгород, 30 ноября – 1 декабря 2017 г. Ed. М. Б. Бессуднова. Новгородский Государственный Университет имени Ярослава Мудрого, Великий Новгород, 81–91.
- Haak, A.** 2011. Kuidas kajastuvad etnilised määratlused arheoloogilises aineses? Mõnest tõlgendusprobleemist Tartu keskaegse allikmaterjali näitel. – Tartu Linnamuseumi aastaraamat. Ed. M. Rennit. Tartu Linnamuseum, Tartu, 11–21.
- Haak, A.** 2015. Problems of defining ethnic identity in medieval towns of Estonia on the basis of archaeological sources. – *Today I Am Not the One I Was Yesterday: Archaeology, Identity, and Change*. Eds A. Haak, V. Lang & M. Lavento. (Interarchaeologia, 4.) Tartu Ülikool, Tartu, 13–27.
- Haak, A.** 2019. Keskaegse Tartu esimene aastasada. – *Horisont*, 2, 36–40.

- Haak, A.** 2022. 'Local' characteristics of the medieval Livonian town. – *Baltic Crusades and Societal Innovation in Medieval Livonia, 1200–1350*. Ed. A. Selart. (The Northern World, 93.) Brill, Leiden, 232–260.
- Haak, A. & Heinloo, E.** 2007. Pottsepi ja tellisepõletus. – *Pudemeid keskaegsest käsitööst Tartus. Näituse Manu et mente / Käte ja mõistusega kataloog*. Ed. A. Haak. Tartu Linnamuuseum, Tartu, 31–38.
- Haak, A. & Russow, E.** 2013. On the development of the town of Viljandi in the light of earliest archaeological find complexes. – *Estonian Journal of Archaeology*, 17: 1, 57–86. <https://doi.org/10.3176/arch.2013.1.04>
- HCL = The Chronicle of Henry of Livonia. 2003. Trans. & ed. J. A. Brundage. Columbia University Press, New York.
- Jegorov, S., Kriiska, A., Saage, R., Gadalšina, M. & Kask, S.-K.** 2023. Archaeological research at Munga Street 18 in Tartu. – *Archaeological Fieldwork in Estonia 2022*, 137–146.
- Johansen, P.** 1934. Eestlane Tallinna Linnaarhiivi allikate kajastuses. – *Ajalooline Ajakiri*, 4, 180–188.
- Johansen, P.** 1951. Nordische Mission. Revals Gründung und die Schwedensiedlung in Estland. (Kungl. Vitterhets Historie och Antikvitets Akademiens handlingar, 74.) Stockholm.
- Johansen, P.** 1965. Die Kaufmannskirche. – *Die Zeit der Stadtgründung im Ostseeraum. Visby-symposiet för historiska vetenskaper 1963*. Ed. M. Stenberger. (Acta Visbyensia, I.) Gotlands Fornsal, Visby, 85–134.
- Johansen, P. & von zur Mühlen, H.** 1973. Deutsch und Undeutsch im mittelalterlichen und frühneuzeitlichen Reval. (Ostmitteleuropa in Vergangenheit und Gegenwart, 15.) Böhlau Verlag, Köln, Wien.
- Kadakas, V. & Nilov, H.** 2004. Various investigations in Tallinn and Harjumaa. – *Archaeological Fieldwork in Estonia 2003*, 160–175.
- Kala, T.** 2002. Tallinna tekkeloo peegeldumine kirjalikes allikates. – *Keskus – tagamaa – ääreala. Uurimusi asustushierahia ja võimukeskuste kujunemisest Eestis*. Ed. V. Lang. (Muinasaja teadus, 11.) Eesti Teaduste Akadeemia Ajaloo Instituut, Tallinn, Tartu, 391–408.
- Kala, T.** 2019a. All-linna tekkimine. – *Tallinna ajalugu 1561. aastani*, I. Eds T. Kala & T. Tamla. Tallinna Linnaarhiiv, Tallinn, 82–84.
- Kala, T.** 2019b. Rahvastiku päritolu ning etniline ja sotsiaalne koosseis. – *Tallinna ajalugu 1561. aastani*, I. Eds T. Kala & T. Tamla. Tallinna Linnaarhiiv, Tallinn, 135–139.
- Kangroopool, R. & Bruns, D.** 1972. Tallinn sajandeis. Eesti Raamat, Tallinn.
- Kapliniski, K.** 1980. Tallinna käsitöölised XIV sajandil, I. Eesti Raamat, Tallinn.
- Kenkmaa, R.** 1937. Eesti linnade tekkimine ja arenemine XIII ja XIV sajandil. – *Eesti ajalugu*, II. Ed. H. Kruus. Eesti Kirjanduse Selts, Tartu, 83–119.
- Khamaiko, N. V., Zhurukhina, O. Y. & Hun, M. O.** 2022. New look to the first glassmaking workshop discovered in Kyiv Podil. – *Archaeology and Early History of Ukraine*, 43: 2, 50–64. <https://doi.org/10.37445/adiu.2022.02.04>
- Kleinenberg, I.** 1962. Tallinna vene kaubahoovi ajaloost XV–XVI sajandil. – *Eesti NSV Teaduste Akadeemia toimetised. Ühiskonnateadused*, 11: 3, 241–257.
- Kolchin, B. A.** 1958 = **Колчин Б. А.** Хронология Новгородских древностей. – *Советская археология*, 2, 92–111.
- Lavi, A.** 2012. Arheoloogia ja Eesti varasemate taluehitiste ajaloo uurimine. – *Maaarhitektuur ja maastik*. Eds H. Pärdis, E. Lutsepp & M. Jõks. (Eesti Vabaõhumuuseumi toimetised, 3.) Eesti Vabaõhumuuseum, Tallinn, 121–138.

- LGU, I = Livländische Güterurkunden, I (aus dem Jahren 1207 bis 1500). 1908. Eds H. von Bruiningk & N. Busch. Jonck & Poliewsky, Riga.
- Lightfoot, E., Naum, M., Kadakas, V. & Russow, E.** 2016. The influence of social status and ethnicity on diet in mediaeval Tallinn as seen through stable isotope analysis. – *Estonian Journal of Archaeology*, 20: 1, 81–107. <https://doi.org/10.3176/arch.2016.1.04>
- Loit, A.** 2003. Inimene ja mägi. – *Tuna. Ajalookultuuri ajakiri*, 4, 6–14.
- Maasing, M. & Mäesalu, M.** 2024. Piiskopkonna ajalugu. Agressiivse välispoliitika periood, 1225–1289. – *Tartu piiskopkond, 1224–1558. Kõige võimsam territoorium*. Comp. K. Rikson. (Võimukeskused, 2.) Eostre, Tallinn, 13–19.
- Mäesalu, A.** 1993. Die Burg Otepää als ein Zentrum in Südostestland im 11.–14. Jh. – *Castella Maris Baltici*, I. Ed. K. Drake. (Archaeologia Medii Aevi Finlandiae, 1.) Almqvist & Wiksell International, Stockholm, 143–148.
- Mäesalu, A.** 1999. Archäologische Erkenntnisse zum Handel in Tartu (Dorpat) vom 12. bis zum 17. Jahrhundert. – *Der Handel*. Ed. M. Gläser. (Lübecker Kolloquium zur Stadtarchäologie im Hanseraum, II.) Schmidt-Römhild, Lübeck, 427–434.
- Mäesalu, A.** 2001. Die Haustypen in hansezeitlichen Tartu (Dorpat). – *Der Hausbau*. Ed. M. Gläser. (Lübecker Kolloquium zur Stadtarchäologie im Hanseraum, III.) Schmidt-Römhild, Lübeck, 581–594.
- Mäesalu, A.** 2023. Kas Tartust leitud pärlnutrist ristikese kaotas Pühal Maal käinud palverändur? – *Tutulus. Eesti arheoloogia aastakiri*, 34–35.
- Mäesalu, M.** 2024. Muinaslinnusest piiskopilinnaks: Tartu 13. sajandi I veerandil. – *Tuna. Ajalookultuuri ajakiri*, 4, 9–31.
- Mäesalu, A. & Vissak, R.** 2002. On the older topography of Tartu. – *The Medieval Town in the Baltic: Hanseatic History and Archaeology*, II. Eds R. Vissak & A. Mäesalu. Tartu Linnamuseum, Tartu, 145–163.
- Mäesalu, A. & Vissak, R.** 2005. Muinas- ja keskaeg. – *Tartu. Ajalugu ja kultuurilugu*. Comp. H. Pullerits. Tartu Linnamuseum, Ilmamaa, Tartu, 13–28.
- Mäesalu, A. & Haak, A.** 2016. Über die Entstehungsgeschichte des mittelalterlichen Dorpats (Tartu). – *Vorbesiedlung, Gründung und Entwicklung*. Eds M. Gläser & M. Schneider. (Lübecker Kolloquium zu Stadtarchäologie im Hanseraum, X.) Schmidt-Römhild, Lübeck, 507–519.
- Mägi, M.** 2015. Rafala. Idateest ja Tallinna algusest. Argo, Tallinn.
- Mäll, J. & Russow, E.** 2000. Kohalik ja importkeraamika Tallinnas aastail 1200–1550. – *Estonian Journal of Archaeology*, 4: 2, 120–128. <https://doi.org/10.3176/arch.2000.2.02>
- Mäll, J. & Russow, E.** 2003. Kuidas otsiti Kalevipoja parteipiletit – 50 aastat arheoloogilistest kaevamistest Tallinnas Raekoja platsil. – *Arheoloogiga Läänemere maades. Uurimusi Jüri Seliranna auks*. Eds V. Lang & Ü. Tamla. (Muinasaja teadus, 13.) Tallinn, Tartu, 173–200.
- Malve, M.** 2025. Tartu südalinnas paljastus arheoloogide labida all kesk- ja varauusaegne sakraalmaastik. – *Horisont*, 6, 54.
- Malve, M. & Mäesalu, A.** 2014. Kuidas Mare Aun leidis Tartus palmide alt keskaegse kiriku ja kalmistu. – *Ajast ja ruumist. Uurimusi Mare Auna auks*. Eds Ü. Tamla & V. Lang. (Muinasaja teadus, 25.) Tallinn, Tartu, 125–138.
- Malve, M. & Valk, H.** 2025. Keskaegsed kirikumüürid ja jäätmekastid Tartus Magasini tänaval. – *Tutulus. Eesti arheoloogia aastakiri*, 64–65.
- Mänd, A.** 2013. Membership and social career in Tallinn merchants' guilds. – *Guilds, Towns, and Cultural Transmission in the North, 1300–1500*. Eds L. Bisgaard, L. B. Mortensen & T. Pettitt. University Press of Southern Denmark, Odense, 229–250.

- Metsallik, R.** 1995. Tartu arheoloogilisest uurimisest. – Tartu arheoloogiast ja vanemast ehitusloost. Artiklite kogumik. Ed. H. Valk. (Tartu Ülikooli arheoloogia kabineti toimetised, 8.) Tartu Ülikooli kirjastus, Tartu, 15–35.
- Moora, H.** 1953. Tallinna tekkimisest ja vanusest. – Eesti NSV Teaduste Akadeemia toimetised, 2: 2, 167–175.
- Musin, A.** 1999 = **Мусин А.** Археология древнерусского паломничества в Святую Землю в XII–XV веках. – Богословские труды, 35, 92–110.
- Naum, M.** 2014. Multi-ethnicity and material exchanges in Late Medieval Tallinn. – *European Journal of Archaeology*, 17: 4, 656–677. <https://doi.org/10.1179/1461957114Y.00000000068>
- Niitemaa, V.** 1949. Die undeutsche Frage in der Politik der livländischen Städte im Mittelalter. PhD thesis. University of Helsinki, Helsinki.
- Otto, R.** 1910. Ueber die Dorpater Klöster und ihre Kirchen. (Verhandlungen der Gelehrten Estnischen Gesellschaft, XXII: II.) [s.n.], Dorpat.
- Otto, R.** 1918. Zur Ortsbeschreibung und Entstehungsgeschichte von Burg und Stadt Dorpat. (Aus Dorpats Vergangenheit, 1.) Laakmann, Dorpat.
- Pärn, A.** 2004a. Die Städtegründungen in Estland. Eine Analyse der Einflüsse aus der Siedlungsentwicklung. – *The European Frontier. Clashes and Compromises in the Middle Ages*. Ed. J. Staecker. (Lund Studies in Medieval Archaeology, 33.) Almqvist & Wiksell International, Lund, 259–282.
- Pärn, A.** 2004b. Külaehitiste jäljed Haapsalu varases linnaehituses. – Linnusest ja linnast. Uurimusi Vilma Trummali auks. Eds A. Haak, E. Russow & A. Tvauri. (Muinasaja teadus, 14.) Tallinn, Tartu, 269–289.
- Piirits, P.** 1998. Arheoloogilised uuringud Tartus Rütli tn. 21 hoone vundamentide kindlustamise ajal. Tartu. (Manuscript in the archive of the Department of Archaeology of the University of Tartu.)
- Protocoll = Protocoll der Catholischen Kirchenvisitation in Livland vom Jahre 1613. – *Archiv für die Geschichte Liv-, Esth- und Curlands*, I. Ed. F. G. von Bunge. Reval, 1842, 23–77.
- RGADA = Russian State Archive of Ancient Documents (Российский государственный архив древних актов), ф. 389, оп. 578, 1. 7: Литовская метрика.
- Russow, E.** 2019a. Tallinna lätited. – *Tuna. Ajalookultuuri ajakiri*, 2, 10–35.
- Russow, E.** 2019b. Vene asustus Sulevimäel. – Tallinna ajalugu 1561. aastani, I. Eds T. Kala & T. Tamla. Tallinna Linnaarhiiv, Tallinn, 211.
- Russow, E.** 2020. Lood ja leiud Tallinna algusest. Stilus, Tallinn.
- Russow, E.** 2025. Unearthing the origins of medieval Tallinn. – *Town and Castle. Early Urban Formation Processes in the Southern Baltics*. Eds R. Atzbach & M. Ebert. (Sonderheft der Archäologischen Nachrichten aus Schleswig-Holstein.) Georg Olms Verlag, Baden-Baden, 73–106.
- Russow, E. & Haak, A.** 2018. An outline of pottery production and consumption in medieval and early modern Estonia. – 2nd meeting of Baltic and North Atlantic Pottery Research Group. Tallinn, 12–13 April 2018. Eds E. Russow & A. Haak. Tallinna Ülikooli humanitaarteaduste instituudi ajaloo, arheoloogia ja kunstiajaloo keskus, Tallinn, 51–75.
- Russow, E. & Tamla, T.** 2019a. Lyndanise linnus Toompeal. – Tallinna ajalugu, 1561. aastani, I. Eds T. Kala & T. Tamla. Tallinna Linnaarhiiv, Tallinn, 63–64.
- Russow, E. & Tamla, T.** 2019b. Vanalinna kultuurikiht. – Tallinna ajalugu 1561. aastani, I. Eds T. Kala & T. Tamla. Tallinna Linnaarhiiv, Tallinn, 65–66.
- Rybakov, B. A.** 1965 = **Рыбаков Б. А.** Ремесло древней Руси. Академия наук СССР, Москва.

- Sedova, M. V.** 1981 = **Седова М. В.** Ювелирные изделия древнего Новгорода (X–XV вв.). Наука, Москва.
- Selart, A.** 2001. Otepää, Pihkva ja püha Jevpraksija. – Muinasaja loojangust omariikluse läveni. Pühendusteos Sulev Vahtre 75. sünnipäevaks. Ed. A. Andresen. Ajaloookirjanduse Sihtasutus Kleio, Tartu, 107–122.
- Selart, A.** 2009a. Orthodox churches in medieval Livonia. – The Clash of Cultures on the Medieval Baltic Frontier. Eds A. Murray & V. A. V. Ashgate. Farnham, Burlington, 273–290.
- Selart, A.** 2009b. Russians in the Livonian towns in the thirteenth and fourteenth centuries. – Segregation – Integration – Assimilation. Religious and Ethnic Groups in the Medieval Towns of Central and Eastern Europe. Eds D. Keene, B. Nagy & K. Szende. (Historical Urban Studies Series.) Ashgate, Farnham, Burlington, 33–50.
- Selart, A.** 2017. Sie kommen, und sie gehen. Zentrale Orte, Randgebiete und die Livländer im Mittelalter. – Livland – eine Region am Ende der Welt? Forschungen zum Verhältnis zwischen Zentrum und Peripherie im späten Mittelalter. / Livonia – a Region at the End of the World? Studies on the Relations between Centre and Periphery in the Later Middle Ages. Eds A. Selart & M. Thumser. (Quellen und Studien zur baltischen Geschichte, 27.) Böhlau Verlag, Köln, Weimar, Wien, 27–60.
- Selart, A., Leimus, I., Kaljundi, L. & Valk, H.** 2025. The Crusades and the Conquest of Livonia. – Medieval Livonia. Eds A. Selart & A. V. Murray. (Studies in the Crusades and the Latin East, 18.) Brepols, Turnhout, 39–67.
- Sergeeva, M. S. & Zhurukhina, O. Yu.** 2018 = **Сергеева М. С. & Журухина О. Ю.** Глиняні форми для виготовлення скляних посудин (за даними розкопок середньовічного виробничого комплексу Київського Подолу). – Археологія і давня історія України, 4: 29, 119–124.
- Sergina, T. V.** 1983 = **Сергина Т. В.** Раскопки в Окольном городе в 1978–1979 гг. – Археологическое изучение Пскова. Наука, Москва, 81–104.
- Shchapova, Yu. L.** 1972 = **Щапова Ю. Л.** Стекло Киевской Руси. МГУ, Москва.
- Sillasoo, Ü. & Hiie, S.** 2007. An archaeobotanical approach to investigating food of the Hanseatic period in Estonia. – Medieval Food Traditions in Northern Europe. Ed. S. Karg. (Publications from the National Museum. Studies in Archaeology & History, 12.) Copenhagen, 73–96.
- Sokolovskij, V.** 2003 = **Соколовский В.** Возникновение Таллина (к 50-летию археологических раскопок на Ратушной площади). – Псков в российской и европейской истории (к 1100-летию первого летописного упоминания). Том 1. Ed. B. В. Седов. Российская академия наук, Институт российской истории РАН, Москва, 244–253.
- Spirģis, R.** 2015. Rīgā un Turaidā atrastie perlamutra krustiņi – liecības par svētceļojumiem uz Svēto zemi 13. gadsimtā. – Senā Rīga. Pētījumi pilsētas arheoloģijā un vēsturē, 8. Latvijas Vēstures institūts, Rīga, 110–127.
- Spirģis, R.** 2018. Finds in Latvia of 13th-century pilgrims' crosses from the Holy Land. – Journal of Historical Archaeology & Anthropological Sciences, 3: 3, 494–499. <https://doi.org/10.15406/jhaas.2018.03.00123>
- Šterns, I.** 1996. Latvieši un krievi viduslaiku Rīgā. – Latvijas vēstures institūta žurnāls, 2, 22–54.
- Stolyarova, E.** 2021. Mediaeval glass bracelets in Rus' (according to the finds in the towns of the north-east of Rus'). – Annales du 21e Congrès de l'Association Internationale pour l'Histoire du Verre. İstanbul, 3–7 Septembre 2018. Ed. O. Sevindik. Association Internationale pour l'Histoire du Verre, 507–520.

- Tamm, J.** 1993. Of the older settlement of Tallinn. – Castella Maris Baltici, 1. Ed. K. Drake. (Archaeologia Medii Aevi Finlandiae, 1). Almqvist & Wiksell International, Stockholm, 205–211.
- Tamm, J.** 1995. Tallinna vanemast asustusest. – Vana Tallinn, V (IX). Estopol, Tallinn, 10–34.
- Tarakanova, S. & Saadre, O.** 1955. Tallinnas 1952.–1953. aastail teostatud arheoloogiliste kaevamiste tulemusi. – Muistsed asulad ja linnused. Arheoloogiline kogumik, I. Eds H. Moora & L. Jaanits. Tallinn, 11–45.
- Tarvel, E.** 1980. Hansalinnana XIII sajandist Liivi sõjani. – Tartu ajalugu. Ed. R. Pullat. Eesti Raamat, Tallinn, 27–57.
- Tarvel, E.** 1999. Genesis of the Livonian town in the 13th century. – Prusy–Polska–Europa. Studia z dziejów średniowiecza i czasów wczesnonowożytnych. Prace ofiarowane Profesorowi Zenonowi Hubertowi Nowakowi w sześćdziesiątą piątą rocznicę urodzin i czterdziestolecie pracy naukowej. Eds A. Radziński & J. Tandecki. Wydawnictwo Uniwersytetu Mikołaja Kopernika, Toruń, 287–301.
- Tiik, L.** 1957. Vana Tallinn. Ajaloolis-geograafiline käsitletu linna tekkimisest ja kujunemisest. Dissertatsioon geograafiateaduste kandidaadi teadusliku astme taotlemiseks. Tartu. (Manuscript in the library of the University of Tartu.)
- Tõnisson, E.** 1996. Zum Problem der frühgeschichtlichen Handelsplätze in Estland (800–1200 n. Chr.). – Congressus primus historiae Fenno-Ugricae. Ed. K. Julku. (Historia Fenno-ugrica, I: 2.) Societas Historiae Fenno-Ugricae, Oulu, 541–551.
- Trummal, V.** 1964. Arheoloogilised kaevamised Tartu linnusel. – Eesti NSV ajaloo küsimusi, III. (Tartu Riikliku Ülikooli toimetised, 161.) Tartu Riiklik Ülikool, Tartu.
- Trummal, V.** 1980. Vanimast ajaloost. – Tartu ajalugu. Ed. R. Pullat. Eesti Raamat, Tallinn, 18–26.
- Trummal, V.** 1996. Über die Entstehung und Herausbildung der Stadt Tartu auf der Grundlage archäologischer Untersuchungen. – Congressus primus historiae Fenno-Ugricae. Ed. K. Julku. (Historia Fenno-ugrica, I: 2.) Societas Historiae Fenno-Ugricae, Oulu, 531–539.
- Trummal, V.** 1997 = **Трумал В.** Археологические исследования средневекового Тарту. – Памятники старины. Концепции. Открытия. Версии. Памяти В. Д. Белецкого (1919–1997), II. Санкт-Петербург, Псков, 344–350.
- Tvauri, A.** 1998. Aruane arheoloogilistest kaevamistest keskaegse keraamikatöökoja alal Viljandis Pikk t 4 krundil 1998. a. Tartu. (Manuscript in the archive of the Department of Archaeology of the University of Tartu.)
- Tvauri, A.** 1999. The medieval potter's kiln from the old town of Viljandi. – Archaeological Field Works in Estonia 1998, 89–95.
- Tvauri, A.** 2000a. Pihkva pottsepad Viljandis ja Tartus 12. sajandil. – Estonian Journal of Archaeology, 4: 1, 21–30. <https://doi.org/10.3176/arch.2000.1.02>
- Tvauri, A.** 2000b. Loode-Vene päritolu slaavi keraamika Eestis 11.–16. sajandil. – Estonian Journal of Archaeology, 4: 2, 91–119. <https://doi.org/10.3176/arch.2000.2.01>
- Tvauri, A.** 2001a. Archaeological investigations in the Old Town of Viljandi, at 4 Pikk Street. – Archaeological Field Works in Estonia 2000, 103–107.
- Tvauri, A.** 2001b. Muinas-Tartu. Urimus Tartu muinaslinnuse ja asula asustusloost. (Muinasaja teadus, 10.) Tartu Ülikool, Tartu, Tallinn.
- Tvauri, A.** 2001c. Viljandi linnamüüri arheoloogilised uuringud aastatel 1997–1999. – Viljandi Muuseumi aastaraamat 2000. Viljandi Muuseum, Viljandi, 92–110.
- Tvauri, A.** 2005. Aruane arheoloogilisest järelevalvest vee- ja kanalisatsioonitrasside renoveerimisel Tartus Magasini tänaval 2005. aastal. Tartu. (Manuscript in the National Heritage Board.)

- Tvauri, A.** 2009. Late medieval hypocausts with heat storage in Estonia. – *Baltic Journal of Art History*, 1, 49–78.
- Tvauri, A.** 2022. Advancement of craftsmanship and manufacturing in medieval Livonia. – *Baltic Crusades and Societal Innovation in Medieval Livonia, 1200–1350*. Ed. A. Selart. (The Northern World, 93.) Brill, Leiden, 261–317.
- Tvauri, A.** 2025. Pskov-style earthenware in Estonia from the 11th to the 15th century: types, subtypes and their distribution areas. – *Estonian Journal of Archaeology*, 29: 2, 158–185. <https://doi.org/10.3176/arch.2025.2.03>
- Valk, H.** 1992. Viljandi noorte huvikeskuse küttetrassi 1991. a. arheoloogiliste kaevamiste leiunimekiri. Tartu. (Manuscript in the archive of the Department of Archaeology of the University of Tartu.)
- Valk, H.** 1993. Aruanne arheoloogilistest kaevamistest Viljandi noorte huvikeskuse küttetrassil 1991. a. Tartu. (Manuscript in the archive of the Department of Archaeology of the University of Tartu.)
- Valk, H.** 1995. Tartu toomkiriku kalmistust ja ümbruskonna varasemast asustusest. – Tartu arheoloogiast ja vanemast ehitusloost. Artiklite kogumik. Ed. H. Valk. (Tartu Ülikooli arheoloogia kabineti toimetised, 8.) Tartu Ülikooli kirjastus, Tartu, 59–80.
- Valk, H.** 2004. Artefacts in Estonian urban churchyards: reflections on different traditions and ideologies. – *Der Ostseeraum und Kontinentaleuropa 1100–1600. Einflußnahme–Rezeption–Wandel*. Eds D. Kattinger, J. Olesen & H. Wernicke. (CCC Papers, VIII.) Thomas Helms Verlag, Schwerin, 103–112.
- Valk, H., Saage, R., Oks, K. & Sammler, S.** 2022. Archaeological excavations in Tarvastu, castle of the Teutonic Order. – *Archaeological Fieldwork in Estonia 2021*, 113–128.
- Yanin, V. L.** 1998 = **Янин В. Л.** Я послал тебе бересту. Языки русской культуры, Москва.
- Yanin, V. L., Zaliznyak, A. A. & Gippius, A. A.** 2004 = **Янин В. Л., Зализняк А. А. & Гиппиус А. А.** Новгородские грамоты на бересте (из раскопок 1997–2000). Русские словари, Москва.
- Zobel, R.** 1980. Tallinna keskaegsed kindlustused. Valgus, Tallinn.
- Zobel, R.** 2008. Tallinn (Reval) in the Middle Ages. Town Building in the 13th–14th Centuries. Estonian Academy of Arts, Tallinn.

Pihkva päritolu asukad Eesti linnades 13. sajandil arheoloogia andmetel

Andres Tvauri

RESÜMEE

Varaseimad linnad Eestis asutati 13. sajandil pärast Saksa-Taani vallutust ja maa ristiusustamist. Lisaks linnu valitsenud saksa kaupmeestele ja käsitöölistele elas neis arvukalt eestlasi ja skandinaavlasti. Arheoloogilised

allikad näitavad, et 13. sajandi keskel saabus Tartusse, Viljandisse ja Tallinna elanikke ka Pihkva linnast või Pihkvamaalt.

Kõigis neis linnades paiknes pihkvalaste asustuskeskus omaaegse linna äärealal: Tartus tänapäevase Tartu Ülikooli botaanikaaia alal, Viljandis Pikk 4 krundil ja Tallinnas Sulevimägi 4/6 kinnistul. Nende inimeste Pihkva päritolu näitab eelkõige mainitud leiukohtadest saadud suur hulk Pihkva-päraste savinõude katkeid. Kogutud arvukas leiuaines tõestab, et Pihkvast pärit käsitöölised elasid neis paigus perekondadena ja tegelesid savinõude tootmisega (Tartus, Viljandis ja Tallinnas), klaashelmeste valmistamisega (Tartus ja Tallinnas) ning väikeste metallehete valamisega (Tartus). Tartu botaanikaaia 1988.–1991. aasta kaevandi 13. sajandi keskpaiga kihist saadi klaasist käevõrude katkeid, Kiievi lähedal paikneva Ovrutši piirkonnast pärit roosast kiltkivist värtnaketrasid, pliist värtnakeder ja taimornamendiga kaunistatud tinast rõngassõlg, mis on omased eelkõige Kiievi-Vene-ainelisele kultuurile. Samast kihist ja Tallinnast Sulevimägi 4/6 krundilt 13. sajandi kihist leiti katkeid klaasanumatest, mida valmistati Kiievis. Need on vanimad Eestist leitud klaasnõude katked. Leiuaines näitab, et Pihkva päritolu inimesed olid Tartus, Viljandis ja Tallinnas 13. sajandil püsielanikud, mitte külalised. Tallinnas Sulevimäel oli ka pihkvalastele kuulunud õigeusu kirik ja kalmistu. Pihkvalased assimileerusid nende linnade elanikkonda hiljemalt 14. sajandi lõpuks.

15. sajandil püstitati Tallinna Vene tänava äärde novgorodlastele kuulunud Püha Nikolai õigeusu kirik. Tõenäoliselt samal sajandil püstitati Tartus novgorodlaste Püha Jüri ja pihkvalaste Püha Nikolai õigeusu kirikud, mida on ka arheoloogiliselt uuritud. Need olid vene kaupmeeste kirikud ja nende juurde kuulunud kaubahoovid ei omanud seost siin 13. sajandil eksisteerinud pihkvalaste asustusega.

Comparing childhood and adulthood diets in a Viking Age population from the Lejasbitēni cemetery, Latvia: a pilot study

Elīna Pētersone-Gordina 

Institute of Latvian History, Faculty of Humanities, University of Latvia, Kalpaka bulvāris 4, LV-1050 Rīga, Latvia
elina.petersone-gordina@lu.lv

Guntis Gerhards 

Institute of Latvian History, Faculty of Humanities, University of Latvia, Kalpaka bulvāris 4, LV-1050 Rīga, Latvia

Antonija Vilcāne 

Institute of Latvian History, Faculty of Humanities, University of Latvia, Kalpaka bulvāris 4, LV-1050 Rīga, Latvia

Andrew Millard 

Department of Archaeology, Durham University, Dawson Building, South Road, DH1 3LE Durham, United Kingdom

Joanna Moore 

Department of Archaeology, Durham University, Dawson Building, South Road, DH1 3LE Durham, United Kingdom

Janet Montgomery 

Department of Archaeology, Durham University, Dawson Building, South Road, DH1 3LE Durham, United Kingdom

Received 23 December 2025, accepted 30 April 2026, available online 6 September 2026

ABSTRACT

This study examines childhood and adulthood diets in selected individuals from the Iron Age Lejasbitēni cemetery population in Latvia (7th–10th centuries CE). Bone samples for isotope analysis were collected from 12 adult individuals; six had previously available isotope data from M1 root dentine. Bone samples from two non-adult individuals of the chronologically later Liv culture were included for preliminary comparison. Results showed that the Lejasbitēni bone carbon ($\delta^{13}\text{C}$) and nitrogen ($\delta^{15}\text{N}$) values were among the lowest in the region, suggesting a diet dominated by terrestrial C_3 -based resources with low-trophic-level animal protein. Unlike dentine data, bone $\delta^{15}\text{N}$ values were not significantly different between gender groups, indicating a more homogeneous adulthood diet. Higher bone $\delta^{15}\text{N}$ values were not always consistent with rich grave inventories, suggesting no clear correlation between social status and diet. Comparison of bone and dentine values revealed a statistically significant shift towards

lower $\delta^{15}\text{N}$ and higher $\delta^{13}\text{C}$ values in adulthood compared to childhood, indicating significant dietary change across the life course. Four out of five individuals with usable isotope data from both tissues showed a decrease in $\delta^{15}\text{N}$ values, and all five showed an increase in $\delta^{13}\text{C}$ values between childhood (dentine) and adulthood (bone), respectively. These results represent only a small group, and further research is necessary to explore childhood-to-adulthood dietary transitions and links between access to resources and grave goods in the Lejasbitēni population.

KEYWORDS

archaeology, burial customs, gender, age, life course, dietary isotopes, social status.

Introduction

This research focuses on childhood and adulthood diets in selected adult individuals from the Lejasbitēni cemetery population in Latvia (7th–10th centuries CE). Lejasbitēni is one of the few completely excavated Iron Age cemeteries in Latvia. It was located near the modern-day town of Aizkraukle on the right bank of the River Daugava, approximately 90 m from the river (Fig. 1). In 1961–1964, due to the construction of the Pļaviņas hydroelectric plant, the Lejasbitēni cemetery was excavated, uncovering 453 burials. The excavation was led by Vladislavs Urtāns, and it has been dated to the 3rd–10th centuries CE according to archaeological artefacts (Urtāns 1965). The area was permanently flooded after the excavation.



FIG. 1. Map of Latvia showing the location of the Lejasbitēni cemetery. The map in the upper right corner shows the geographic location of Latvia. Maps by Antonija Vilcāne.

The chronology of the Lejasbitēni cemetery corresponds to the second half of the Middle and Late Iron Age in Latvia (Vasks 2018, 28–38), partly overlapping with the period conventionally known as the Viking Age in Scandinavia and neighboring regions (c. 750–1050 CE; Brink & Price 2008). During this period, several Baltic peoples lived in the territory of modern-day Latvia (Vilcāne 2018, 59–84).

The history of the Aizkraukle region suggests that this territory was inhabited by both ancient Baltic peoples (Semigallians, Selonians, and Latgalians) and Baltic Finnic peoples – the predecessors of the Liv culture (Atgāzis 2001). The first burials from the 3rd–5th centuries CE at the Lejasbitēni cemetery may have been interred in several small burial mounds. These have been completely flattened due to anthropogenic activities, and only separate archaeological finds have helped to identify the destroyed graves (Urtāns 1965).

During the 6th–7th centuries CE, the dead were interred in graves organised in a semi-circular pattern around the first burial mounds. Although the grave orientation was thus variable, it was always inverted between male and female gender individuals (Fig. 2). From the 8th century CE onwards, as the cemetery grew, the graves were organised in rows, which were particularly pronounced in the 9th–10th centuries CE. During this period, the characteristic Latgalian inverted grave orientation of the two gender groups was established, with males and females buried with their heads to the east and west, respectively. At Lejasbitēni, there are burials with grave goods characteristic of Selonian and Latgalian cultures (Atgāzis 2001). Calibrated ^{14}C dates suggest that the Lejasbitēni cemetery was predominantly used during the 7th–10th centuries CE, between 610 and 980 cal. CE, with a 68.3% probability (Pētersone-Gordina et al. 2022).

In the western part of the cemetery, there were Liv burials from the end of the 10th to the beginning of the 11th century CE (Fig. 2). The Liv burials in the Lejasbitēni cemetery are distinguished by the cremation rite for adult females, which is atypical of Latgalian practice; grave goods (jewellery, pottery, etc.) characteristically associated with the Liv culture; and their peripheral spatial position, consistent with a later episode of burial activity (Urtāns 1965). Lejasbitēni is geographically the easternmost known area of Liv burials in the Daugava basin (Urtāns 1965). Archaeological data suggest that Liv cemeteries appeared by the River Daugava only in the 10th century CE, and none are known in this area in the centuries before (Mugurēvičs 2006; Vasks 2018).

Although rich in archaeological material, the Lejasbitēni cemetery offers very limited potential for osteological analysis. This is because skeletal remains from this cemetery were collected based on the selection of what were then considered the most informative skeletal elements, which were

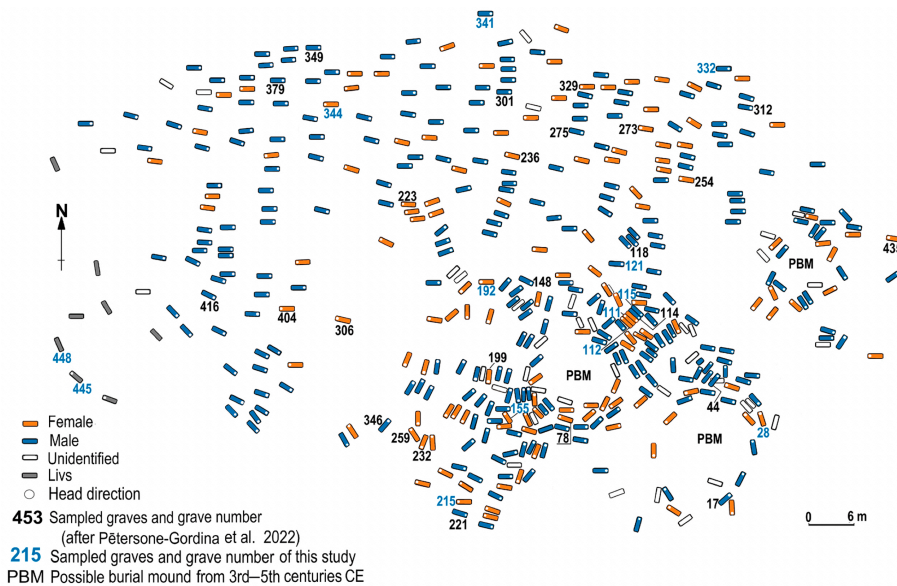


FIG. 2. Plan of the Lejasbitēni cemetery showing burials by gender and burials sampled for isotope analysis, redrawn and supplemented by Vilcāne from Urtāns (1970, 69; fig. 5). The oldest burials in the cemetery are concentrated around the three burial mounds (PBM).

almost exclusively crania and mandibles, including teeth, and occasionally, long bones. Since thorough osteological and palaeopathological analysis of this cemetery population is not possible, most information has so far been obtained through alternative means, including stable isotope, ancient DNA, and amelogenin peptide analyses (Pētersone-Gordina et al. 2022; Ķimsis et al. 2023).

Due to the incomplete nature of the skeletal remains, it has not been possible to estimate biological sex in all adult individuals by osteological analysis. For this reason, throughout this study all individuals will be referred to according to their gender as expressed by grave goods and grave orientation, unless specified otherwise. This approach does not imply that there were only two gender categories in the Lejasbitēni population and accepts that gender might have been a complex concept, as has been pointed out previously (Arnold 2006, 138–140; Moen 2019).

The current pilot study builds on previously acquired archaeological and isotopic evidence from the Lejasbitēni cemetery, which explored whether and how the advance of the Viking Age in Europe might have affected the diet of the Lejasbitēni people of different genders and social statuses, according to grave goods and burial ritual (Pētersone-Gordina et al. 2022). Dentine from the first permanent molar root, representing the age range between three and ten years (Dean & Scandrett 1995; Beaumont & Montgomery 2016), was mainly used for dietary isotope analysis, thus limiting the information

to childhood in non-adults as well as adults (Pētersone-Gordina et al. 2022). It should be noted that bulk dentine analysis integrates isotopic signals over the entire root formation period, thereby averaging short-term dietary fluctuations, including weaning-period stress events (Beaumont & Montgomery 2016; Beaumont et al. 2018). In individuals who died in childhood, the age at death may fall within this formation window, and values may represent a partial rather than complete developmental period.

The aim of the current pilot study is to explore dietary change across the life course in selected adult male and female gender individuals from the Lejasbitēni population by comparing stable carbon and nitrogen isotope data from bone collagen (reflecting adulthood diet) with previously published dentine isotope data (reflecting childhood diet), using data from the same individuals where possible. The following objectives support this aim:

1. To identify and characterise dietary changes across the transition from childhood to adulthood in the Lejasbitēni population;
2. To assess whether the gender-related dietary differences previously documented in childhood are also present in adulthood;
3. To explore whether social status, as expressed by grave goods, correlates with access to dietary resources.

To place the Lejasbitēni bone isotope data in its broader regional context, the results will be compared with published isotope data from broadly contemporary archaeological populations across the eastern Baltic and the wider region.

Stable carbon and nitrogen isotope analysis

Stable carbon ($\delta^{13}\text{C}$) and nitrogen ($\delta^{15}\text{N}$) isotope analysis has become a useful and reliable tool for reconstructing diet in archaeological populations. Information about diet can be obtained by measuring $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values in collagen (Schoeninger et al. 1983), as the body records dietary signals during the deposition of new bone and other body tissues (Fuller et al. 2006; D’Ortenzio et al. 2015). Bone is often used to obtain a dietary average for an individual, but its turnover rate varies considerably depending on the skeletal element and the health, nutrition, activity, and age of the individual (Hedges et al. 2007; Fahy et al. 2017). Thus, to enable comparability, it is important to sample the same skeletal element in all individuals where possible (Beaumont 2020). In contrast, analysing dentine provides information about childhood diet, as teeth form at specific ages and primary dentine, once formed, does not remodel (Dean & Scandrett 1995), locking in dietary information from the period of tooth formation (Fuller et al. 2003; Beaumont and Montgomery 2016). While bone can cease to grow in response to physiological stress (Beaumont et al. 2018; Beaumont 2020), dentine keeps forming even during

undernutrition (Elamin & Liversidge 2013) and can record factors such as breastfeeding, weaning, in-utero stress, and periods of dietary deficiency (Beaumont & Montgomery 2016; Beaumont et al. 2018; King et al. 2018; Crowder et al. 2019).

$\delta^{13}\text{C}$ analysis can be used to detect the presence of plants with different photosynthetic pathways in the diet: C_3 and C_4 plants. C_3 plants (including crops such as wheat, rye, and oats) grow worldwide and have yielded values between -35‰ and -20‰ , while C_4 plants (e.g. millet) mainly originate from warm, arid regions and have produced values between -14‰ and -9‰ (Katzenberg 2008, 423). In regions where diets are dominated by C_3 plants, such as northern Europe, $\delta^{13}\text{C}$ analysis can detect the contribution of marine resources, which have $\delta^{13}\text{C}$ values between -17.0‰ and -5.0‰ (Schoeninger & DeNiro 1984). Freshwater resources are more difficult to determine in human populations using bulk collagen $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ isotope analysis because of overlap with a terrestrial C_3 plant-based diet, including herbivores and omnivores consuming these resources. It has been suggested that lower $\delta^{13}\text{C}$ values in combination with higher $\delta^{15}\text{N}$ values might indicate the consumption of freshwater resources (Müldner & Richards 2005; Ottalagano & Loponte 2017; Eriksson et al. 2018), although some studies have shown that this might not always be the case, as freshwater resources can have wider-than-expected isotopic ranges (Guiry 2019; Etu-Sihvola et al. 2022). In consumer tissues, $\delta^{13}\text{C}$ values are higher than in the diet, by around 1‰ in flesh and by 5‰ in skeletal tissues (Schoeninger & DeNiro 1984; Bocherens & Drucker 2003).

$\delta^{15}\text{N}$ analysis provides information about the sources of protein in the diet and shows the individual's position in the food chain, or their trophic level (Hedges & Reynard 2007). Organisms at higher trophic levels (e.g. omnivores and carnivores) typically have higher $\delta^{15}\text{N}$ values than those at lower levels (e.g. herbivores), which translates into higher or lower $\delta^{15}\text{N}$ values, respectively, in human populations consuming these resources. In archaeological populations, individuals or population groups with higher bone collagen $\delta^{15}\text{N}$ values compared to the rest of the population have been used as indicators of diets with a higher proportion of animal protein and thus, potentially, higher social status (e.g. Müldner & Richards 2005; Reitsema 2013). However, this relationship is not universal and must be evaluated on a case-by-case basis. During breastfeeding, a baby occupies one trophic level above their mother or wet nurse (Fogel et al. 1989). In skeletal tissue, a dietary shift to a higher trophic level will be expressed as an increase of $2\text{--}5\text{‰}$ (ibid.). Values of $\delta^{15}\text{N}$ can also increase during episodes of physiological or nutritional stress (Mekota et al. 2006; Reitsema & McIlvaine 2014). As mentioned above, several studies have detected short-term dietary changes and episodes of nutritional stress by analysing increments of dentine

in archaeological populations (e.g. Beaumont & Montgomery 2016; Beaumont et al. 2018; King et al. 2018; Crowder et al. 2019; DeWitte et al. 2025).

Materials and methods

The gender of the individuals at Lejasbitēni had been estimated previously by grave goods and orientation. In total, there were 230 adult males, 103 adult females, and 10 adult individuals for whom it was not possible to estimate gender; and 46 non-adult males, 46 non-adult females, as well as six non-adult individuals for whom gender estimation was not possible (Pētersone-Gordina et al. 2022). Biological sex estimation in adult individuals used in this analysis was based on morphological characteristics of the skull (as described in Buikstra & Ubelaker 1994), since no pelvic bones were present. Throughout this study, ‘gender’ refers to the archaeologically attributed category based on the typology of grave goods and burial orientation (Arnold 2006; Moen 2019), while ‘biological sex’ refers to estimates derived from osteological morphology (Buikstra & Ubelaker 1994) or molecular analysis.

To understand what resources the Lejasbitēni human population might have relied on, previously published local archaeological faunal $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values were used as a guide (Gunnarssone et al. 2020).

The primary focus of this study was to explore adulthood diet in individuals with available childhood data from dentine, and this was possible for six individuals (three females and three males; Table 1). Seven adult individuals (including one with available dentine data, LB28) were selected based on grave inventories or mortuary rituals that could be indicative of a particular social status. These comprised five female burials (LB28, LB111, LB112, LB155, and LB215) that contained an axe in their grave inventory; a richly furnished male burial (LB341); and another male burial (LB115). One of the female burials (LB215) contained an axe with a decorative bronze strip wound around the handle. Only 30 such axes (four of them in female gender burials) have been found in the territory of Latvia, mainly in the Latgalian and Selonian territories (Gerhards et al. 2024). The assessment of social status followed the established tradition in Latvian Iron Age archaeology, in which the richness and rarity of grave goods serve as the primary criteria for status attribution (Gerhards 2002; Gerhards et al. 2024). No formal quantitative scoring system was applied; individuals were classified as richly furnished based on items rare in the Lejasbitēni assemblage (Pētersone-Gordina et al. 2022). By selecting individuals with rich or unusual grave inventories, we intended to explore any potential status-related differences in diet within this small group.

Finally, two non-adult individuals thought to date from the 11th century CE Liv culture from the periphery of the cemetery were sampled to complement the dataset from the Lejasbitēni cemetery. The reason for their inclusion was to provide a point of dietary comparison with the chronologically earlier and ethnically distinct Lejasbitēni population. Since the Liv adult individuals at Lejasbitēni were cremated, bone collagen isotope analysis of adults from this group is not possible, meaning that the non-adults represent the only available biological material from this population at the site. Moreover, there are currently no isotope data from any other Liv population in Latvia that could be used for comparison. These results are discussed separately in Subsection 'Adulthood and childhood diet at Lejasbitēni' and are not included in the primary statistical analyses.

In total, dietary isotope analysis was carried out on bone samples from 12 adult individuals (seven females and five males; Table 1) and two non-adults. Poor preservation of skeletal material and the lack of post-cranial bones prevented the sampling of fragments from the same bone, with the selected samples including femora and hand phalanges, but mostly different bones of the skull (Table 1). Because of the selection of bone samples with differential turnover rates in this study, we acknowledge that the data obtained from this assemblage might not be comparable with respect to the time of life represented by the data. While this sample selection strategy is extremely limited in terms of population-level analysis, it provides valuable individual data from the people buried in the Lejasbitēni cemetery.

The documentation of the excavations, as well as all artefacts, is curated and is available for scientific research at the National History Museum of Latvia. The skeletal material from Lejasbitēni is curated at the Repository of Bioarchaeological Material, Institute of Latvian History, University of Latvia.

For the stable isotope analysis, bone samples were cleaned and abraded to a depth of >100 µm using a tungsten carbide dental drill. Collagen extraction was carried out using the method of O'Connell & Hedges (1999), briefly summarised here: unpowdered bone and dentine samples (c. 400 mg) were demineralised in refrigerated 0.5M HCl for several weeks and then thoroughly washed in Millipore Alpha Q water before gelatinisation in a pH 3 solution of HCl at 70 °C for 48 hours. The samples were then Eze-filtered, frozen, and freeze-dried before being sent to the University of Bradford for analysis. At Bradford, samples and reference material (c. 0.3–0.5 mg) were weighed into tin capsules and introduced to the EA IsoLink™ via a MAS 200 autosampler (Thermo Fisher Scientific), alongside a pulse of oxygen to aid combustion. The combusted gases were then carried in a helium stream over a single quartz reactor column containing combustion catalysts (silvered cobaltous oxide and chromium oxide) and a reduction phase of high-purity copper wires to produce N₂, CO₂, and water. Water was removed using a

water trap (magnesium perchlorate). The resulting gases were then separated on a GC column held at a constant temperature of 40 °C and were then transferred to a DELTA V™ Advantage isotope ratio mass spectrometer via a ConFlo IV Universal interface, where they were ionised and accelerated. Gas species of different masses were separated in a magnetic field, then simultaneously measured on a Faraday cup universal collector array. Analysis was based on monitoring of m/z 28 and 29 for N_2 , then m/z 44, 45, and 46 for CO_2 .

The results were calibrated against both internal and international standards that were run at the same time as the samples. The samples were batch processed, and standards were run at the start and end of the sequence to check for drift. One duplicate was run for every ten samples. Only one sample (LB112; Table 1) from this batch of samples was analysed in duplicate. The internal lab standards used for carbon and nitrogen isotopes were Bovine Liver ($\delta^{13}C_{v-PDB} = -21.59$; $\delta^{15}N_{v-AIR} = +7.65$) and Fish Gel ($\delta^{13}C_{v-PDB} = -15.52$; $\delta^{15}N_{v-AIR} = +14.25$). These in-house standards are calibrated against and traceable to inter-laboratory comparison standards distributed by the International Atomic Energy Agency (IAEA) with internationally accepted values: IAEA 600 ($\delta^{13}C_{v-PDB} = -27.77$; $\delta^{15}N_{v-AIR} = +1$), IAEA CH3 ($\delta^{13}C_{v-PDB} = -24.72$), IAEA N1 ($\delta^{15}N_{v-AIR} = +0.40$), and IAEA N2 ($\delta^{15}N_{v-AIR} = +20.41$). The analytical error for carbon and nitrogen isotopes is $\leq 0.2\text{‰}$.

Bone and comparative dentine samples from previous research were processed using an identical collagen extraction protocol (O'Connell & Hedges 1999) at the same laboratory (Durham University). The mass spectrometric analysis of the previous dentine samples was, however, performed at Durham University, while the bone samples from this study were analysed at the University of Bradford. Both laboratories use continuous-flow isotope ratio mass spectrometry and are calibrated against the same international standards (IAEA). The expected inter-laboratory variability for well-calibrated facilities is typically $\leq 0.2\text{‰}$ for both $\delta^{13}C$ and $\delta^{15}N$, which is within the analytical error reported in both studies and is considerably smaller than the observed differences between dentine and bone values. Collagen quality indicators (carbon and nitrogen content, atomic C:N ratio) for both tissue types fall within accepted ranges (DeNiro 1985) and are reported in Table 1. The observed isotopic differences between bone and dentine are therefore attributed to genuine biological differences reflecting distinct tissue formation periods, rather than methodological artefacts (Szpak et al. 2017; Roberts et al. 2018).

Because of the small sample size, a two-tailed t-test was used to calculate statistical differences between adult male and female $\delta^{15}N$ and $\delta^{13}C$ values. The same test was applied to calculate differences between adulthood and childhood diets using results from the previous dietary analysis from dentine.

Both results were then confirmed with a non-parametric Mann–Whitney U-test. A Wilcoxon signed-rank test was applied to calculate the differences between dentine and bone values in the five individuals with both sets of data available.

Results

The results of the dietary stable isotope analysis are presented in Table 1 and Fig. 3. Sample LB114 had an atomic C:N ratio (4.8) outside the acceptable range (2.9–3.6; DeNiro 1985) and was not included in further analysis. The bone sample of individual LB112 was measured in duplicate, and for further analysis, the mean $\delta^{15}\text{N}\text{‰}$ and $\delta^{13}\text{C}\text{‰}$ values of the two measurements were used (9.03‰ and –21.70‰, respectively). The Liv burials are reported at the bottom of Table 1.

The mean, minimum, and maximum $\delta^{15}\text{N}$ (‰) and $\delta^{13}\text{C}$ (‰) values for all the other samples are presented in Table 2.

There were no statistically significant differences in $\delta^{15}\text{N}$ values between the adult males ($N = 4$, $M = 9.4\text{‰}$, $SD = 0.8\text{‰}$) and females ($N = 7$, $M = 9.0\text{‰}$, $SD = 0.4\text{‰}$) from the Lejasbitēni group, although the sample size for males was very small ($t(9) = -0.96$, $p = 0.360$, Cohen's $d = 0.60$). Likewise, the differences in $\delta^{13}\text{C}$ values between males ($M = -21.7\text{‰}$, $SD = 0.1\text{‰}$) and females ($M = -21.8\text{‰}$, $SD = 0.3\text{‰}$) were not significant ($t(9) = 0.70$, $p = 0.504$, Cohen's $d = 0.44$). The lack of significance was confirmed by a Mann–Whitney U-test for $\delta^{15}\text{N}$ values ($U = 10$, $p = 0.450$) and $\delta^{13}\text{C}$ values ($U = 9$, $p = 0.345$). The Liv non-adults were excluded from this comparison, as they belong to a different archaeological population group.

Comparative analysis revealed that the results from adult bone samples were significantly different from the dentine samples in this population, both in terms of their $\delta^{15}\text{N}$ values ($N = 12$, $M = 8.9\text{‰}$ and $N = 29$, $M = 9.9\text{‰}$, respectively, $t(38) = -3.00$, $p = 0.005$, Cohen's $d = 1.06$) and $\delta^{13}\text{C}$ values ($M = -21.8\text{‰}$ and $M = -22.7\text{‰}$, respectively, $t(38) = 6.30$, $p < 0.001$, Cohen's $d = 2.23$). The significant differences were confirmed by the Mann–Whitney U-test ($U = 58.50$, $p = 0.002$ for $\delta^{15}\text{N}$ values and $U = 10.00$, $p < 0.001$ for $\delta^{13}\text{C}$ values).

Four of the five adult individuals for whom childhood (dentine) and adulthood (bone) dietary data were available showed a shift from higher to lower $\delta^{15}\text{N}$ values, respectively, while the male gender individual from burial 332 had a slightly lower dentine $\delta^{15}\text{N}$ value than bone $\delta^{15}\text{N}$ value (10.3‰ and 10.5‰, respectively; Fig. 4). The shift from lower to higher $\delta^{13}\text{C}$ values in dentine compared to bone, however, was the same in all five individuals. The difference between bone and dentine in this small group was calculated with

TABLE 1. Individuals selected from the Lejasbitēni population and results of carbon and nitrogen stable isotope analysis

Burial No.	Gender	Age	Grave orientation (head first)	Sample type	$\delta^{15}\text{N}_{\text{V. AIR}} (\text{‰})$	$\delta^{13}\text{C}_{\text{V. PDB}} (\text{‰})$	%N	%C	C/N
LB28*^	F	20–25	NW–SE	Femur	8.7	–22.2	13.3	39.7	3.5
				M ¹ dentine	9.3	–22.7	15.3	41.2	3.2
LB111^	F	>40	NW–SE	Parietal	9.2	–21.7	13.9	39.0	3.3
LB112a^	F	18+	NW–SE	Mandible	9.0	–21.8	13.4	37.9	3.3
LB112b^					9.0	–21.6	13.5	38.1	3.3
LB114*	M	>30	SE–NW	Parietal	5.9	–23.2	6.7	2.8	4.8
				M ¹ dentine	9.6	–22.7	15.6	42.9	3.2
LB115	M		SE–NW	Frontal	8.8	–21.9	6.3	18.4	3.4
LB155^	F	16–18	NW–SE	Hand phalanx	8.8	–21.6	11.8	34.4	3.4
LB199*	F	25–30	SW–NE	Mandible	8.6	–21.9	12.6	35.9	3.3
				M ₁ dentine	8.8	–22.6	15.0	42.9	3.2
LB215^	F	>30	W–E	Hand phalanx	9.2	–21.4	13.9	38.8	3.2
LB221*	M	45–50	E–W	Mandible	9.2	–21.6	8.0	23.5	3.4
				M ¹ dentine	9.3	–22.2	15.5	43.1	3.2
LB332*	M	55–65	E–W	Zygomatic	10.5	–21.7	12.8	36.9	3.4
				M ₁ dentine	11.4	–22.0	15.5	42.8	3.2
LB341	M	30–35	E–W	Femur	9.0	–21.6	13.3	38.7	3.4
LB344*	F	45–50	W–E	Parietal	9.8	–21.9	12.3	36.6	3.5
				M ₁ dentine	10.0	–23.2	15.5	42.7	3.2
LB445**	M	10–11	NW–SE	Parietal	10.2	–21.5	13.7	38.9	3.3
LB448**	M	7–8	NW–SE	Parietal	10.1	–21.5	14.1	39.8	3.3

* Individuals with available carbon and nitrogen isotope data from dentine (Pētersone-Gordina et al. 2022); ** Liv culture non-adult individuals; ^ – axe in grave inventory; %N – nitrogen content; %C – carbon content; C/N – atomic C:N ratio; M¹ – maxillary first molar; M₁ – mandibular first molar

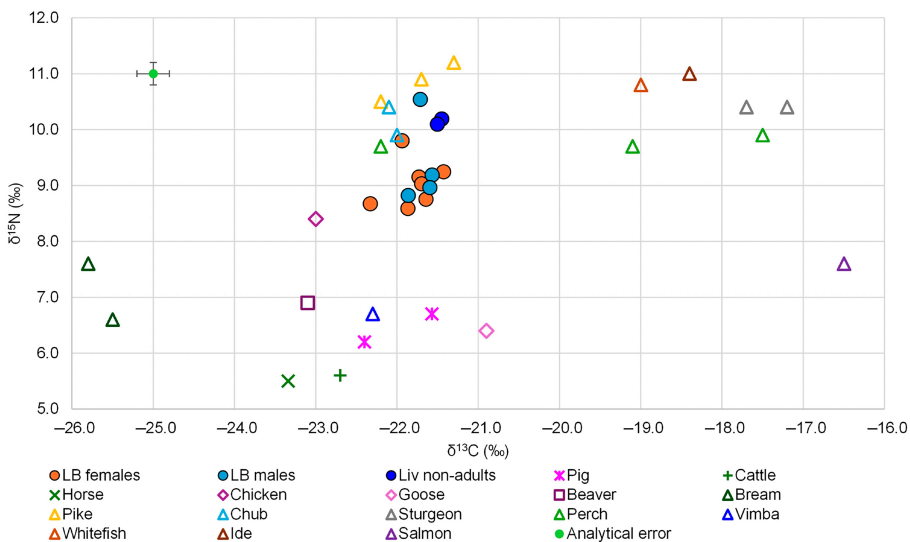


FIG. 3. Lejasbitēni (LB) male and female, and Liv non-adult isotope bone values obtained during this study (see Table 1 for bone elements sampled), along with previously published faunal data from Gunnarssone et al. (2020), including domestic animals (two pigs, a cow, and a horse), birds (a chicken and a goose), a beaver from Aizkraukle, and several freshwater (bream, chub, and pike), freshwater/brackish (perch, whitefish, and ide), migratory (vimba and sturgeon), and marine Baltic (salmon) fish from Daugmale, with both archaeological sites (Aizkraukle and Daugmale) located next to the River Daugava. Analytical error ($\leq 0.2\text{‰}$) is shown in the upper left corner of the graph.

a Wilcoxon signed-rank test and proved to be statistically significant both in terms of $\delta^{15}\text{N}$ values ($N = 5$, $M = 9.4\text{‰}$ (bone) and $M = 9.8\text{‰}$ (dentine), $W = 0.00$, $p = 0.043$) and $\delta^{13}\text{C}$ values ($M = -21.9\text{‰}$ (bone) and $M = -22.5\text{‰}$ (dentine), $W = 0.00$, $p = 0.043$).

When compared within the same gender groups, the difference between the mean dentine and bone $\delta^{15}\text{N}$ values was more pronounced in males (1.1‰, 10.4‰, and 9.4‰, respectively) than in females (0.4‰, 9.4‰, and 9.0‰, respectively). In fact, the mean male bone $\delta^{15}\text{N}$ value was almost identical to the mean female dentine $\delta^{15}\text{N}$ value. With regard to $\delta^{13}\text{C}$ values, the difference between the mean dentine and bone values in males was 0.8‰ (-22.5‰ and -21.7‰ , respectively), while in females it was 1.0‰ (-22.8‰ and -21.8‰ , respectively), reaching one trophic level (Fig. 4). Female bone $\delta^{15}\text{N}$ values were not significantly lower than dentine values when calculated by a t-test ($N = 7$, $M = 9.0\text{‰}$ and $N = 15$, $M = 9.4\text{‰}$, respectively, $t(20) = -2.03$, $p = 0.056$, Cohen's $d = 0.93$), but the difference was significant by Mann–Whitney U-test ($U = 24.50$, $p = 0.048$), while male bone values were significantly lower than dentine values according to both tests ($N = 4$, $M = 9.4\text{‰}$ and $N = 14$, $M = 10.4\text{‰}$, $t(16) = -2.78$, $p = 0.014$, Cohen's

TABLE 2. Mean, standard deviation, minimum, and maximum $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ values for Lejasbitēni bone samples from adult individuals and previously published dentine samples

Gender	Sample size	Mean		Standard deviation		Minimum		Maximum	
		$\delta^{15}\text{N}$ (‰)	$\delta^{13}\text{C}$ (‰)	$\delta^{15}\text{N}$ (‰)	$\delta^{13}\text{C}$ (‰)	$\delta^{15}\text{N}$ (‰)	$\delta^{13}\text{C}$ (‰)	$\delta^{15}\text{N}$ (‰)	$\delta^{13}\text{C}$ (‰)
Bone (adulthood values)									
Male	4	9.4	−21.7	0.8	0.1	8.8	−21.9	10.5	−21.6
Female	7	9.0	−21.8	0.4	0.3	8.6	−22.3	9.8	−21.4
Overall	11	9.3	−21.7	0.6	0.2	8.6	−22.3	10.5	−21.4
Dentine (childhood values)*									
Male	14	10.4	−22.5	0.6	0.4	9.3	−23.2	11.5	−22.0
Female	15	9.4	−22.8	0.4	0.5	8.8	−23.6	10.0	−21.7
Overall	29	9.9	−22.7	0.7	0.5	8.8	−23.6	11.5	−21.7

* Data from Pētersone-Gordina et al. (2022)

$d = 1.57$ and $U = 8.00$, $p = 0.034$). In contrast, the $\delta^{13}\text{C}$ values were significantly higher in bone than dentine samples both in males, according to both statistical tests ($N = 4$, $M = -21.7\text{‰}$ and $N = 14$, $M = -22.5\text{‰}$, respectively, $t(16) = 4.26$, $p < 0.001$, Cohen's $d = 2.42$ and $U = 0.00$, $p = 0.003$) and females ($N = 7$, $M = -21.8\text{‰}$ and $N = 15$, $M = -22.8\text{‰}$, respectively, $t(20) = 5.30$, $p < 0.001$, Cohen's $d = 2.43$ and $U = 4.00$, $p < 0.001$) (Fig. 4).

Discussion

ADULTHOOD AND CHILDHOOD DIET AT LEJASBITĒNI

Bone values in the Lejasbitēni adult population are characterised by comparatively low $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values, which point to a diet mainly comprising terrestrial resources based on C_3 crops and a small proportion of domestic animal proteins such as meat and dairy. In particular, the $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values for the cow and horse were, respectively, 1.1‰ and 3.3‰ lower than the mean human bone values, indicative of a trophic-level shift. The inclusion of some aquatic resources cannot be ruled out, based on the highly variable $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values of local fish, as shown by previously published values from Latvia (Gunnarssone et al. 2020; Fig. 3). To understand whether aquatic resources were indeed used in the Lejasbitēni population, and how

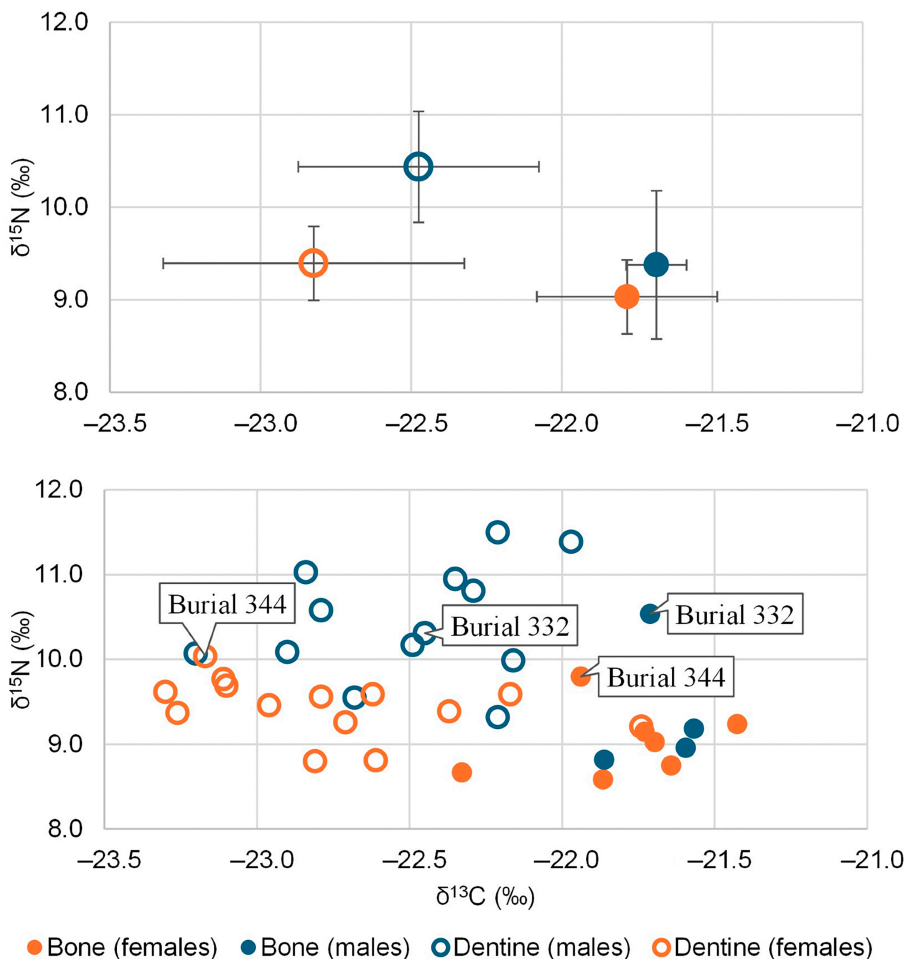


FIG. 4. Lejasbitēni male and female mean dentine and bone values ± 1 SD (upper graph) and individual bone and dentine values (lower graph).

important they were as a resource, compound-specific isotope analysis is necessary.

To identify differences in childhood and adulthood diets, the values obtained from bone during this study were compared with previously acquired dentine values, testing for statistical differences between the two sets of results (Fig. 4). Overall, the bone $\delta^{15}\text{N}$ values were significantly lower and $\delta^{13}\text{C}$ values significantly higher compared with those from dentine. In the two gender groups, the difference between bone and dentine $\delta^{15}\text{N}$ values was more pronounced in males than in females, while the difference between bone and dentine $\delta^{13}\text{C}$ values was pronounced in both gender groups. The same trend was observed in the five adult individuals for whom both sets of data were available, with the exception of the male gender individual from

burial 332, whose dentine and bone $\delta^{15}\text{N}$ values remained similarly high, while the bone $\delta^{13}\text{C}$ value demonstrated a similar shift to that observed in other individuals from this group.

The key finding of the previous study about childhood diet in this population was that during the Viking Age, male gender non-adults had significantly higher $\delta^{15}\text{N}$ values and thus likely access to sources of higher-trophic-level protein compared with female gender non-adults, indicating that the source of protein in the diet during childhood was linked to gender. Since the human $\delta^{13}\text{C}$ values from dentine were similar to those of the domestic fauna, without demonstrating a trophic-level shift of 1‰, it was suggested that dietary sources with lower $\delta^{13}\text{C}$ values, such as freshwater organisms, were present in non-adults' diets. However, no childhood dietary differences were observed between individuals of different social status within the same gender group (Pētersone-Gordina et al. 2022).

The present study has demonstrated that, unlike in dentine, there were no statistically significant differences in either $\delta^{15}\text{N}$ or $\delta^{13}\text{C}$ bone values between gender groups, suggesting that in adulthood, both gender groups had access to similar sources of protein.

The isotopic trajectories from dentine to bone therefore suggest that the dietary differentiation observed in childhood did not persist into adulthood, and that individuals of both gender groups converged on a broadly similar diet dominated by terrestrial domesticated animals. This pattern may reflect a change in the subsistence resources available or consumed across the life course, or alternatively a relaxation of gender-based dietary distinctions, as individuals transitioned from childhood to adulthood. The transition to the adulthood diet was especially pronounced in male gender individuals, who appear to have had access to higher-trophic-level protein during childhood. Because the sample size is so small, it is possible that isotope analysis of bone in more individuals from this population, and preferably from individuals with already available dentine isotope values, will reveal more variation in the transition from childhood to adulthood diet.

Regarding the potential link between social status and diet, the highest bone $\delta^{15}\text{N}$ values were observed in individuals LB332 (a male) and LB344 (a female) (Fig. 4). Individual LB344 had the highest dentine $\delta^{15}\text{N}$ value among the tested female gender individuals, and the bone value was also the highest in the female gender group. Individual LB332 had a close-to-mean dentine $\delta^{15}\text{N}$ value, but the highest bone $\delta^{15}\text{N}$ value in the male gender group and overall (Fig. 4). Both individuals had richly furnished graves. In contrast, five female gender individuals who were buried with an axe (burials LB28, LB111, LB112, LB155, and LB215) and the richly furnished male burial LB341 all had close-to-mean $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ values, which formed a cluster with most other analysed individual values (Fig. 4). The lack of a clear pattern

suggests that in this group of adult individuals, social status as expressed by grave goods might not have been related to access to resources. To test whether any individuals with higher or lower isotope values might have been non-local, including from a neighbouring community, incremental dentine $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ and enamel strontium isotope analyses would be necessary.

As to why there were significant dietary differences observed between the gender groups in childhood, but not in adulthood in the Lejasbitēni population, the demographic profile might provide a clue. In this cemetery, the number of male gender burials is twice that of female gender, and the number of adult burials far exceeds that of non-adults (Pētersone-Gordina et al. 2022). Such deviation from the expected demographic profile of a living population is commonplace in most Latgalian cemeteries from the 7th–10th centuries CE. Researchers have suggested that these common burial places were only reserved for individuals with a particular social status (Gerhards 2002). In this pilot study, dietary isotope analysis included five females who were buried with an axe, which is a very rare item in female gender burials (Table 1; Fig. 5). There were no statistically significant differences in bone isotope values between the Lejasbitēni females who had an axe in their grave inventory ($N = 5$) and males ($N = 4$), either in their $\delta^{15}\text{N}$ values ($M = 9.0\text{‰}$ and $M = 9.4\text{‰}$, respectively, $t = -1.11$, $p = 0.304$, Cohen's $d = 0.74$) or $\delta^{13}\text{C}$ values ($M = -21.7\text{‰}$ and $M = -21.7\text{‰}$, $t = -0.30$, $p = 0.771$, Cohen's $d = 0.20$). Due to the insufficient dietary isotope data from other female gender individuals in the cemetery, however, it is not clear whether the currently observed lack of adulthood dietary differences between gender groups applied only to selected individuals or to the whole adult population at Lejasbitēni. This will be explored in an upcoming study.

Finally, comparison between the mean bone values of the two Liv non-adults and the previously published Lejasbitēni dentine values suggests dietary differences between the two groups. Their mean bone $\delta^{15}\text{N}$ value (10.1‰) fell between the mean male (10.4‰) and female gender (9.4‰) Lejasbitēni dentine values, although both differences were below 1‰ and thus considerably short of one trophic level. The mean Liv bone $\delta^{13}\text{C}$ value (-21.5‰) was 1.0‰ and 1.3‰ higher than the mean male and female Lejasbitēni dentine values (-22.5‰ and -22.8‰ , respectively), a difference equivalent to approximately one trophic level. The combination of $\delta^{15}\text{N}$ values broadly comparable to the Lejasbitēni population but notably higher $\delta^{13}\text{C}$ values suggests that the Liv non-adults had access to a different protein source, such as freshwater resources or terrestrial animals with different isotopic baselines, rather than simply consuming more or less protein overall. However, given the sample size of only two individuals, these observations are preliminary and should be interpreted with caution.



FIG. 5. Grave inventory of female gender burial LB215 from the Lejasbitēni cemetery. The artefacts are stored in the National History Museum of Latvia (LNVM A11912). Photo by Antonija Vilcāne.

COMPARISON OF THE LEJASBITĒNI BONE AND DENTINE ISOTOPE DATA WITH OTHER LOCAL AND REGIONAL SITES

To place the Lejasbitēni isotope data in a wider context, it is necessary to compare them with broadly contemporary local and regional archaeological populations. The mean Lejasbitēni bone $\delta^{15}\text{N}$ value (9.3‰) is slightly higher than that from the contemporary Čunkāni-Dreņģeri cemetery from Zemgale ($N = 29$, $M = 8.9\text{‰}$; Pētersone-Gordina et al. 2023), and slightly lower than that of the rural 13th–15th-century Siksali site in Estonia ($N = 16$, $M = 9.6\text{‰}$; Agurauja-Lätti & Malve 2023); the Siksali population is thought to have retained Iron Age traditions well into the medieval period (Valk & Laul 2014), and according to the interpretation of recent isotopic data, its diet was based almost entirely on terrestrial resources (Agurauja-Lätti & Malve 2023). The mean Lejasbitēni bone $\delta^{15}\text{N}$ value is also comparable with the mean bone value of the Estonian Iron Age population of Kukruse ($N = 10$, $M = 10.0\text{‰}$), where pottery lipid compound-specific stable isotope analysis

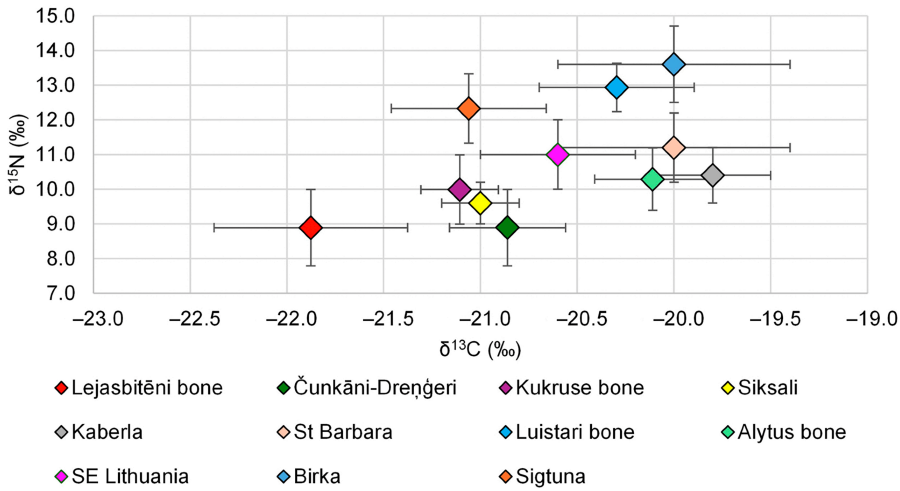


FIG. 6. Lejasbitēni bone values against the mean bone values ± 1 SD of comparative sites in Čunkāni-Dreņģeri, Latvia ($N = 29$, 7th–11th centuries CE; Pētersone-Gordina et al. 2023); Alytus, Lithuania ($N = 35$, 14th–18th centuries CE; Whitmore et al. 2019), three barrow sites in SE Lithuania ($N = 3$, 3rd–5th centuries CE; Bliujienė et al. 2020); Kukruse ($N = 10$, 12th–13th centuries CE; Oras et al. 2018), Siksali ($N = 16$, 13th–15th centuries CE; Agurauja-Lätti & Malve 2023), Kaberla ($N = 29$, 12th–16th centuries CE; Agurauja-Lätti & Lõugas 2019), and St Barbara, Estonia ($N = 30$, 12th–16th centuries CE; *ibid.*); Luistari, Finland ($N = 23$, 7th–11th centuries CE; Etu-Sihvola et al. 2022); Birka ($N = 19$, 8th–9th centuries CE; Linderholm et al. 2008) and Sigtuna, Sweden ($N = 76$, 12th–14th centuries CE; Kjellström et al. 2009).

(CSIA) detected evidence for aquatic (marine and freshwater) resource use in ceramic vessel contents (Oras et al. 2018); the elevated mean bone $\delta^{15}\text{N}$ value (10.0‰) is broadly consistent with this inference, though the CSIA evidence derives from ceramic vessels rather than human tissues directly.

In other regional archaeological sites with mainly C_3 food-chain diets, the mean bone $\delta^{15}\text{N}$ values were higher, including those from Alytus, Lithuania ($N = 35$, $M = 10.3\text{‰}$; Whitmore et al. 2019) and three barrow sites from SE Lithuania ($N = 3$, $M = 11.0\text{‰}$; Bliujienė et al. 2020), and the Estonian sites of Kaberla ($N = 29$, $M = 10.4\text{‰}$; Agurauja-Lätti & Lõugas 2019) and St Barbara ($N = 30$, $M = 11.2\text{‰}$; *ibid.*). In broadly contemporary sites further afield, with diets likely comprising a higher proportion of aquatic resources, bone $\delta^{15}\text{N}$ values were higher still, for example, in the Finnish site of Luistari ($N = 23$, $M = 12.0\text{‰}$; Etu-Sihvola et al. 2022), and the Swedish sites of Birka ($N = 19$, $M = 13.6\text{‰}$; Linderholm et al. 2008) and Sigtuna ($N = 76$, $M = 12.33\text{‰}$; Kjellström et al. 2009) (Fig. 6).

In contrast, the mean $\delta^{13}\text{C}$ values in all comparative sites used in this study were higher than those at Lejasbitēni (-21.9‰), including those from the contemporary Čunkāni-Dreņģeri cemetery (-20.9‰ ; Pētersone-Gordina

et al. 2023), as well as the Estonian sites of Siksali (−21.0‰; Agurauja-Lätti & Malve 2023) and Kukruse (−21.1‰; Oras et al. 2018), and also that from the Swedish site of Sigtuna (−21.1‰; Kjellström et al. 2009), although the difference with these sites was less than 1‰. In all other comparative sites, the mean $\delta^{13}\text{C}$ bone values were at least 1‰ higher than those at Lejasbitēni. Altogether, the lower mean $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ values in the Lejasbitēni individuals compared with most other populations likely indicate that they mainly relied on low-trophic-level protein and insignificant amounts of marine or brackish-water fish. The possible explanations for the exceptionally low mean $\delta^{13}\text{C}$ value at Lejasbitēni (−21.9‰) are as follows: (1) the canopy effect, whereby domestic cattle grazed in forested areas – ancient and modern wild herbivores foraging under a closed canopy have yielded lower $\delta^{13}\text{C}$ values than those grazing in open areas (e.g. Drucker et al. 2008); (2) the complete absence of C_4 resources (notably millet), consistent with the very low values observed, as millet consumption typically raises $\delta^{13}\text{C}$ above −20‰ (Katzenberg 2008; Danielisova et al. 2025); and (3) unusual local faunal isotope baselines reflecting specific ecological conditions in the Daugava floodplain environment. To explore this possibility, a systematic isotopic study of contemporary local domestic fauna is necessary.

Three regional sites had available data from both dentine and bone, including Kukruse in Estonia (Oras et al. 2018), Luistari in Finland (Etu-Sihvola et al. 2022), and Alytus in Lithuania (Whitmore et al. 2019). Further afield, data were available from Mikulčice, the Czech Republic (9th–10th centuries CE; Jílková et al. 2019), and Solt-Tételhegy, Hungary (13th century CE; Gugora et al. 2018). These comparative populations revealed a wide variety of childhood and adulthood diets, rather than specific trends. Differences between childhood and adulthood diets were observed in all comparative populations except for the mean dentine and bone $\delta^{15}\text{N}$ values in Alytus, which were almost identical (Whitmore et al. 2019), and the observed differences were dependent on the type of tooth sampled, geographic location, and available resources (e.g. diets dominated by C_3 and C_4 plants, terrestrial and/or aquatic resources), the local traditions of weaning, as well as factors such as social status and biological sex, among many others. To understand what factors might have influenced the shift from childhood to adulthood diet at Lejasbitēni, more data are necessary from the rest of the population, as the current results are based only on selected individuals.

Conclusions

This pilot study has achieved its aim of comparing childhood and adulthood diets in selected individuals from the Lejasbitēni population. Comparison of bone collagen isotope data obtained during this study with previously

published dentine isotope data revealed a statistically significant shift towards lower $\delta^{15}\text{N}$ and higher $\delta^{13}\text{C}$ values in adulthood, indicating a change in the trophic level of animal protein consumed and a diet more clearly dominated by domesticated terrestrial animals across the life course in the Lejasbitēni population. Unlike dentine data, bone $\delta^{15}\text{N}$ values were not significantly different between gender groups, suggesting a more homogeneous diet in adulthood. This may reflect the fact that this cemetery was reserved for individuals of a particular social status, as supported by the highly uneven ratio of adult male to female gender burials.

Higher bone $\delta^{15}\text{N}$ values were not always consistent with rich grave inventories, suggesting that social status as expressed by grave goods did not clearly correlate with access to dietary resources in this group. The low $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ bone values place Lejasbitēni among the lowest in the wider region, consistent with a diet based primarily on C_3 terrestrial resources with no detectable marine contribution. Preliminary isotope data from two Liv culture non-adults buried at the periphery of the cemetery suggest dietary differences from the main Lejasbitēni population, though the very small sample size precludes firm conclusions.

As this study is based on a small and selected group of individuals, further research is necessary to establish whether these patterns apply to the broader Lejasbitēni population and to clarify the relationship between life-course dietary change, gender, and social status.

DATA AVAILABILITY STATEMENT

All data are included within the paper.

ACKNOWLEDGEMENTS

We would like to thank the National History Museum of Latvia for permission to use the Lejasbitēni cemetery grave goods for this study. We also thank the anonymous reviewers who have considerably improved this paper with their comments. This research was funded by the Latvian Council of Science, project No. lzp-2022/1-0059. The publication costs of this article were partially covered by the Estonian Academy of Sciences.

References

- Agurauja-Lätti, Ü. & Lõugas, L.** 2019. Stable isotope evidence for medieval diet in urban and rural northern Estonia. – *Journal of Archaeological Science: Reports*, 26, 101901. <https://doi.org/10.1016/j.jasrep.2019.101901>
- Agurauja-Lätti, Ü. & Malve, M.** 2023. Dietary habits in medieval and early modern Estonia: evidence from stable isotope analysis. – *Estonian Journal of Archaeology*, 27: 3S, 144–164. <https://doi.org/10.3176/arch.2023.3S.07>
- Arnold, B.** 2006. Gender in mortuary ritual. – *Reader in Gender Archaeology*. Ed. S. M. Nelson. AltaMira, Walnut Creek, 137–170.

- Atgāzis, M.** 2001. Vidējais dzelzs laikmets, 400–800. g. – Latvijas senākā vēsture. Eds J. Apals, M. Atgāzis, J. Graudonis, I. Loze, Ē. Mugurēvičs, A. Vasks et al. Latvijas vēstures institūta apgāds, Rīga, 232–289.
- Beaumont, J.** 2020. The whole tooth and nothing but the tooth: or why temporal resolution of bone collagen may be unreliable. – *Archaeometry*, 62: 3, 626–645. <https://doi.org/10.1111/arc.12544>
- Beaumont, J. & Montgomery, J.** 2016. The Great Irish Famine: identifying starvation in the tissues of victims using stable isotope analysis of bone and incremental dentine collagen. – *PLoS One*, 11: 8, e0160065. <https://doi.org/10.1371/journal.pone.0160065>
- Beaumont, J., Atkins, E.-C., Buckberry, J., Haydock, H., Horne, P., Howcroft, R. et al.** 2018. Comparing apples and oranges: why infant bone collagen may not reflect dietary intake in the same way as dentine collagen. – *American Journal of Biological Anthropology*, 167: 3, 524–540. <https://doi.org/10.1002/ajpa.23682>
- Bliujienė, A., Skipitytė, R., Garbaras, A., Miliauskienė, Ž., Šapolaitė, J., Ežerinskis, Ž. et al.** 2020. The first data on the human diet in Late Roman and Early Migration period western Lithuania: evidence from stable isotope, archaeobotanical and zooarchaeological analyses. – *Journal of Archaeological Science: Reports*, 33, 102545. <https://doi.org/10.1016/j.jasrep.2020.102545>
- Bocherens, H. & Drucker, D.** 2003. Trophic level isotopic enrichment of carbon and nitrogen in bone collagen: case studies from recent and ancient terrestrial ecosystems. – *International Journal of Osteoarchaeology*, 13: 1–2, 46–53. <https://doi.org/10.1002/oa.662>
- Brink, S. & Price, N. S.** (eds) 2008. *The Viking World*. Vol. 585. Routledge, London.
- Buikstra, J. E. & Ubelaker, D. H.** (eds) 1994. *Standards for Data Collection from Human Skeletal Remains: Proceedings of a Seminar at The Field Museum of Natural History*. (Archeological Survey Research Seminar Series, 44.) Arkansas Archeological Survey, Fayetteville.
- Crowder, K. D., Montgomery, J., Gröcke, D. R. & Filipek, K. L.** 2019. Childhood “stress” and stable isotope life-histories in Transylvania. – *International Journal of Osteoarchaeology*, 29: 4, 644–653. <https://doi.org/10.1002/oa.2760>
- Danielisová, A., Hajnalová, M., Pokorná, A., Kočár, P., Kertés, S., Bursák, D. et al.** 2025. Multiproxy evidence of millet reliance and selective dietary change during Iron Age transformation in Central Europe. – *Scientific Reports*, 15: 1, 41364. <https://doi.org/10.1038/s41598-025-25274-z>
- Dean, M. C. & Scandrett, A. E.** 1995. Rates of dentine mineralization in permanent human teeth. – *International Journal of Osteoarchaeology*, 5: 4, 349–358. <https://doi.org/10.1002/oa.1390050405>
- DeNiro, M. J.** 1985. Postmortem preservation and alteration of *in vivo* bone collagen isotope ratios in relation to palaeodietary reconstruction. – *Nature*, 317, 806–809. <https://doi.org/10.1038/317806a0>
- DeWitte, S. N., Beaumont, J., Walter, B. S., Towers, J. R. & Brennan, E. J.** 2025. Childhood nutritional stress and later-life health outcomes in medieval England: evidence from incremental dentine analysis. – *Science Advances*, 11: 31, eadw7076. <https://doi.org/10.1126/sciadv.adw7076>
- D’Ortenzio, L., Brickley, M., Schwarcz, H. & Prowse, T.** 2015. You are not what you eat during physiological stress: isotopic evaluation of human hair. – *American Journal of Biological Anthropology*, 157: 3, 374–388. <https://doi.org/10.1002/ajpa.22722>
- Drucker, D. G., Bridault, A., Hobson, K. A., Szuma, E. & Bocherens, H.** 2008. Can carbon-13 in large herbivores reflect the canopy effect in temperate and boreal ecosystems? Evidence from modern and ancient ungulates. – *Palaeogeography, Palaeoclimatology, Palaeoecology*, 266: 1–2, 69–82. <https://doi.org/10.1016/j.palaeo.2008.03.020>

- Elamin, F. & Liversidge, H. M.** 2013. Malnutrition has no effect on the timing of human tooth formation. – *PLoS One*, 8: 8, e72274. <https://doi.org/10.1371/journal.pone.0072274>
- Eriksson, G., Frei, K. M., Howcroft, R., Gummesson, S., Molin, F., Lidén, K. et al.** 2018. Diet and mobility among Mesolithic hunter-gatherers in Motala (Sweden) – the isotope perspective. – *Journal of Archaeological Science: Reports*, 17, 904–918. <https://doi.org/10.1016/j.jasrep.2016.05.052>
- Etu-Sihvola, H., Salo, K., Naito, Y. I., Kytökari, M., Ohkouchi, N., Oinonen, M. et al.** 2022. Isotopic insights into the early Medieval (600–1100 CE) diet in the Luistari cemetery at Eura, Finland. – *Archaeological and Anthropological Sciences*, 14, 143. <https://doi.org/10.1007/s12520-022-01613-3>
- Fahy, G. E., Deter, C., Pitfield, R., Miszkiewicz, J. J. & Mahoney, P.** 2017. Bone deep: variation in stable isotope ratios and histomorphometric measurements of bone remodelling within adult humans. – *Journal of Archaeological Science*, 87, 10–16. <https://doi.org/10.1016/j.jas.2017.09.009>
- Fogel, M. L., Tuross, N. & Owsley, D. W.** 1989. Nitrogen isotope tracers of human lactation in modern and archaeological populations. – *Carnegie Institution of Washington Yearbook*, 88, 111–117.
- Fuller, B. T., Richards, M. P. & Mays, S. A.** 2003. Stable carbon and nitrogen isotope variations in tooth dentine serial sections from Wharram Percy. – *Journal of Archaeological Science*, 30: 12, 1673–1684. [https://doi.org/10.1016/S0305-4403\(03\)00073-6](https://doi.org/10.1016/S0305-4403(03)00073-6)
- Fuller, B. T., Fuller, J. L., Harris, D. A. & Hedges, R. E. M.** 2006. Detection of breastfeeding and weaning in modern human infants with carbon and nitrogen stable isotope ratios. – *American Journal of Biological Anthropology*, 129: 2, 279–293. <https://doi.org/10.1002/ajpa.20249>
- Gerhards, G.** 2002. Dažas dzelzs laikmeta pētniecības problēmas antropoloģiskā skatījumā. – *Latvijas Vēstures muzeja raksti*, 8: Arheoloģija, numismātika, antropoloģija, paleobotānika. N.I.M.S, Rīga, 41–53.
- Gerhards, G., Vilcāne, A. & Pētersone-Gordina, E.** 2024. Cirvis sieviešu dzimtes indivīdu 8.–9. gadsimta apbedījumos latgaļu un sēļu apdzīvotajā teritorijā Latvijā. – *Arheoloģija un etnogrāfija*, XXXIII, 122–156.
- Gugora, A., Dupras, T. L. & Fóthi, E.** 2018. Pre-dating paprika: reconstructing childhood and adulthood diet at medieval (13th century CE) Solt-Tételhegy, Hungary from stable carbon and nitrogen isotope analyses. – *Journal of Archaeological Science: Reports*, 18, 151–160. <https://doi.org/10.1016/j.jasrep.2017.12.036>
- Guiry, E.** 2019. Complexities of stable carbon and nitrogen isotope biogeochemistry in ancient freshwater ecosystems: implications for the study of past subsistence and environmental change. – *Frontiers in Ecology and Evolution*, 7, 313. <https://doi.org/10.3389/fevo.2019.00313>
- Gunnarssone, A., Oras, E., Talbot, H. M., Ilves, K. & Legzdina, D.** 2020. Cooking for the living and the dead: lipid analyses of Rauši settlement and cemetery pottery from the 11th–13th century. – *Estonian Journal of Archaeology*, 24: 1, 45–69. <https://doi.org/10.3176/arch.2020.1.02>
- Hedges, R. E. M., Clement, J. G., Thomas, C. D. L. & O'Connell, T. C.** 2007. Collagen turnover in the adult femoral mid-shaft: modeled from anthropogenic radiocarbon tracer measurements. – *American Journal of Biological Anthropology*, 133: 2, 808–816. <https://doi.org/10.1002/ajpa.20598>
- Hedges, R. E. M. & Reynard, L. M.** 2007. Nitrogen isotopes and the trophic level of humans in archaeology. – *Journal of Archaeological Science*, 34: 8, 1240–1251. <https://doi.org/10.1016/j.jas.2006.10.015>

- Jílková, M., Kaupová, S., Černíková, A., Poláček, L., Brůžek, J. & Velemínský, P.** 2019. Early medieval diet in childhood and adulthood and its reflection in the dental health of a Central European population (Mikulčice, 9th–10th centuries, Czech Republic). – *Archives of Oral Biology*, 107, 104526. <https://doi.org/10.1016/j.archoralbio.2019.104526>
- Katzenberg, M. A.** 2008. Stable isotope analysis: a tool for studying past diet, demography, and life history. – *Biological Anthropology of the Human Skeleton*. 2nd ed. Eds M. A. Katzenberg & S. R. Saunders. John Wiley & Sons, Hoboken, 413–441.
- Ķimsis, J., Pokšāne, A., Kazarina, A., Vilcāne, A., Petersone-Gordina, E., Zayakin, P. et al.** 2023. Tracing microbial communities associated with archaeological human samples in Latvia, 7–11th centuries AD. – *Environmental Microbiology Reports*, 15: 5, 383–391. https://doi.org/10.1111/1758-2229.13157?urlappend=%3Futm_source%3Dresearchgate.net%26utm_medium%3Darticle
- King, C. L., Halcrow, S. E., Millard, A. R., Gröcke, D. R., Standen, V. G., Portilla, M. et al.** 2018. Let's talk about stress, baby! Infant-feeding practices and stress in the ancient Atacama desert, Northern Chile. – *American Journal of Biological Anthropology*, 166: 1, 139–155. <https://doi.org/10.1002/ajpa.23411>
- Kjellström, A., Storå, J., Possnert, G. & Linderholm, A.** 2009. Dietary patterns and social structures in medieval Sigtuna, Sweden, as reflected in stable isotope values in human skeletal remains. – *Journal of Archaeological Science*, 36: 12, 2689–2699. <https://doi.org/10.1016/j.jas.2009.08.007>
- Linderholm, A., Jonson, C. H., Svensk, O. & Lidén, K.** 2008. Diet and status in Birka: stable isotopes and grave goods compared. – *Antiquity*, 82: 316, 446–461. <https://doi.org/10.1017/S0003598X00096939>
- Mekota, A.-M., Grupe, G., Ufer, S. & Cuntz, U.** 2006. Serial analysis of stable nitrogen and carbon isotopes in hair: monitoring starvation and recovery phases of patients suffering from anorexia nervosa. – *Rapid Communications in Mass Spectrometry*, 20: 10, 1604–1610. <https://doi.org/10.1002/rcm.2477>
- Moen, M.** 2019. Gender and archaeology: where are we now? *Archaeologies*, 15, 206–226. <https://doi.org/10.1007/s11759-019-09371-w>
- Mugurēvičs, Ē.** 2006. Lībiešu izcelsmes un kultūras veidošanās problēmas. – *Latvijas vēstures institūta žurnāls*, 4, 15–37.
- Möldner, G. & Richards, M. P.** 2005. Fast or feast: reconstructing diet in later medieval England by stable isotope analysis. – *Journal of Archaeological Science*, 32: 1, 39–48. <https://doi.org/10.1016/j.jas.2004.05.007>
- O'Connell, T. C. & Hedges, R. E. M.** 1999. Investigations into the effect of diet on modern human hair isotopic values. – *American Journal of Biological Anthropology*, 108: 4, 409–425. [https://doi.org/10.1002/\(sici\)1096-8644\(199904\)108:4%3C409::aid-ajpa3%3E3.0.co;2-e](https://doi.org/10.1002/(sici)1096-8644(199904)108:4%3C409::aid-ajpa3%3E3.0.co;2-e)
- Oras, E., Tõrv, M., Jonuks, T., Malve, M., Radini, A., Isaksson, S. et al.** 2018. Social food here and hereafter: multiproxy analysis of gender-specific food consumption in conversion period inhumation cemetery at Kukruse, NE-Estonia. – *Journal of Archaeological Science*, 97, 90–101. <https://doi.org/10.1016/j.jas.2018.07.001>
- Ottalagano, F. & Loponte, D.** 2017. Stable isotopes and diet in complex hunter-gatherers of Paraná River Basin, South America. – *Archaeological and Anthropological Sciences*, 9, 865–877. https://doi.org/10.1007/s12520-015-0308-6?urlappend=%3Futm_source%3Dresearchgate.net%26utm_medium%3Darticle

- Pētersone-Gordina, E., Gerhards, G., Vilcāne, A., Millard, A. R., Moore, J., Ķimsis, J. et al.** 2022. Diet and social status in the Lejasbitēni Iron Age population from Latvia. – *Journal of Archaeological Science: Reports*, 44, 103519. <https://doi.org/10.1016/j.jasrep.2022.103519>
- Pētersone-Gordina, E., Gerhards, G., Vilcāne, A., Millard, A. & Moore, J.** 2023. The first dietary stable isotope data from the Čunkāni–Dreņģeri Iron Age population (seventh–eleventh centuries CE) from Latvia. – *Archaeological and Anthropological Sciences*, 15, 185. <https://doi.org/10.1007/s12520-023-01880-8>
- Reitsema, L. J.** 2013. Beyond diet reconstruction: stable isotope applications to human physiology, health, and nutrition. – *American Journal of Human Biology*, 25: 4, 445–456. <https://doi.org/10.1002/ajhb.22398>
- Reitsema, L. J. & McIlvaine, B. K.** 2014. Reconciling “stress” and “health” in physical anthropology: what can bioarchaeologists learn from the other subdisciplines? – *American Journal of Biological Anthropology*, 155: 2, 181–185. <https://doi.org/10.1002/ajpa.22596>
- Roberts, P., Fernandes, R., Craig, O. E., Larsen, T., Lucquin, A., Swift, J. et al.** 2018. Calling all archaeologists: guidelines for terminology, methodology, data handling, and reporting when undertaking and reviewing stable isotope applications in archaeology. – *Rapid Communications in Mass Spectrometry*, 32: 5, 361–372. <https://doi.org/10.1002/rcm.8044>
- Schoeninger, M. J., DeNiro, M. J. & Tauber, H.** 1983. Stable nitrogen isotope ratios of bone collagen reflect marine and terrestrial components of prehistoric human diet. – *Science*, 220: 4604, 1381–1383. <https://doi.org/10.1126/science.6344217>
- Schoeninger, M. J. & DeNiro, M. J.** 1984. Nitrogen and carbon isotopic composition of bone collagen from marine and terrestrial animals. – *Geochimica et Cosmochimica Acta*, 48: 4, 625–639. [https://doi.org/10.1016/0016-7037\(84\)90091-7](https://doi.org/10.1016/0016-7037(84)90091-7)
- Szpak, P., Metcalfe, J. Z. & Macdonald, R. A.** 2017. Best practices for calibrating and reporting stable isotope measurements in archaeology. – *Journal of Archaeological Science: Reports*, 13, 609–616. <https://doi.org/10.1016/j.jasrep.2017.05.007>
- Urtāns, V.** 1965. Izrakumi Lejasbitēnu un Lejasziedu apmetnēs, Kalnaziedu pilskalnā un Lejasbitēnu kapulaukā. – Zinātniskās atskaites sesijas referātu tēzes par arheologu, etnogrāfu un folkloristu 1964. gada ekspedīcijām. LPSR ZA Vēstures institūts, Rīga, 21–24.
- Urtāns, V.** 1970. Etniskās atšķirības apbedīšanās tradīcijās un kapu inventārā 5.–9. gs. – *Arheoloģija un etnogrāfija*, 9, 105–125, 61–83.
- Valk, H. & Laul, S.** 2014. Siksālā kalme I: muistis ja ajalugu. Tartu Ülikool, Tartu.
- Vasks, A.** 2018. The pre-history of Latvia (10500 BCE–1200 CE). – *Latvia and Latvians: Collection of Scholarly Articles*. Vol. 2, Part 3. Latvian Academy of Sciences, Riga, 9–39.
- Vilcāne, A.** 2018. The Balts and the Baltic Finns. – *Latvia and Latvians: Collection of Scholarly Articles*. Vol. 2, Part 3. Latvian Academy of Sciences, Riga, 40–90.
- Whitmore, K. M., Dupras, T. L., Williams, L. J., Skipitytė, R., Schultz, J. J. & Jankauskas, R.** 2019. Stable carbon and nitrogen isotope inter- and intra-individual dietary reconstruction from the late 14th to early 18th century site of Alytus, Lithuania. – *American Journal of Biological Anthropology*, 168: 2, 279–291. <https://doi.org/10.1002/ajpa.23742>

Lapse- ja täiskasvanuea toitumise võrdlus Lāti viikingiaegse Lejasbitēni kalmistu populatsioonis: pilootuuring

Elīna Pētersone-Gordina, Guntis Gerhards,
Antonija Vilcāne, Andrew Millard, Joanna Moore ja
Janet Montgomery

RESÜMEE

Pilootuuringu eesmärk oli uurida toitumise muutusi elukaare jooksul valitud täiskasvanud indiviididel Lejasbitēni kalmistult (Lāti, 7.–10. saj pKr), võrreldes luukollageeni stabiilsete süsiniku- ($\delta^{13}\text{C}$) ja lämmastikuisotoopide ($\delta^{15}\text{N}$) väärtusi, mis peegeldavad täiskasvanuea toitumist, varem avaldatud esimese jäävpurihamba dentiini isotoopandmetega, mis kajastavad lapsepõlve toitumist. Lisaks oli eesmärk hinnata sooga seotud toitumiserinevuste püsimist täiskasvanueas ning uurida võimalikke seoseid sotsiaalse staatuse (mida väljendavad hauapanused) ja ressurssidele juurdepääsu vahel.

Luukollageen eraldati 12 täiskasvanud indiviidilt ja kahelt liivi kultuuri mittetäiskasvanud indiviidilt, kasutades standardset demineraliseerimise ja želatiniseerimise protokollit. Isotoopsuhted määrati pidevvoolu-isotoopsuhte massispektromeetria abil ning andmeid analüüsiti t-testide, Manni-Whitney U-testide ja Wilcoxoni astakmärgitustestide abil.

Uuringu peamised tulemused näitavad, et Lejasbitēni täiskasvanuea toitumist iseloomustasid suhteliselt madalad $\delta^{13}\text{C}$ ja $\delta^{15}\text{N}$ väärtused luukollageenis, mis paigutab selle populatsiooni Baltikumi laiemas kontekstis madalaimate hulka ning viitab maismaa C_3 -taimedel põhinevate ressursside domineerimisele ja loomse valgu suhteliselt vähesele osakaalule toidus.

Statistiliselt oluline nihe lapsepõlvest täiskasvanuikka madalamate $\delta^{15}\text{N}$ ja kõrgemate $\delta^{13}\text{C}$ väärtuste suunas tuvastati kogu valimis (vastavalt $p = 0,005$ ja $p < 0,001$) ning sama tendents kinnitati ka viiel indiviidil, kelle kohta olid andmed mõlemast koest. Erinevalt lapsepõlvest, mil meessoost indiviididel esinesid naissoost indiviididega võrreldes märksa kõrgemad $\delta^{15}\text{N}$ väärtused, ei ilmnunud täiskasvanueas statistiliselt olulisi soopõhiseid isotoopilisi erinevusi, mis viitab täiskasvanute toitumise suuremale homogeensusele.

Kõrgemad $\delta^{15}\text{N}$ väärtused luukollageenis ei korreleerunud järjekindlalt rikkalikumate hauapanustega, mistõttu selget seost sotsiaalse staatuse ja toiduressurssidele juurdepääsu vahel ei ilmnunud. Kahe liivi kultuuri mittetäiskasvanud indiviidi esialgsed isotoopandmed viitasid erinevustele võrreldes Lejasbitēni põhipopulatsiooniga, eriti $\delta^{13}\text{C}$ väärtuste osas, kuid väga väikese valimi tõttu jäävad järeldused esialgseks.

Autorid rõhutavad, et kuna uuring põhineb väikesel ja sihipäraselt valitud indiviidide rühmal, on vajalikud edasised isotoopuuringud Lejasbitēni ülejäänud populatsiooni kohta, et kinnitada täheldatud mustreid ning täpsustada toitumise muutuste, soo ja sotsiaalse staatuse vahelisi seoseid elukaare jooksul.

Animal exploitation over two millennia at Aukuras hill hillfort at the Kernavė archaeological complex, Lithuania: zooarchaeological evidence from birds, fish, and mammals (c. 800 cal BC–1400 cal AD)

Giedrė Piličiauskienė 

Department of Archaeology, Vilnius University, Universiteto g. 7, LT-01131 Vilnius, Lithuania
giedre.pilciauskiene@if.vu.lt

Saulius Rumbutis 

Laboratory of Avian Ecology, Nature Research Centre, Akademijos g. 2, LT-08412 Vilnius, Lithuania
Kaunas Tadas Ivanauskas Museum of Zoology, Laisvės al. 106, LT-4253 Kaunas, Lithuania
sauliusrumbutis@gmail.com

Karolis Minkevičius 

Department of Archaeology, Vilnius University, Universiteto g. 7, LT-01131 Vilnius, Lithuania
karolis.minkevicius@if.vu.lt

Rokas Vengalis 

Department of Archaeology, Vilnius University, Universiteto g. 7, LT-01131 Vilnius, Lithuania
rokasven@gmail.com

Gintautas Vėlius 

Department of Archaeology, Vilnius University, Universiteto g. 7, LT-01131 Vilnius, Lithuania
archvelius@gmail.com

Received 5 June 2026, accepted 21 August 2026, available online 5 October 2026

ABSTRACT

The Kernavė archaeological complex in eastern Lithuania provides a rare opportunity to investigate long-term changes in human–animal relationships within a single site landscape. This paper presents the results of zooarchaeological analyses of 15 339 animal remains recovered from Aukuras hill hillfort in Kernavė, of which 4207 were identified to various taxonomic levels, from order and family to species. The assemblage spans four occupation phases between c. 800 cal BC and 1400 cal AD and includes mammals, birds, and fish, allowing the reconstruction of animal husbandry, hunting, and fishing practices over nearly two millennia. The results demonstrate that farming was already fully established during the Late Bronze Age, with pigs and sheep/goats forming the basis of animal husbandry. During the late Pre-Roman and Roman periods, cattle became increasingly important, likely reflecting the intensification of crop cultivation. The same period yielded the earliest known chicken remains in Lithuania, indicating the introduction of the domestic chicken by c. 200 cal BC–200 cal AD. The medieval assemblage reveals a distinct pattern of elite consumption and hunting. Compared with the inhabitants of Kernavė's medieval Upper and Lower Towns, pork, birds, fish, and wild game appear to have played a more important role in the diet of the residents of Aukuras hill hillfort. The abundance of northern goshawk remains and hare bones points to the importance of falconry and specialised hunting focused on small game. The assemblage provides new insights into the interaction between farming, social status, and animal exploitation in the eastern Baltic from prehistory to the medieval period.

KEYWORDS

animal husbandry, falconry, fishing, chickens, eastern Baltic.

Introduction

Animal and plant remains recovered during archaeological excavations are among the most important sources for reconstructing past subsistence strategies, dietary practices, environmental conditions, and economic activities. In recent decades, increasing opportunities offered by scientific methods, including stable isotope and ancient DNA analyses, have substantially increased scholarly interest in archaeological faunal remains. At the same time, traditional zooarchaeological studies have often remained overshadowed by laboratory-based approaches. In Lithuania, detailed zooarchaeological research has focused primarily on major medieval centres, including the Vilnius Lower Castle (Piličiauskienė & Blaževičius 2018; 2019; Rumbutis et al. 2018; Ehrlich et al. 2023), Klaipėda Castle (Ehrlich et al. 2020), Kernavė (Baublienė et al. 2004; Vėlius et al. 2025), and Trakai Peninsula Castle (Piličiauskienė et al. 2024). Consequently, the zooarchaeology of medieval Lithuania is comparatively well understood.

A different situation exists for earlier periods. Although Late Bronze Age¹ subsistence in Lithuania and the wider Baltic region has received increasing attention (Luik et al. 2022; Micelicaitytė et al. 2023; Minkevičius et al. 2023; 2026), studies addressing long-term economic developments between the establishment of farming and the medieval period remain scarce. This is largely due to the limited availability of bioarchaeological material and the rarity of well-preserved, continuously occupied settlement sites (Minkevičius 2020; Minkevičius et al. 2025).

The Kernavė archaeological complex in east-central Lithuania provides a rare opportunity to investigate such long-term developments. Human activity is documented there from the Upper Palaeolithic until the end of the 14th century AD, while abundant bioarchaeological remains dating from the late 1st millennium BC onwards enable the reconstruction of long-term changes in subsistence practices, environmental conditions, and human–animal relationships. Particularly important in this respect are the excavations conducted at Aukuras hill hillfort in 2021–2022, which yielded a large and well-dated assemblage of mammal, bird, and fish remains. Owing to the exceptional preservation of archaeological deposits and the presence of stratigraphically distinct occupation horizons spanning from the Late Bronze Age to the 13th–14th centuries AD, the site offers a rare opportunity to examine long-term changes in animal exploitation within a single settlement location (Minkevičius et al. 2025; Vėlius et al. 2025).

In this paper, we analyse long-term changes in animal exploitation at Aukuras hill hillfort in Kernavė between c. 800 cal BC and 1400 cal AD, based on the faunal material from the site and using standard zooarchaeological methods. The results are discussed in relation to subsistence practices and, where relevant, compared with data from other sites in the Kernavė archaeological complex.

Site description

Kernavė, located approximately 35 km northwest of Vilnius on the eastern bank of the River Neris, is one of the most significant archaeological sites in the southeastern Baltic and is widely recognised as the first historical capital of the Grand Duchy of Lithuania. The archaeological complex occupies

1 In this paper, we use the following chronological periods for Lithuanian prehistory and history: Subneolithic (5000–2900 cal BC), Neolithic (2900–1800 cal BC), Early Bronze Age (1800–1100 cal BC), Late Bronze Age (1100 cal BC–500 cal AD), Pre-Roman Iron Age (500–1 cal BC), Roman Period (1–400 cal AD), Migration and Post-Migration periods (400–800 cal AD), Viking Period (800–1100 cal AD), and Medieval Period (1100–1400 cal AD).

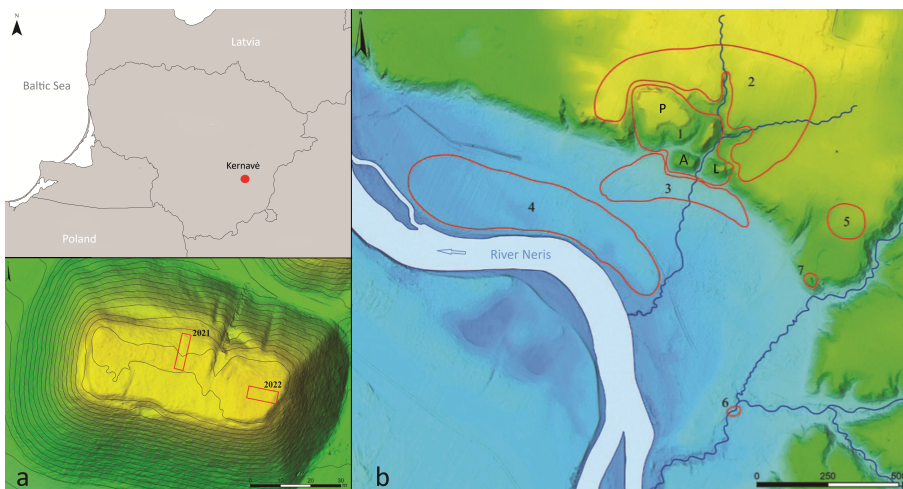


FIG. 1. Location map of the Kernavė archaeological complex and Aukuras hill hillfort: (a) Aukuras hill hillfort, with the areas excavated in 2021–2022; (b) medieval Kernavė in the late 12th–early 13th centuries: 1 – castle and fortified part of the town: A – Aukuras hill hillfort, P – Pilies hill hillfort, L – Lizdeika hillfort; 2 – Upper Town; 3 – Lower Town in a wet peaty area; 4 – Lower Town near the River Neris; 5, 6 – cemeteries; 7 – Kriveikiškis hillfort.

around 200 ha and includes a diverse cultural landscape consisting of hillforts, settlements, and burial sites spanning from prehistory to the medieval period (Fig. 1). Owing to its exceptional preservation and long-term cultural continuity, Kernavė was inscribed on the UNESCO World Heritage List.

Archaeological evidence indicates repeated human occupation from the Upper Palaeolithic (c. 10 000 cal BC) until the decline of the medieval centre following the Baltic crusades and the abandonment of much of the settlement at the end of the 14th century AD. Since systematic excavations began in 1979, Kernavė has produced one of the richest archaeological datasets in Lithuania, including material from five hillforts, eight burial grounds, and several chronologically distinct settlement areas (Vengalis 2016; Minkevičius et al. 2025; Vėlius et al. 2025).

Settlement activity in Kernavė became more prominent from the Late Bronze Age and reached its greatest extent in the medieval period (1200–1400 cal AD). The chronology of Kernavė broadly follows established phases of Lithuanian prehistory, including the Pre-Roman and Roman Iron Ages, the Migration and Post-Migration periods, and the Viking Age (Vengalis 2012; Podėnas et al. 2016; Baltramiejūnaitė et al. 2019; Minkevičius et al. 2025). Most archaeological sites at Kernavė are concentrated in the River Neris valley, where prehistoric and medieval settlement areas, including the Lower Town, have been identified (Vengalis

2012). The most distinctive features of the Kernavė archaeological complex, however, are the hillforts and associated medieval town on the upper terrace (Fig. 1b). Excavations indicate occupation beginning around 1000 cal BC, with gradual development into a major medieval centre. The largest hillfort, Pilies (Castle) hill hillfort, functioned as a fortified market area from the medieval period onward (Luchtanas 1986), while Lizdeika hillfort formed part of the 13th–14th-century defensive system (Vengalis & Vėlius 2019). North of the hillforts, the area called the Upper Town emerged during the 13th century as medieval Kernavė expanded onto the upper terrace of the River Neris (Vaičiūnienė 2000; Vengalis et al. 2020).

Aukuras (Altar) hill hillfort is one of the principal hillforts of the Kernavė archaeological complex (Fig. 1a). Archaeological investigations began there in 1992 and have continued intermittently since, revealing evidence of occupation from approximately 1000 cal BC onward. The site developed from a Late Bronze Age and Iron Age settlement into part of medieval Kernavė, and by the 13th–14th centuries AD, it likely functioned as the residence of the Grand Duke of Lithuania and the elite, as indicated by changes in material culture and reduced evidence of everyday household activities. The hillfort is therefore important for studying both long-term settlement continuity and social differentiation. Excavations conducted in 2021–2022 yielded one of the richest bioarchaeological assemblages in Kernavė, including extensive archaeobotanical and zooarchaeological material, making it one of the most intensively investigated areas within the Kernavė complex (Minkevičius et al. 2025; Vėlius et al. 2025).

Historical and archaeological evidence suggests that repeated attacks by the Teutonic Order in 1365 and 1390 led to the relocation of political and economic power away from Kernavė (Vitkūnas 2005). The subsequent abandonment of large parts of the settlement halted further urban development and contributed to the exceptional preservation of the archaeological layers visible today.

Zooarchaeological research at Kernavė began alongside the first archaeological excavations, when large quantities of animal remains were recovered and recognised as an important source of information about past subsistence practices (Kulikauskas & Luchtanas 1979; Volkaitė-Kulikauskienė 1984; Luchtanas 1990). Over several decades of fieldwork, one of the largest zooarchaeological collections in Lithuania was assembled from various locations within the Kernavė archaeological complex, including the Upper and Lower Towns, Aukuras hill hillfort, and other excavated areas, making Kernavė an important site for the study of animal husbandry, hunting, and diet in the past (Bilskienė & Daugnora 2001; Baublienė et al. 2004; Vengalis 2010; 2014; 2020; Vėlius et al. 2025).

Today, the Kernavė zooarchaeological collection comprises approximately 35 000 animal skeletal specimens recovered during more than four decades of archaeological investigations and is stored at the Zooarchaeological Repository of Vilnius University. As one of the largest faunal collections in Lithuania, it represents an important resource for investigating long-term changes in subsistence practices, animal exploitation, and human–animal relationships.

Material and methods

During the archaeological excavations in 2021–2022, a total of 234 m² was investigated in two areas of Aukuras hill hillfort, yielding 15 339 animal remains (Table 1). During the 2021–2022 excavations at Aukuras hill hillfort dry sieving with a 4-mm mesh size was used. This allowed the recovery of very small bone fragments, including small fish bones and remains of small mammals, which might otherwise have been missed. The use of sieving also resulted in the recovery of a substantial amount of highly fragmented material, of which only 4207 specimens (27.4%) were identified to various taxonomic levels, from order and family to species. The methods used to collect faunal remains during the excavations may therefore have influenced the composition of the zooarchaeological assemblage. Based on archaeological evidence and primarily on radiocarbon dates obtained from charred cultivated plant remains, five occupation phases from 800 cal BC to 1400 cal AD were identified at the site:

1. c. 800–200 cal BC (Late Bronze Age–early Pre-Roman Iron Age);
2. c. 200 cal BC–200 cal AD (late Pre-Roman–early Roman Iron Age);
3. c. 200–700 cal AD (late Roman Iron Age–Post-Migration Period);
4. c. 700–1200 cal AD (Late Iron Age);
5. c. 1200–1400 cal AD (medieval period).

The earliest analysed samples were dated to 2508 ± 26 BP (777–544 cal BC), while the latest yielded dates of 665 ± 30 BP (1278–1393 cal AD), approximately corresponding to the second 14th-century fire event in Kernavė (Minkevičius et al. 2025; Vėlius et al. 2025). Zooarchaeological material was recovered from cultural layers representing four of the five occupation phases; no animal remains were found from the Late Iron Age.

TABLE 1. Chronological distribution of analysed faunal remains from Aukuras hill hillfort

Chronology	Identified mammals		Undetermined mammals		Birds		Fish		Total	
	n	%	n	%	n	%	n	%	n	%
c. 800–200 cal BC	31	15.3	171	84.7	–	–	–	–	202	1.3
c. 200 cal BC–200 cal AD	246	16.7	1138	77.4	49	3.3	38	2.6	1471	9.6
c. 200–700 cal AD	76	15.5	405	82.5	9	1.8	1	0.2	491	3.2
c. 1200–1400 cal AD	3087	23.5	8920	68.0	671	5.1	438	3.3	13 116	85.5
Undetermined, c. 200 cal BC–1400 cal AD	13	22.0	43	72.9	2	3.4	1	1.7	59	0.4
Total	3453	22.5	10 677	69.6	731	4.8	478	3.1	15 339	100.0

Sheep (*Ovis aries*) and goat (*Capra hircus*) remains were identified following the criteria proposed by Boessneck et al. (1964), Payne (1985), and Prummel and Frisch (1986). Specimens that could not be attributed to either taxon were classified as *Ovis/Capra* (sheep/goat). Similarly, specimens that could not be distinguished between auroch and European bison were classified as *Bos primigenius* / *Bison bonasus* (auroch/bison). Remains of the mountain hare (*Lepus timidus*) and European hare (*Lepus europaeus*) were not reliably distinguished at the species level and were therefore grouped and recorded as *Lepus timidus* / *L. europaeus*.

Osteometric measurements were taken according to von den Driesch (1976). Age-at-death estimations were based on epiphyseal fusion and tooth eruption patterns following Silver (1969). The minimum number of individuals (MNI) was calculated following White (1953), taking into account animal age and body size. Age profiles for sheep/goats were assessed using tooth wear stages following Payne (1973), while those for pigs (*Sus scrofa domesticus*) and cattle (*Bos taurus*) were evaluated according to Grant (1982).

Sex determination in cattle was based on metacarpal and metatarsal measurements using the discriminant function developed by Kobryńczuk and Kobryń (1993). Withers height in cattle was reconstructed from the greatest lengths (GL) of metacarpal and metatarsal bones using Tsalkin's (1960) coefficients. The withers height of sheep was estimated from radial bone length (GL), applying the coefficients of Teichert (1975). The withers height of pigs was calculated using the coefficients proposed by Teichert (1969).

Fish size was estimated by comparing archaeological specimens with modern fish of known size from the reference collection.

Mammal and fish remains were analysed at the Zooarchaeology Laboratory, Faculty of History, Vilnius University, using a comparative collection of modern animal skeletons. Bird bones were identified at the Kaunas Tadas Ivanauskas Museum of Zoology using a reference collection of modern bird skeletons.

Results

A total of 15 339 zooarchaeological specimens were analysed. The 2021 excavations yielded faunal remains ($n = 7269$) from four chronological periods, spanning from the Late Bronze Age to the 13th–14th centuries AD, whereas the 2022 investigations produced exclusively medieval animal remains ($n = 7794$). The quantitative analyses presented below are based only on specimens identified to the species, family, or order level. Unidentified faunal remains, as well as a few small rodent bones ($n = 26$; 0.2%), were excluded from further analyses.

The earliest cultural layers (c. 800–200 cal BC) yielded the fewest animal remains ($n = 202$). Of these, 31 identified bone and tooth fragments belonged to at least six wild and domestic animal taxa (Tables 1 and 2). Domestic animals accounted for 90.3% of identified remains, with pigs being the most frequent taxon (35.5%), followed by sheep/goats (25.8%) and cattle (19.4%). Pig remains included a newborn animal and at least two individuals older than one year. Sheep/goat remains comprised a newborn animal and at least one individual older than 1.5 years. All identified cattle remains belonged to mature animals (older than 3–4 years). Horse (*Equus ferus caballus*) remains represented at least two individuals, including one yearling animal and one adult horse with cut marks on the first phalanx. Wild fauna was represented only by hare and red deer remains.

Faunal remains were considerably more abundant ($n = 1471$) in the cultural layer dated to c. 200 cal BC–200 cal AD (Table 1). In addition to the dominant mammal remains, bird and fish bones accounted for 3.3% and 2.6% of the assemblage, respectively. Among identified mammals (Table 2), cattle predominated (42.3%), representing at least six individuals of different ages. At least three cattle were adults, while the remains of one newborn calf and one approximately 1.5-year-old individual were identified; at least one more animal was younger than 3–4 years. Pig (26.8%) and sheep/goat (17.9%) remains were less abundant. Pig remains ($n = 66$) represented at least five individuals of various ages, ranging from newborn piglets to animals older than 2–3 years. Sheep/goat remains also belonged to at least five individuals, including one newborn and at least three animals older than 1.5–2 years.

TABLE 2. Species distribution of mammal bones during the different occupation phases of Aukuras hill hillfort. MNI – minimum number of individuals, NISP – number of identified specimens

Species	800–200 cal BC		200 cal BC–200 cal AD		200–700 cal AD		1200–1400 cal AD	
	NISP/ MNI	%NISP/ %MNI	NISP/ MNI	%NISP/ %MNI	NISP/ MNI	%NISP/ %MNI	NISP/ MNI	%NISP/ %MNI
Cattle (<i>Bos taurus</i>)	6/2	19.4/18.2	104/6	42.3/25.0	36/3	47.4/25.0	1128/32	36.5/23.5
Sheep (<i>Ovis aries</i>)							21/6	0.7/4.4
Goat (<i>Capra hircus</i>)							3/2	0.1/1.5
Sheep/goat (<i>Ovis/Capra</i>)	8/2	25.8/18.2	44/5	17.9/20.8	11/2	14.7/16.7	455/10	14.7/7.4
Pig (<i>Sus scrofa domesticus</i>)	11/3	35.5/27.3	66/5	26.8/20.8	19/3	25.0/25.0	1043/33	33.8/24.3
Horse (<i>Equus ferus caballus</i>)	3/2	9.4/18.2	2/1	0.8/4.0	2/1	2.6/8.3	13/2	0.4/1.5
Dog (<i>Canis familiaris</i>)							17/3	0.6/2.2
Bison/auroch (<i>Bison bonasus</i> / <i>Bos primigenius</i>)							14/3	0.5/2.2
Elk (<i>Alces alces</i>)			1/1	0.4/4.0			7/2	0.2/1.5
Red deer (<i>Cervus elaphus</i>)	2/1	6.5/9.1	14/2	5.7/8.3	2/1	2.6/8.3	80/5	2.6/3.7
Roe deer (<i>Capreolus capreolus</i>)			1/1	0.4/4.0			9/3	0.3/2.2
Boar (<i>Sus scrofa</i>)			8/2	3.3/8.3			21/3	0.7/2.2
Mountain/European hare (<i>Lepus timidus</i> / <i>L. europaeus</i>)	1/1	3.2/9.1	6/1	2.4/4.0	5/1	6.6/8.3	242/20	7.8/14.7
Beaver (<i>Castor fiber</i>)					1/1	1.3/8.3	4/1	0.1/0.7
Fox (<i>Vulpes vulpes</i>)							3/2	0.1/1.5
Pine marten (<i>Martes martes</i>)							1/1	0.0/0.7
Red squirrel (<i>Sciurus vulgaris</i>)							25/7	0.8/5.1
Northern white-breasted hedgehog (<i>Erinaceus roumanicus</i>)							1/1	0.0/0.7
Total	31/11	100.0/100.0	246/24	100.0/100.0	76/12	100.0/100.0	3087/136	100.0/100.0

A horse tibia fragment had cut marks. Wild animals accounted for 12.2% of identified mammalian remains and were dominated by red deer (*Cervus elaphus*) (n = 14) and wild boar (*Sus scrofa*) (n = 8).

Bird remains from this period included 49 specimens, of which 32 (65.3%) were identified to species, family or order level (Table 3). The assemblage represented at least seven bird species and was dominated by wild and domestic Galliformes (n = 24). Domestic chicken (*Gallus gallus domesticus*) was particularly well represented with at least seven identified bones, while two additional specimens could not be distinguished from willow grouse or black grouse. Other taxa included mallard (*Anas platyrhynchos*), western capercaillie (*Tetrao urogallus*), common raven (*Corvus corax*), western jackdaw (*Corvus monedula*) and a few others.

Among the 26 identified fish remains, freshwater species predominated (Table 4). Pike (*Esox lucius*) was the most frequently recorded species. Estimated pike sizes ranged from 40 to 110 cm, with most individuals measuring 60–70 cm. Among cyprinid remains (n = 12), only bream could be identified. At least six bream (*Abramis brama*) individuals represented fish measuring approximately 40–45 cm in length. In addition, a palatine bone fragment of a large catfish (*Silurus glanis*), over 2.0–2.5 m long, was

TABLE 3. Anatomical and species distribution of bird bones, 200 cal BC–200 cal AD.
NISP – number of identified specimens

Species/element	Tibiotarsus	Humerus	Ulna	Radius	Carpometacarpus	Ossa digitorum manus	Sternum	Coracoideum	Scapula	Pelvis et synsacrum	Vertebrae cervicales speciales	Undetermined	Total	%NISP
Mallard (<i>Anas platyrhynchos</i>)								1	1				2	6.3
Western capercaillie (<i>Tetrao urogallus</i>)					1						6		7	21.9
Grey partridge / hazel grouse (<i>Perdix perdix</i> / <i>Bonasa bonasia</i>)			2				1	3					6	18.8
Willow grouse / domestic chicken (<i>Lagopus lagopus</i> / <i>Gallus gallus domesticus</i>)			1		2								3	9.4
Domestic chicken / black grouse (<i>Gallus gallus domesticus</i> / <i>Tetrao tetrix</i>)	1												1	3.1
Domestic chicken (<i>Gallus gallus domesticus</i>)	1		1		1			2		2			7	21.9
Common raven (<i>Corvus corax</i>)					1	1							2	6.3
Western jackdaw (<i>Corvus monedula</i>)		1											1	3.1
Galliformes sp.		1											1	3.1
Columba sp.				1									1	3.1
Passeriformes sp.		1											1	3.1
Aves, undetermined	1									2		14	17	–
Total	3	3	4	1	5	1	1	6	1	4	6	14	49	100.0

recovered. Dentaries of three eels (*Anguilla anguilla*) indicated individuals measuring approximately 80–90 cm in length.

Faunal remains recovered from deposits dated to 200–700 cal AD were sparse, comprising only 491 animal bone fragments, the vast majority of which were mammalian remains (98.0%) (Table 1). Among the 76 identified specimens, domestic animals predominated (89.5%). Cattle were the most common species (47.4%), although no remains of juvenile or newborn individuals were recorded; identified specimens included one animal younger than 3.5–4 years and at least one older than 8–9 years. Pig remains ranked second (25.0%), while sheep/goat remains (14.7%) were nearly half as abundant. No juvenile pigs or sheep/goats were identified. Horse remains, as in other periods, were scarce (2.6%). Among wild animals, hare remains were the most frequent (Table 2).

Most of the nine bird bone fragments were highly fragmented and very small. It can only be stated that at least four likely belonged to Galliformes. The single identified fish remain belonged to a 30–35-cm-long perch (*Perca fluviatilis*) (Table 4).

TABLE 4. Species composition of fish remains during the different occupation phases of Aukuras hill hillfort. NISP – number of identified specimens

Species/dating	200 cal BC–200 cal AD		200–700 cal AD		1200–1400 cal AD	
	NISP	%NISP	NISP	%NISP	NISP	%NISP
Pike (<i>Esox lucius</i>)	10	38.5			99	29.8
Zander (<i>Sander lucioperca</i>)					8	2.4
Perch (<i>Perca fluviatilis</i>)			1	100.0	12	3.6
Wels catfish (<i>Silurus glanis</i>)	1	3.8			10	3.0
Salmon (<i>Salmo salar</i>)					27	8.1
Sturgeon (<i>Acipenser</i> sp.)					15	4.5
Eel (<i>Anguilla anguilla</i>)	3	11.5			4	1.2
Cyprinids (Cyprinidae)	6	23.1			55	16.6
Bream (<i>Abramis brama</i>)	6	23.1			67	20.0
Tench (<i>Tinca tinca</i>)					9	2.7
Crucian carp (<i>Carassius carassius</i>)					1	0.3
Common rudd (<i>Scardinius erythrophthalmus</i>)					7	2.1
Roach (<i>Rutilus rutilus</i>)					6	1.8
Common chub (<i>Squalius cephalus</i>)					3	0.9
Ide (<i>Leuciscus idus</i>)					1	0.3
Asp (<i>Leuciscus aspius</i>)					2	0.6
Vimba bream (<i>Vimba vimba</i>)					6	1.8
Identified, total	26		1		332	
Undetermined	12				106	
Total	38	100.0	1	100.0	438	100.0

The medieval period, representing the latest chronological phase, yielded by far the largest zooarchaeological assemblage, comprising 13 116 animal bone fragments (Table 1). In addition to the dominant mammalian remains (91.5%), bird (5.1%) and fish (3.3%) remains were also quite abundant. Among the 3087 identified specimens, domestic animals accounted for 86.8%, with cattle (36.5%) and pigs (33.8%) being the most frequent taxa (Table 2).

Due to their high fragmentation, age could be estimated for only eight cattle individuals and ranged from newborns to animals aged 8–9 years, with no clear predominance of any age group. The sex and withers height of three individuals were determined: two bulls measured 106 cm and 108 cm, while one cow measured 105 cm in height. Pig remains represented individuals of various ages, from newborn piglets to animals aged 5–6 years, although one- and two-year-old pigs predominated, as is commonly observed (Piličiauskienė & Blaževičius 2018). Estimated withers heights of three pigs were 63 cm, 66 cm, and 47 cm.

Sheep and goat remains comprised 479 fragments, representing at least six sheep, two goats, and eight additional undetermined sheep/goat individuals (Table 2). The age range of sheep and goats varied from newborns to animals aged 4–6 years. At least five sheep had been slaughtered at approximately 9 months of age, while one individual survived to around 3 years. One goat was younger than 2–3 years, whereas another was older. In the sheep/goat group, remains of animals aged 1.5–2 years predominated. Based on radius length, the estimated withers height of sheep was approximately 66 cm.

Horse remains were extremely scarce in the medieval assemblage (0.4%). The 13 horse bone and tooth fragments represented at least two adult individuals. Only a single horse bone, a pelvic fragment, had cut marks. A total of 17 highly fragmented dog bones belonged to at least three adult individuals.

Wild mammals accounted for 13.2% of identified mammalian remains during the medieval period. Hare bones were the most abundant (7.8%), while considerably fewer remains of red deer (2.6%) and other large ungulates, including bison/auroch and elk (*Alces alces*), were identified. Unusually high numbers of small mammals not previously recorded at Kernavė were also recovered: 25 red squirrel (*Sciurus vulgaris*) bones, representing at least seven individuals. In addition, a hedgehog mandible (*Erinaceus roumanicus*) was found (Table 2).

Of the 671 bird bones recovered, 372 were identified, representing at least 23 bird species (Table 5). Domestic chicken was the most frequent taxon, accounting for 34.4% of identified remains. Most chicken bones belonged to adult birds. Additional chicken remains were likely included within the broader category of unidentified Galliformes, as birds of domestic chicken size comprised approximately half of the unidentified galliform fragments. Remains of birds comparable in size to black grouse (*Tetrao tetrix*) and capercaillie were also relatively common. Among wild Galliformes, black grouse predominated (n = 11), followed by western capercaillie (n = 6) and hazel grouse (*Bonasa bonasia*) (n = 5); three grey partridge (*Perdix perdix*) bones were also recorded (Table 5).

TABLE 5. Species composition of bird remains from medieval Aukuras hill hillfort, 1200–1400 AD. NISP – number of identified specimens

Bird species	♀	♂	Undetermined	NISP	%NISP
	n	n	n		
White stork / black stork (<i>Ciconia ciconia</i> / <i>C. nigra</i>)			1	1	0.3
Mute swan / whooper swan (<i>Cygnus olor</i> / <i>C. cygnus</i>)			1	1	0.3
Greylag goose (<i>Anser anser</i>)			3	3	0.8
Goose (<i>Anser</i> sp.)			9	9	2.4
Anseriformes			2	2	0.5
Anas (<i>Anas</i> sp.)			2	2	0.5
Diving ducks (<i>Aythya</i> sp.)			1	1	0.3
Northern goshawk (<i>Accipiter gentilis</i>)	7	4	3	14	3.8
Eurasian sparrowhawk (<i>Accipiter nisus</i>)	2			2	0.5
Golden eagle (<i>Aquila chrysaetos</i>)		1		1	0.3
Falconiformes			1	1	0.3
Common buzzard (<i>Buteo buteo</i>)	3			3	0.8
Hazel grouse (<i>Bonasa bonasia</i>)			5	5	1.3
Black grouse (<i>Tetrao tetrix</i>)	3	6	2	11	3.0
Western capercaillie (<i>Tetrao urogallus</i>)		3	3	6	1.6
Black grouse / western capercaillie (<i>Tetrao tetrix</i> / <i>T. urogallus</i>)			3	3	0.8
Grey partridge (<i>Perdix perdix</i>)			3	3	0.8
Domestic chicken (<i>Gallus gallus domesticus</i>)		4	124	128	34.4
Galliformes			137	137	36.8
Stock dove (<i>Columba oenas</i>)			2	2	0.5
Common wood pigeon (<i>Columba palumbus</i>)	1	1		2	0.5
Eurasian magpie (<i>Pica pica</i>)			1	1	0.3
Rook (<i>Corvus frugilegus</i>)			1	1	0.3
Hooded crow (<i>Corvus cornix</i>)			2	2	0.5
Common raven (<i>Corvus corax</i>)	2		25	27	7.3
Western jackdaw (<i>Coloeus monedula</i>)			2	2	0.5
Eurasian jay (<i>Garrulus glandarius</i>)			2	2	0.5
Total	18	19	335	372	100.0

Domestic chicken was the only undoubtedly domestic bird species identified in medieval Kernavė. Although remains of greylag goose (*Anser anser*) (n = 3) were recovered, it was not possible to determine whether they belonged to wild or domestic individuals. A relatively high proportion (5.6%) of bird remains belonged to birds of prey, most commonly the northern goshawk (*Accipiter gentilis*) (n = 14). Additional remains included the golden eagle (*Aquila chrysaetos*), Eurasian sparrowhawk (*Accipiter nisus*), common

buzzard (*Buteo buteo*), and an unidentified falcon (Table 5). Unexpectedly large numbers of common raven bones were identified ($n = 27$), including at least two female individuals. Other corvids, such as the hooded crow (*Corvus cornix*), Eurasian magpie (*Pica pica*), rook (*Corvus frugilegus*), western jackdaw, and Eurasian jay (*Garrulus glandarius*), were also present. Less frequent finds included remains of stock dove (*Columba oenas*) and common wood pigeon (*Columba palumbus*). In addition, remains of a white or black stork (*Ciconia ciconia* / *C. nigra*) and either a mute swan or whooper (*Cygnus olor* / *C. cygnus*) were recovered (Table 5).

Of the 438 fish bones and bone fragments recovered from the medieval cultural layer, 332 were identified, representing at least 16 freshwater and migratory fish species (Table 4). Remains of three migratory fish taxa accounted for 13.9% ($n = 46$) of identified fish remains. Among these, salmon (*Salmo salar*) bones were the most frequent ($n = 27$), followed by sturgeon (*Acipenser* sp.) scutes ($n = 15$) and eels, represented by four dentaries. Salmon were large in size; no individuals smaller than 90–100 cm were identified, while most specimens derived from fish measuring 100–110 cm or slightly more. Vertebrae and dentaries predominated among salmon remains. Based on the size of the recovered dentaries, the eels were approximately 80–100 cm long.

Cyprinids were the most abundant fish, comprising 47.3% ($n = 157$) of identified remains. A total of nine cyprinid species were identified. Bream was the most common species ($n = 67$), whereas common rudd (*Scardinius erythrophthalmus*), roach (*Rutilus rutilus*), tench (*Tinca tinca*), and vimba bream (*Vimba vimba*) were represented by 6–9 fragments each (Table 4). Less frequent taxa included asp (*Leuciscus aspius*), ide (*Leuciscus idus*), common chub (*Squalius cephalus*), and crucian carp (*Carassius carassius*). Most bream measured 40–45 cm, with another common size group ranging from 30 to 35 cm. Rudd were typically 25–30 cm long. Tench and asp tended to be relatively large, with estimated lengths of 40–45 cm and 60–70 cm, respectively. Crucian carp measured approximately 20–25 cm, whereas chub reached 50–60 cm.

Pike accounted for 29.8% of all identified fish remains. Estimated body lengths ranged from 30–40 cm to 110–120 cm or more. Small pikes (30–40 cm) were very scarce (4.4%), while individuals measuring 60–80 cm predominated (50.7%). More than one-fifth (21.7%) of the pike were exceptionally large, reaching 90–120 cm in length.

Other predatory fish were generally large in size. Perch ranged from 25 to 45 cm, while zander (*Sander lucioperca*) were most commonly 40–60 cm long. Most catfish were large individuals; although some measured 50–60 cm, specimens representing fish 100–150 cm in length predominated. Various skeletal elements were recovered, although cranial bones were considerably

more frequent than vertebrae. Approximately 80 fish scales were also found, most of which belonged to cyprinids and percids.

Discussion

Long-term changes in farming and subsistence practices at Kernavė are assessed through the analysis of faunal remains from Aukuras hill hillfort. Particular attention is paid to temporal variation in taxonomic representation, the relative abundance of domestic and wild taxa, and changes in faunal diversity and exploitation patterns over time.

FROM THE NEOLITHIC TO THE LATE BRONZE AGE: REGIONAL DEVELOPMENTS IN FARMING AND SUBSISTENCE

The earliest zooarchaeological material recovered from Aukuras hill hillfort reflects the subsistence economy of local communities during the Late Bronze Age. By the end of the 2nd millennium BC, agriculture had already become fully established in Lithuania, although the precise timing and regional variability of this process remain unclear. Domestic animals first appeared in present-day Lithuania at the beginning of the 3rd millennium BC (Piličiauskas et al. 2017a; 2017b; Piličiauskas 2018). However, knowledge concerning the nature and economic significance of animal husbandry during the 3rd–2nd millennia BC remains extremely limited. This is largely due to the near absence of zooarchaeological material dating from the Neolithic to the Late Bronze Age. With the exception of the Alksnynė 3 site, faunal evidence is limited to a small number of directly dated domestic animal bones recovered from multi-period settlements where material from different periods is mixed (Piličiauskas et al. 2017b; Piličiauskas 2018). Therefore, while Neolithic economies can still be reconstructed from limited faunal remains and human skeletal material, the Early Bronze Age record relies almost exclusively on organic residue analyses, as human remains from this period are absent and animal bones are exceedingly rare. Evidence derived from analyses of Early Bronze Age pottery suggests that during this period, fish remained an important component of the diet despite the introduction of domestic animals (Piličiauskas 2018; Piličiauskas et al. 2018; Podėnas et al. 2023).

The situation changes considerably during the Late Bronze Age, when fortified settlements first appear in the archaeological record. Excavations at these sites, as well as at open sites, have recovered abundant and well-preserved faunal and plant remains, making this period considerably better documented than the preceding Neolithic and Early Bronze Age (Luik et al. 2022; Minkevičius et al. 2023; 2026). The earliest cultivated crops in the region, primarily barley and millet, appeared around 1300 cal BC

(Piličiauskas et al. 2021; 2022). By around 1000 cal BC, crop cultivation had intensified significantly, as reflected in the increasing diversity of cultivated plant taxa (Minkevičius et al. 2020; 2023). Faunal analyses from northeastern Lithuanian hillforts indicate that between 900 and 600 cal BC, small domestic ungulates, particularly pigs and, to a lesser extent, sheep, predominated in animal husbandry and consumption practices. In contrast, cattle and horses occur only in small numbers, accounting for up to 10% and 5% of identified faunal remains, respectively. The relatively low representation of cattle, which likely served primarily as draught animals, may reflect the still limited scale of crop cultivation in eastern Lithuania during this period. Consequently, Late Bronze Age communities in the region appear to have relied more heavily on animal husbandry than on arable farming (Bliujienė et al. 2020; Minkevičius et al. 2023).

The representation of wild animals at fortified Late Bronze Age sites across both eastern and western Lithuania was consistently low, generally accounting for only 7–10% of identified faunal remains (Luik et al. 2022; Micelicaite et al. 2023; Minkevičius et al. 2026). This pattern appears to have been characteristic of the entire territory of present-day Lithuania and suggests that wild fauna no longer played a significant role in subsistence during this period. According to zooarchaeological evidence, stable isotope analyses of pottery food crusts, and human remains, fish were likewise of relatively minor importance during the Late Bronze Age (Piličiauskas et al. 2017a; Simčenka et al. 2022; Podėnas et al. 2023). In eastern Lithuania, fish remains generally comprise up to 3.6% of faunal assemblages (Luik et al. 2022; Micelicaite et al. 2023), whereas a somewhat higher proportion (10%) was recorded at the Kukuliškiai fortified site in coastal Lithuania (Minkevičius et al. 2026).

Bird remains are almost entirely absent from Late Bronze Age fortified site assemblages throughout Lithuania, although birds are known from Stone Age settlements (Stančikaitė et al. 2009). This likely indicates that the hunting of wild birds had greatly declined by this period, while the earliest domestic birds, specifically chickens, had not yet reached the territory of present-day Lithuania.

The representation of horses at Late Bronze Age settlement sites in western Lithuania and Latvia increased at least ten- to twentyfold compared with Stone Age sites, reaching 10–40% of identified faunal remains (Bliujienė et al. 2020; Minkevičius et al. 2026). Furthermore, around 1000 cal BC in western Latvia (Vasks et al. 2019; 2021) and later, during the late Pre-Roman period in western Lithuania (Bliujienė et al. 2020; Piličiauskienė et al. 2022; Budvydas & Juškaitis 2024), horse burial and sacrifice practices emerged. The notable increase in horse remains, together with the appearance of horse-related ritual practices, was most likely related to the spread of

modern DOM2-type horses (Niskanen 2023; Anthony et al. 2026), which may also have contributed to the emergence of a horse cult in the eastern Baltic region.

ANIMAL EXPLOITATION AT AUKURAS HILL HILLFORT, LATE BRONZE AGE–EARLY ROMAN PERIOD

Although the number of identified specimens is relatively small, the faunal assemblage from Aukuras hill hillfort appears relatively typical compared with those from other 1st-millennium BC sites in Lithuania, suggesting that the main pattern observed is unlikely to be substantially biased by the limited sample size. Wild mammals accounted for approximately 10% of identified mammal remains during the Late Bronze Age, and their representation remained largely unchanged until the medieval period, varying between 10% and 13%. From the Late Bronze Age onward, the inhabitants of Kernavė kept all major domestic animal species, although their representation changed over time. During the Late Bronze Age, animal husbandry was dominated by small domestic ungulates – sheep/goats and especially pigs – which together accounted for 61.3% of identified domestic animal remains. This proportion is somewhat higher than at Kukuliškiai fortified site in coastal Lithuania (Minkevičius et al. 2026), but lower than at hillforts in northeastern Lithuania, where pig remains alone comprised 45–58% of faunal assemblages (Fig. 2).

Changes in animal husbandry practices at Kernavė became apparent during the late Pre-Roman–early Roman period. At this time, the proportion of cattle more than doubled, reaching 42.3%, while the proportion of pigs and sheep/goats decreased by approximately one-third (Fig. 2). No major subsequent changes are evident, and a similar taxonomic composition of domestic animals persisted until the medieval period.

The increase in cattle during the late Pre-Roman–early Roman period may be associated with the intensification of arable farming. Expanding cultivated areas would have required larger numbers of draught animals, as well as greater quantities of manure, both of which were primarily provided by cattle. These changes and the possible intensification of crop cultivation broadly coincide with the climatic optimum associated with the Roman Warm Period (Campbell et al. 1998). Archaeobotanical analyses from Aukuras hill hillfort indicate substantial agricultural changes, particularly the introduction of rye cultivation, which gradually replaced the previously dominant millet. However, these developments likely began somewhat later, around the 5th century AD (Minkevičius et al. 2025).

One of the most significant discoveries among the Aukuras hill hillfort faunal remains is related to the appearance of another domesticated animal species in Lithuania and the eastern Baltic region. Bones (Fig. 3) of at least

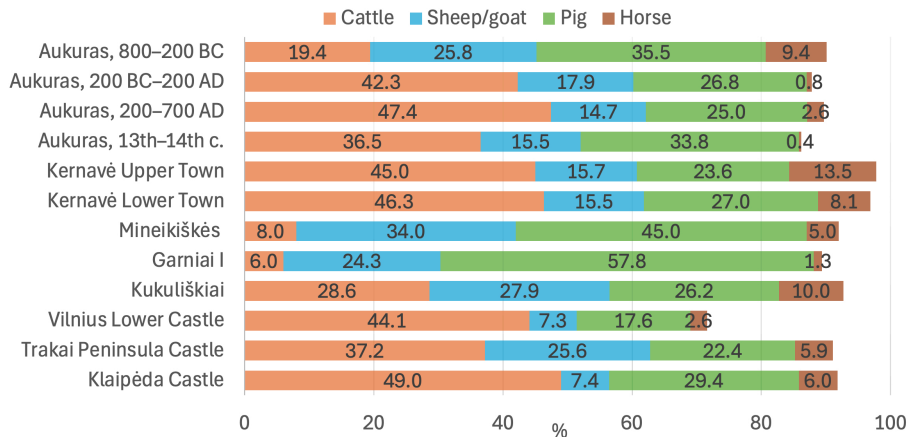


FIG. 2. Taxonomic composition of domestic animals at Aukuras hill hillfort during different occupation periods and at other archaeological sites in Lithuania. Chronologies of the sites and references for the data: Garniai I and Mineikiškės fortified sites, 900–500 cal BC (Micelicaite et al. 2023); Kukuliškiai fortified site, 900–500 cal BC (Minkevičius et al. 2026); Kernavė Lower Town, 13th–14th centuries (Luchtanas 1990); Kernavė Upper Town, 13th–14th centuries (Baublienė et al. 2004); Vilnius Lower Castle, 13th–mid-14th centuries (Piličiauskienė & Blaževičius 2018); Klaipėda Castle, 13th–14th centuries (Ehrlich et al. 2020); Trakai Peninsula Castle, late 14th–15th centuries (Piličiauskienė et al. 2024). For more details, see Table 2.

three chickens (MNI = 3) were recovered from a cultural layer dated to 200 cal BC–200 cal AD, representing the earliest evidence of domestic chicken currently known in Lithuania. Chickens appeared in Scandinavia and Estonia during approximately the same period (Lepiksaar 1977; Ehrlich et al. 2021; Olli et al. 2026), and their discovery in Lithuania was therefore not entirely unexpected. Nevertheless, prior to this study, confirmed chicken remains in Lithuania had only been known from medieval contexts (Rumbutis et al. 2018).

ANIMAL EXPLOITATION AND ELITE PRACTICES AT MEDIEVAL AUKURAS HILL HILLFORT

The relatively small faunal assemblage dated to 200–700 cal AD from Aukuras hill hillfort does not indicate major changes in farming practices. In contrast, the 13th–14th-century zooarchaeological material is considerably more informative. During the medieval period, wild animals accounted for 13.2% of identified mammal remains at the site, which can be considered a relatively high proportion. In medieval contexts, wild fauna is generally more abundant at sites associated with elites, particularly castles and hillforts. For example, wild animals constituted 28% of identified mammal remains at the Vilnius Lower Castle during the 13th–14th centuries (Piličiauskienė & Blaževičius 2018), 9% at Trakai Peninsula Castle (Piličiauskienė et al. 2024),



FIG. 3. The earliest remains of domestic chicken from Aukuras hill hillfort, 200 cal BC–200 cal AD.

and 7% at Klaipėda Castle (Ehrlich et al. 2020). In contrast, wild animal remains in medieval towns usually comprise less than 1% of assemblages (Piličiauskienė, unpublished data; Piličiauskienė & Blaževičius 2018).

Differences are also evident between contemporaneous but socially distinct areas of medieval Kernavė, including Aukuras hill hillfort, the Upper Town, and the Lower Town. The latter two were inhabited by ordinary townspeople, and wild animal remains there account for only around 1% of identified fauna – approximately ten times less than at the hillfort (Luchtanas 1990; Baublienė et al. 2004; Vėlius et al. 2025). In contrast, Aukuras hill hillfort served as the residence of the ruling elite, and hunting during the medieval period was closely associated with aristocratic privilege and lifestyle. It functioned not only as a form of leisure but also as an important means of political interaction and a practice connected with economic prestige and benefit (Jaworski 2001; Petrauskas 2003).

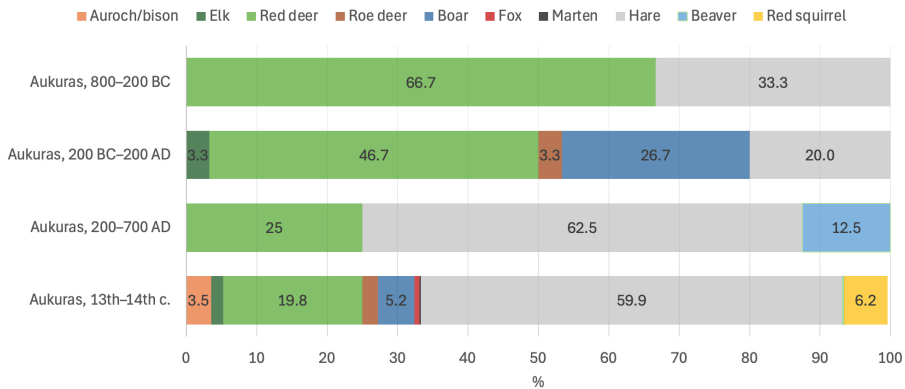


FIG. 4. Taxonomic composition of the main wild game species at Aukuras hill hillfort during different occupation periods. For more details, see Table 2.

Although wild animal remains are relatively well represented at Aukuras hill hillfort, as is typical of high-status sites, the taxonomic composition of the hunted fauna is unusual and differs significantly from that observed at other medieval castles and hillforts. Rather than being dominated by large ungulates – the typical prey associated with aristocratic hunting – the assemblage at Aukuras hill hillfort is characterised primarily by small game, especially hares. Hare remains account for as much as 59.9% of identified wild mammals, while red squirrels comprise an additional 6.2% (Fig. 4). In contrast, remains of bison/auroch and elk are scarce, representing only a few per cent of the assemblage. Conversely, hare and red squirrel remains are generally rare in medieval castles, even when faunal remains are collected by sieving (Ehrlich et al. 2020; Vengalis 2020; Piličiauskienė et al. 2024; Piličiauskienė & Micelicaite 2026).

The unusually high abundance of hares and red squirrels at medieval Kernavė may reflect the character of local hunting practices, particularly hunting with birds of prey. Notably, remains of the northern goshawk, the most popular hunting bird in medieval Lithuania, were also exceptionally abundant at Aukuras hill hillfort, accounting for 3.8% of identified bird remains (Fig. 4). Goshawks may have been used to hunt small mammals, including red squirrels and hares, especially juveniles, as well as wild Galliformes, waterfowl, and pigeons (Tornberg 1997). Approximately 30% of hare remains from the site belonged to young individuals, some of them very young animals. Moreover, most of the hare bones at the site likely belonged to the mountain hare, which is smaller than the European hare, as the mountain hare was more widespread in Lithuania until the 17th–18th centuries (Isokas 2006). Large numbers of squirrel and hare remains have also been recorded in medieval Novgorod, where these animals were extensively hunted for their

fur (Maltby et al. 2020). Similarly, it cannot be ruled out that hares and red squirrels at Kernavė were hunted primarily for their fur.

Compared with other medieval castles and hillforts, cattle remains are less abundant at Aukuras hill hillfort. In the 13th–14th-century assemblage, the proportion of cattle unexpectedly declines to 36.5%, while pig remains increase correspondingly. This shift may reflect the dietary preferences of the higher-status residents at the hillfort. Pork, especially preserved products such as slabs of smoked bacon and ham, was highly valued and more widely consumed among medieval and early modern-period elites (Dambrauskaitė 2018; 2019; Piličiauskienė & Blaževičius 2018). This interpretation might be supported by the fact that pig remains were about 10% less common in the Upper and Lower Towns of Kernavė, where they account for only 23–27% of identified fauna (Fig. 2).

Cattle dominate Lithuanian urban faunal assemblages of the 15th–16th centuries, where they comprise 40–70% or more of identified mammal remains. The long-term increase in the importance of cattle began already during the Late Bronze Age, but intensified considerably from the second half of the 16th century onward, following the land reform, when expanding cultivated land increased the demand for draught animals and manure, resulting in more intensive cattle breeding and greater beef consumption in urban areas (Piličiauskienė & Blaževičius 2018).

Differences in the faunal assemblages between the distinct medieval zones of Kernavė are also particularly evident in relation to horses (Fig. 2). In contrast to Aukuras hill hillfort – the presumed ducal residence area – horse remains were exceptionally abundant in the contemporaneous urban contexts of the Upper and Lower Towns, where they accounted for 8–13% of identified mammal remains (Luchtanas 1990; Baublienė et al. 2004). By comparison, horse remains are considerably less common (2.6–6.0%) at other high-status medieval sites in Lithuania, including Klaipėda Castle, Vilnius Lower Castle, and Trakai Peninsula Castle. In most other 15th–16th-century urban assemblages, horses generally comprise no more than 2–3% of identified mammals (Piličiauskienė & Blaževičius 2018; Ehrlich et al. 2020; Piličiauskienė et al. 2024).

The unusually numerous horse remains in the Kernavė Upper and Lower Towns may indicate specialised activities, possibly including the slaughter and processing of horses no longer suitable for work. However, horse bones bearing butchery marks are rare in all medieval contexts at Kernavė, generally accounting for only 5–10% of horse remains (Piličiauskienė, unpublished data; Vengalis 2020). Valentina Danilchenko, who analysed the faunal assemblage from the Lower Town, likewise stated that horse meat consumption was uncommon there (Luchtanas 1990). In contrast, horse bones with butchery marks comprise up to 30% or even 40% of horse remains

at the Vilnius Lower Castle and Trakai Peninsula Castle (Piličiauskienė & Blaževičius 2018; Piličiauskienė et al. 2024).

The inhabitants of Aukuras hill hillfort appear to have kept predominantly sheep rather than goats. This interpretation is supported by both the identified specimens and the wider zooarchaeological record from Lithuania. From the Late Bronze Age onward, sheep remains consistently outnumbered goat remains in settlement assemblages (Micelicaite et al. 2023). This pattern persisted throughout the medieval and post-medieval periods. Estate inventories from the post-medieval period similarly indicate that goats, unlike sheep, were usually kept only in very small numbers. Zooarchaeological evidence confirms the same tendency. For example, at the Vilnius Lower Castle, sheep-to-goat ratios vary between 7:3 and 8:2, depending on the chronological period (Piličiauskienė & Blaževičius 2018).

FISH, BIRDS, AND FALCONRY AT MEDIEVAL AUKURAS HILL HILLFORT

The diversity of fish remains recovered from Aukuras hill hillfort is exceptionally high, comprising at least 16 species. By comparison, 12 fish species have been identified at the Vilnius Lower Castle, ten at Trakai Peninsula Castle, and nine at Klaipėda Castle (Piličiauskienė & Blaževičius 2018; Ehrlich et al. 2020; Piličiauskienė et al. 2024). The higher diversity at Aukuras hill hillfort may partly be related to excavation methods, as the material from the other sites was not systematically sieved, potentially resulting in the underrepresentation of small fish remains. Most fish species identified at Aukuras hill hillfort were likely caught in the nearby River Neris. In general, fish, particularly sturgeon, salmon, and large pike, were expensive and highly valued food in the medieval period, commonly associated with elite diets. Remains of such fish are usually encountered only in high-status contexts. Pike, in particular, appears to have been the most popular fish among the Lithuanian nobility during the medieval and post-medieval periods (Piličiauskienė & Blaževičius 2019). The abundance of large and valuable fish species, including salmon, sturgeon, and pike, at Aukuras hill hillfort further supports the interpretation of the high social status of the inhabitants of this area.

Nevertheless, despite the presence of several prestigious fish species, fish do not appear to have played an important role in the diet of either commoners or elites. The final decline in fish consumption that began during the Late Bronze Age remained evident throughout the Migration and Viking periods. The importance of fish increased somewhat after the Christianisation of Lithuania in 1387, although primarily among elite social groups. Even during the late medieval and post-medieval periods, however, fish consumption in Lithuania remained lower than in neighbouring Poland and

in northern and western Europe, while peasants consumed fish only rarely (Whitmore 2014; Piličiauskienė & Blaževičius 2019; Whitmore et al. 2019; Skipitytė et al. 2020; Skipitytė 2022).

Bird remains account for 3.1% of the assemblage dated to 200 cal BC–200 cal AD and 5.1% of the medieval assemblage. The latter value is relatively high and is typical of elite medieval sites. The high proportion of bird remains at Aukuras hill hillfort may also partly reflect the use of sieving during excavation, which likely increased the recovery of small bird bones. Birds were consumed more frequently by higher social strata, and their remains therefore occur in greater numbers at castles and manor sites. At the Vilnius Lower Castle, bird remains comprised 3.1% of the assemblage during the 13th–mid-14th centuries and increased to 8.1% during the 16th–mid-17th centuries. In contrast, bird remains in Lithuanian urban contexts of the 15th–16th centuries generally account for only 1–2% of identified fauna. Domestic chicken bones constitute approximately 60–70% of bird remains in Lithuanian assemblages dated to the 13th–16th centuries (Rumbutis et al. 2018; Ehrlich et al. 2020; 2023; Piličiauskienė & Micelicaitė 2026).

In the 200 cal BC–200 cal AD assemblage, domestic chickens accounted for at least 21.9% of identified bird remains. In the 13th–14th-century bird assemblage, chickens comprise at least 34.4%, while a further 36.8% of remains were identified only generally as Galliformes (Fig. 5). Considering that chickens account for the majority of identified galliform remains, it is likely that many of the unidentified galliform specimens also represent chickens. Greylag goose and other *Anser* remains are relatively rare at Aukuras hill hillfort, making up only 3.2% of the medieval bird assemblage, despite being common in medieval faunal collections. For example, geese comprised approximately 25% of bird remains at the Vilnius Lower Castle (Rumbutis et al. 2018). However, hand-collecting at the Vilnius Castle likely contributed to the more efficient recovery of goose bones. Morphological analysis did not allow determination of whether the greylag geese recovered at Aukuras hill hillfort were wild or domestic individuals.

Among wild birds from the 13th–14th centuries, Galliformes formed the largest group, particularly black grouse, with smaller numbers of capercaillie, hazel grouse, and partridge. During the medieval period, these birds were among the most frequently hunted and consumed game birds of the elite. Similar taxa have been recorded at the Vilnius Lower Castle (Rumbutis et al. 2018; Ehrlich et al. 2023). Western capercaillie and black grouse are widely regarded as indicators of elite environments (Makowiecki et al. 2013).

Northern goshawk remains at Aukuras hill hillfort are almost three times more abundant than at the Vilnius Lower Castle, accounting for 3.8% and 1.3% of identified bird remains, respectively (Rumbutis et al. 2018). As is typical in falconry assemblages, females outnumber males. Female goshawks

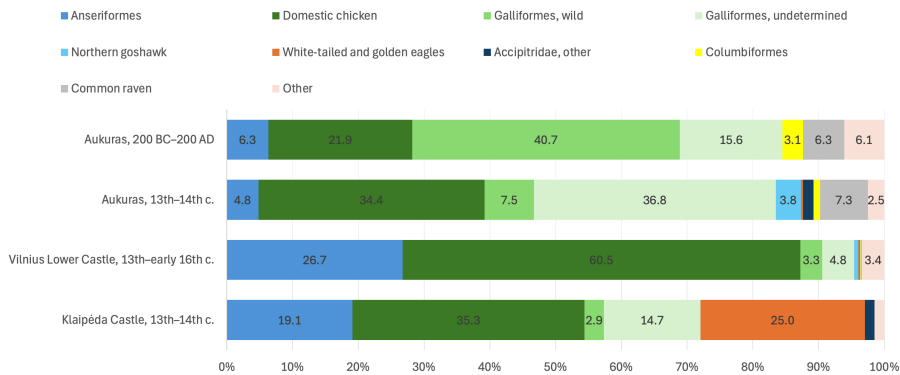


FIG. 5. Bird taxa identified at Aukuras hill hillfort, Vilnius Lower Castle (Rumbutis et al. 2018; Ehrlich et al. 2023), and Klaipėda Castle (Ehrlich et al. 2020).

are larger and capable of hunting larger prey, making them more desirable for hunting purposes. According to historical and zooarchaeological data (Rumbutis et al. 2018; Zarankaitė-Margienė 2018; Ehrlich et al. 2023), goshawks were the most popular birds used in medieval falconry in the region, owing to their local availability, suitability for hunting in the regional environment, and relatively low cost compared with other birds of prey (Dynak 1993; Makowiecki 2009). Other raptors identified at the site include the sparrowhawk, golden eagle, and falcon. Under Lithuanian environmental conditions, hunting with golden eagles would likely have been difficult, whereas sparrowhawks were commonly used to hunt small galliform, columbigorm, and passerine birds (Prummel 1997). Although birds of prey are exceptionally abundant at Aukuras hill hillfort, no remains of other expensive birds commonly associated with elite medieval contexts – such as the common pheasant (*Phasianus colchicus*) and peafowl (*Pavo cristatus*), which became relatively frequent in the Vilnius Lower Castle assemblages during the late 14th–early 16th centuries – have yet been identified at Kernavė (Rumbutis et al. 2018; Ehrlich et al. 2023).

Exceptionally large numbers of common raven bones ($n = 27$; 7.3%) were recovered from the 13th–14th-century layers at Aukuras hill hillfort, together with remains of other corvids. These birds may have been used in the training of hunting raptors and may also have served as food for birds of prey (Hamilton-Dyer et al. 2016). On the other hand, owing to their intelligence and social behaviour, corvids were also frequently kept as pets (Tyrberg 2002), and this possibility cannot be excluded in the case of Kernavė. Ravens and crows also occupied a prominent place in Lithuanian and broader European mythology, often being associated with the afterlife (Racėnaitė 2005; Plachovičiūtė 2023). Various skeletal elements of corvids were recovered, particularly humeri and tarsometatarsi, although it remains

difficult to determine the precise reasons for the unusually high frequency of common raven remains at the site.

Taken together, in the context of Kernavė and Lithuania, the faunal assemblage from Aukuras hill hillfort broadly follows regional patterns during the Late Bronze Age and Iron Age, while the medieval assemblage reveals greater differences between sites. The medieval fauna shares features with other high-status sites but also differs from that of the contemporaneous Upper and Lower Towns of Kernavė. These comparisons demonstrate that animal exploitation varied not only through time but also between different social and functional contexts within the same archaeological complex.

Conclusions

The faunal assemblage from Aukuras hill hillfort provides valuable evidence for understanding long-term developments in animal exploitation and subsistence practices from the Late Bronze Age through the Iron Age and medieval period in the eastern Baltic. Although the number of identified specimens varies between periods, the overall patterns are broadly consistent with those observed at other sites in Lithuania. The study indicates that farming was already fully established during the Late Bronze Age and followed the general pattern observed in northeastern Lithuania. During the late Pre-Roman and early Roman periods, the increasing importance of cattle may indicate changes in farming strategies, likely associated with the intensification of crop cultivation and the expansion of arable farming. The appearance of domestic chickens during this period provides some of the earliest evidence of chicken husbandry in Lithuania.

The medieval assemblage from Aukuras hill hillfort reveals a distinct pattern of elite consumption that differed from that of the contemporaneous urban population of Kernavė and, in some respects, from those of other elite centres in the region. Pork, birds, fish, and wild game appear to have played a more important role in the diet of the hillfort inhabitants.

Unlike many contemporary elite centres, where hunting was primarily oriented towards large ungulates, the medieval faunal remains from Aukuras hill hillfort point to the greater importance of falconry. The abundance of northern goshawk remains and small game animals, particularly hares, suggests that elite hunting in Kernavė was characterised by specialised hunting practices focused on smaller prey. This pattern may suggest that hunting at Kernavė was oriented towards falconry and small game rather than the prestigious large-ungulate hunts characteristic of many contemporary elite centres. The scarcity of large game may indicate that the inhabitants of Aukuras hill hillfort occupied a somewhat different social and political position from the elites of major political centres, where large-game hunting

played a more prominent role in social status, political culture, and elite interaction.

DATA AVAILABILITY STATEMENT

All data supporting the results of this study are included within the article.

ACKNOWLEDGEMENTS

Giedrė Piličiauskienė is very grateful to Viktorija Micelicaitė for her invaluable assistance with the faunal analysis. We are also very grateful to the reviewers for their thoughtful comments and suggestions, which helped us improve the quality of the manuscript. We also sincerely thank the copyeditor for the careful editing of the article. This research was funded by the Research Council of Lithuania (grant No. S-MIP-21-22). The publication costs of this article were partially covered by the Estonian Academy of Sciences.

References

- Anthony, D., Trautmann, M. & Heyd, V.** 2026. Horse genetics, archaeology, and the beginning of riding. – *Science Advances*, 12: 20, eady7336. <https://doi.org/10.1126/sciadv.ady7336>
- Baltramiejūnaitė, D., Poškienė, J., Vengalis, R. & Vėlius, G.** 2019. The Discovered Kernavė: A Catalogue of the Archaeological Site Museum of Kernavė. Petro ofsetas, Vilnius.
- Baublienė, J., Daugnora, L., Trainienė, R., Vaičiūnienė, D. & Veličkaitė, S.** 2004. XIV a. sodyboje (Viršutinis Kernavės miestas) iškastos osteologinės medžiagos analizė. – *Lietuvos archeologija*, 26, 161–166.
- Bilskienė, R. & Daugnora, L.** 2001. Paukščiai Lietuvos pilyse. – *Lietuvos pilių archeologija*. Klaipėdos universiteto leidykla, Klaipėda, 251–260.
- Bliujienė, A., Skipitytė, R., Garbaras, A., Miliauskienė, Ž., Šapolaitė, J., Ežerinskis, Ž. et al.** 2020. The first data on the human diet in Late Roman and Early Migration period western Lithuania: evidence from stable isotope, archaeobotanical and zooarchaeological analyses. – *Journal of Archaeological Science: Reports*, 33, 102545. <https://doi.org/10.1016/j.jasrep.2020.102545>
- Boessneck, J., Müller, H.-H. & Teichert, M.** 1964. Osteologische Unterscheidungsmerkmale zwischen Schaf (*Ovis aries* Linnaeus) und Ziege (*Capra hircus* Linnaeus). – *Kühn-Archiv*, 78, 1–129.
- Budvydas, U. & Juškaitis, V.** 2024. Slengių kapinynas. – *Archeologiniai tyrinėjimai Lietuvoje 2023 metais*. Lietuvos archeologijos draugija, Vilnius, 84–88.
- Campbell, I. D., Campbell, C., Apps, M. J., Rutter, N. W. & Bush, A. B. G.** 1998. Late Holocene ~1500 yr climatic periodicities and their implications. – *Geology*, 26: 5, 471–473. [https://doi.org/10.1130/0091-7613\(1998\)026<0471:LHYCPA>2.3.CO;2](https://doi.org/10.1130/0091-7613(1998)026<0471:LHYCPA>2.3.CO;2)
- Dambrauskaitė, N.** 2018. Mėšos ir žuvies vartojimo reikšmė Lietuvos didžiųjų kunigaikščių virtuvėje. – *Vilniaus pilių fauna: nuo kepsnio iki draugo*. Eds P. Blaževičius, N. Dambrauskaitė, H. Luik, G. Piličiauskienė, S. Rumbutis & T. Zarankaitė-Margienė. Vilniaus universiteto leidykla, Vilnius, 216–242.
- Dambrauskaitė, N.** 2019. Lietuvos Didžiosios Kunigaikštystės bajorų namai XVI a.–XVII a. pirmoje pusėje. Vilniaus universiteto leidykla, Vilnius.
- von den Driesch, A.** 1976. A Guide to the Measurement of Animal Bones from Archaeological Sites. Peabody Museum Press, Cambridge, MA.

- Dynak, W.** 1993. Łowy, łowcy i zwierzyzna w przysłowiach polskich. Towarzystwo Przyjaciół Polonistyki Wrocławskiej, Wrocław.
- Ehrlich, F., Piličiauskienė, G., Ubė-Urbonaitė, M. & Rannamäe, E.** 2020. The meaning of eagles in the Baltic region: a case study from the castle of the Teutonic Order in Klaipėda, Lithuania (13th–14th century). – *Archaeologia Lituana*, 21, 59–78. <https://doi.org/10.15388/ArchLit.2019.21.4>
- Ehrlich, F., Rannamäe, E., Laneman, M., Tõrv, M., Lang, V., Oras, E. et al.** 2021. In search of Estonia's earliest chicken. – *Estonian Journal of Archaeology*, 25: 2, 160–181. <https://doi.org/10.3176/arch.2021.2.04>
- Ehrlich, F., Piličiauskienė, G. & Blaževičius, P.** 2023. Bird remains from Vilnius Lower Castle, Lithuania (13th–19th centuries) reveal changes in social status and unusual bird pathologies. – *International Journal of Osteoarchaeology*, 33: 4, 731–741. <https://doi.org/10.1002/oa.3193>
- Grant, A.** 1982. The use of tooth wear as a guide to the age of domestic ungulates. – *Ageing and Sexing Animal Bones from Archaeological Sites*. Eds B. Wilson, C. Grigson & S. Payne. (British Archaeological Reports. British Series, 109.) BAR Publishing, Oxford, 91–108.
- Hamilton-Dyer, S., Brisbane, M. & Maltby, M.** 2016. Fish, feather, fur and forest: exploitation of wild animals in medieval Novgorod and its territory. – *Quaternary International*, 460, 97–107. <https://doi.org/10.1016/j.quaint.2016.04.024>
- Isokas, G.** 2006. Lietuvos girių ir medžioklės istorija. Mintis, Vilnius.
- Jaworski, R.** 2001. Łowy Władysława Jagiełły. – *Z biografistyki Polski późnego średniowiecza*. Ed. M. Koczerska. (Fasciculi Historici Novi, IV.) Wydawnictwo DiG, Warszawa, 7–86.
- Kobryńczuk, F. & Kobryń, H.** 1993. Sexing of domestic cattle from the early ages on the basis of osteometry of metapodia. – *Annals of Warsaw Agricultural University*, 17, 11–18.
- Kulikauskas, P. & Luchtanas, A.** 1979. „Mindaugo sosto“ piliakalnio tyrinėjimai 1979 m. Dienoraštis. – Unpublished excavations report in the archive of the Lithuanian Institute of History, f. 1, b. 700.
- Lepiksaar, J.** 1977. Människan och husdjuren. – *Fauna och Flora*, 72, 79–101.
- Luchtanas, A.** 1986. Kernavės Pilies kalno tyrinėjimai. – *Archeologiniai tyrinėjimai Lietuvoje 1984 ir 1985 metais*, Vilnius, 32–35.
- Luchtanas, A.** 1990. Tyrinėjimai Pajautos slėnyje Kernavėje. – *Archeologiniai tyrinėjimai Lietuvoje 1988 ir 1989 metais*, Vilnius, 148–152.
- Luik, H., Piličiauskienė, G., Podėnas, V., Micelicaitytė, V., Minkevičius, K. & Čivilytė, A.** 2022. Animal bones, bone artefacts and bone working at Late Bronze Age fortified settlements in north-eastern Lithuania: Sokiškiai, Mineikiškės and Garniai I. – *Archaeologia Lituana*, 23, 237–268. <https://doi.org/10.15388/ArchLit.2022.23.14>
- Makowiecki, D.** 2009. Animals in the landscape of the medieval countryside and urban agglomerations of the Baltic Sea countries. – *Città e campagna nei secoli altomedievali*: Spoleto, 27 marzo – 1 aprile 2008. Settimane di studio del Centro italiano di studi sull'alto medioevo, 56: 1, 427–444.
- Makowiecki, D., Tomek, T. & Bochenski, Z. M.** 2013. Birds in early medieval Greater Poland: consumption and hawking. – *International Journal of Osteoarchaeology*, 24: 3, 358–364. <https://doi.org/10.1002/oa.2366>

- Maltby, M., Hamilton-Dyer, S., Zinoviev, A. V. & Sablin, M.** 2020. The exploitation of wild mammals in Novgorod and sites in its immediate hinterland. – *Animals and Archaeology in Northern Medieval Russia: Zooarchaeological Studies in Novgorod and its Region*. Eds M. Maltby, M. Brisbane, E. Hambleton, S. Hamilton-Dyer, O. A. Krylovich, M. Sablin et al. (The Archaeology of Medieval Novgorod Series.) Oxbow Books, Oxford, 223–238.
- Micelicaite, V., Piličiauskienė, G., Podėnas, V., Minkevičius, K. & Damušytė, A.** 2023. Zooarchaeology of the Late Bronze Age fortified settlements in Lithuania. – *Heritage*, 6: 1, 333–350. <https://doi.org/10.3390/heritage6010017>
- Minkevičius, K.** 2020. Žemdirbystės raida ir gyvenviečių dinamika Lietuvoje XI a. pr. Kr.–XII a. (archeobotaninių tyrimų duomenimis). Doctoral thesis. Vilnius University, Vilnius.
- Minkevičius, K., Podėnas, V., Urbonaitė-Ubė, M., Ubis, E. & Kisieliene, D.** 2020. New evidence on the southeast Baltic Late Bronze Age agrarian intensification and the earliest AMS dates of *Lens culinaris* and *Vicia faba*. – *Vegetation History and Archaeobotany*, 29, 327–338. <https://doi.org/10.1007/s00334-019-00745-2>
- Minkevičius, K., Piličiauskienė, G., Podėnas, V., Micelicaite, V., Kontrimas, D., Šapolaitė, J. et al.** 2023. New insights into the subsistence economy of the Late Bronze Age (1100–400 cal BC) communities in the southeastern Baltic. – *Archaeologia Baltica*, 30, 58–79. <https://doi.org/10.15181/ab.v30i0.2564>
- Minkevičius, K., Vengalis, R., Piličiauskienė, G., Poškienė, J., Pilkauskas, M. & Vėlius, G.** 2025. Agricultural development in the southeastern Baltic region from the Late Bronze Age to the medieval period: a case study of Kernavė, southeast Lithuania. – *Vegetation History and Archaeobotany*, 34, 349–362. <https://doi.org/10.1007/s00334-024-01016-5>
- Minkevičius, K., Piličiauskienė, G., Urbonaitė-Ubė, M., Out, W. A., Mikkelsen, H. P., Jensen, P. M. et al.** 2026. Paradise lost: the rise and fall of the Late Bronze Age coastal farmers at Kukuliškiai, NW Lithuania. – *Vegetation History and Archaeobotany*. <https://doi.org/10.1007/s00334-026-01109-3>
- Niskanen, M.** 2023. The prehistoric origins of the domestic horse and horseback riding. – *Bulletins et Mémoires de la Société d'Anthropologie de Paris*, 35: 1, 54–73. <https://doi.org/10.4000/bmsap.11881>
- Olli, S., Gustavsson, R., Kivikero, H., Lõugas, L., Mannermaa, K., Piličiauskienė, G. et al.** 2026. Ancient DNA unravels the history of chickens in the Baltic Sea region and the continuity of landrace lineages. – *Heredity*, 135, 397–408. <https://doi.org/10.1038/s41437-026-00842-9>
- Payne, S.** 1973. Kill-off patterns in sheep and goats: the mandibles from Aşvan Kale. – *Anatolian Studies*, 23, 281–303. <https://doi.org/10.2307/3642547>
- Payne, S.** 1985. Morphological distinctions between the mandibular teeth of young sheep, *Ovis*, and goats, *Capra*. – *Journal of Archaeological Science*, 12: 2, 139–147. [https://doi.org/10.1016/0305-4403\(85\)90058-5](https://doi.org/10.1016/0305-4403(85)90058-5)
- Petrauskas, R.** 2003. Vytauto dvaras: struktūra ir kasdienybė. – *Naujasis Židinyš-Aidai*, 1: 2, 39–44.
- Piličiauskas, G.** 2018. Virvelinės keramikos kultūra Lietuvoje 2800–2400 cal BC. Lietuvos istorijos institutas, Vilnius.
- Piličiauskas, G., Jankauskas, R., Piličiauskienė, G., Craig, O. E., Charlton, D. & Dupras, T.** 2017a. The transition from foraging to farming (7000–500 cal BC) in the SE Baltic: a re-evaluation of chronological and palaeodietary evidence from human remains. – *Journal of Archaeological Science: Reports*, 14, 530–542. <https://doi.org/10.1016/j.jasrep.2017.06.004>

- Piličiauskas, G., Kisielienė, D. & Piličiauskienė, G.** 2017b. Deconstructing the concept of Subneolithic farming in the southeastern Baltic. – *Vegetation History and Archaeobotany*, 26, 183–193. <https://doi.org/10.1007/s00334-016-0584-9>
- Piličiauskas, G., Skipitytė, R. & Heron, C.** 2018. Mityba Lietuvoje 4500–1200 cal BC maisto liekanų keramikoje bendrųjų mėginių izotopinių tyrimų duomenimis. – *Lietuvos archeologija*, 44, 9–37.
- Piličiauskas, G., Vengalis, R., Minkevičius, K., Kisielienė, D., Ežerinskis, Ž., Šapolaitė, J. et al.** 2021. The earliest evidence for crop cultivation during the Early Bronze Age in the southeastern Baltic. – *Journal of Archaeological Science: Reports*, 36, 102881. <https://doi.org/10.1016/j.jasrep.2021.102881>
- Piličiauskas, G., Vengalis, R., Minkevičius, K., Skridlaitė, G. & Piličiauskienė, G.** 2022. Towards a better understanding of the Late Bronze Age in the southeastern Baltic: Tarbiškės settlements. – *Archaeologia Baltica*, 29, 149–168.
- Piličiauskienė, G. & Blaževičius, P.** 2018. Žinduoliai Vilniaus pilyse. – *Vilniaus pilių fauna: nuo kepsnio iki draugo*. Eds P. Blaževičius, N. Dambrauskaitė, H. Luik, G. Piličiauskienė, S. Rumbutis & T. Zarankaitė-Margienė. Vilniaus universiteto leidykla, Vilnius, 19–101.
- Piličiauskienė, G. & Blaževičius, P.** 2019. Archaeoichthyological and historical data on fish consumption in Vilnius Lower Castle during the 14th–17th centuries – *Estonian Journal of Archaeology*, 23: 1, 39–55. <https://doi.org/10.3176/arch.2019.1.03>
- Piličiauskienė, G., Kurila, L., Ežerinskis, Ž., Šapolaitė, J., Garbaras, A., Zagurskytė, A. et al.** 2022. Horses in Lithuania in the Late Roman–medieval period (3rd–14th C AD) burial sites: updates on size, age and dating. – *Animals*, 12: 12, 1549. <https://doi.org/10.3390/ani12121549>
- Piličiauskienė, G., Minkevičius, K., Šmigelskas, R. & Micelicaitytė, V.** 2024. Naujausi zooarcheologinės ir archeobotaninės medžiagos iš Trakų pusiasalio pilies tyrimai. – *Prakalbinta priešistorė*. Ed. G. Zabiela. Klaipėdos universiteto leidykla, Klaipėda, 260–278.
- Piličiauskienė, G. & Micelicaitytė, V.** 2026. Faunos liekanų iš Vilniaus Žemutinės pilies 2019–2020 m. archeologinių tyrinėjimų zooarcheologinė analizė. – Unpublished zooarchaeological report. Archive of the National Museum – Palace of the Grand Dukes of Lithuania, Vilnius.
- Plachovičiūtė, D.** Varna ir kranklys lietuvių ir slavų frazeologijoje bei etninėje kultūroje. – *Slavistica Vilnensis*, 68: 2, 101–114. [https://doi.org/10.15388/SlavViln.2023.68\(2\).8](https://doi.org/10.15388/SlavViln.2023.68(2).8)
- Podėnas, V., Luchtanas, A. & Čivilytė, A.** 2016. Narkūnų piliakalnių ir papėdės gyvenvietės keramika: elgsenos atspindžiai. – *Lietuvos archeologija*, 42, 191–241.
- Podėnas, V., Garbaras, A., Micelicaitytė, V., Minkevičius, K., Šapolaitė, J., Ežerinskis, Ž. et al.** 2023. Diet of the fortified settlement communities in Lithuania from 1000cal. BC to 200cal. AD. – *Journal of Archaeological Science: Reports*, 51, 104184. <https://doi.org/10.1016/j.jasrep.2023.104184>
- Prummel, W.** 1997. Evidence of hawking (falconry) from bird and mammal bones. – *International Journal of Osteoarchaeology*, 7: 4, 333–338. [https://doi.org/10.1002/\(SICI\)1099-1212\(199707/08\)7:4<333::AID-OA374>3.0.CO;2-7](https://doi.org/10.1002/(SICI)1099-1212(199707/08)7:4<333::AID-OA374>3.0.CO;2-7)
- Prummel, W. & Frisch, H. J.** 1986. A guide for the distinction of species, sex and body side in bones of sheep and goat. – *Journal of Archaeological Science*, 13: 6, 567–577. [https://doi.org/10.1016/0305-4403\(86\)90041-5](https://doi.org/10.1016/0305-4403(86)90041-5)
- Racėnaitė, R.** 2005. Gyvūnai mirties pranašai senojoje kultūroje. – *Gamta ir religija*. Ed. E. Usačiovaitė. Versus aureus, Vilnius, 178–205.
- Rumbutis, S., Blaževičius, P. & Piličiauskienė, G.** 2018. Paukščiai Vilniaus pilyse. – *Vilniaus pilių fauna: nuo kepsnio iki draugo*. Eds P. Blaževičius, N. Dambrauskaitė, H. Luik, G. Piličiauskienė, S. Rumbutis & T. Zarankaitė-Margienė. Vilniaus universiteto leidykla, Vilnius, 104–130.

- Silver, I. A.** 1969. The ageing of domestic animals. – Science in Archaeology. Eds D. Brothwell & E. S. Higgs. Thames and Hudson, London, 283–302.
- Simčėnka, E., Kozakaitė, J., Piličiauskienė, G., Gaižauskas, L. & Piličiauskas, G.** 2022. Human diet during Stone Age and Early Metal Period (7000–1 cal BC) in Lithuania: an update. – Radiocarbon, 64: 5, 1171–1189. <https://doi.org/10.1017/RDC.2022.41>
- Skipitytė, R.** 2022. Žmonių ir gyvūnų paleoekologija mitybos aspektu: stabilųjų izotopų tyrimai. Doctoral thesis. Vilnius University, Vilnius.
- Skipitytė, R., Lidén, K., Eriksson, G., Kozakaitė, J., Laužikas, R., Piličiauskienė, G. et al.** 2020. Diet patterns in medieval to early modern (14th–early 20th c.) coastal communities in Lithuania. – Anthropologischer Anzeiger, 77: 4, 299–312. <https://doi.org/10.1127/anthranz/2020/1092>
- Stančikaitė, M., Daugnora, L., Hjelle, K. & Hufthammer, A. K.** 2009. The environment of the Neolithic archaeological sites in Šventoji, western Lithuania. – Quaternary International, 207: 1–2, 117–129. <https://doi.org/10.1016/j.quaint.2009.01.012>
- Teichert, M.** 1969. Osteometrische Untersuchungen zur Berechnung der Widerristhöhe bei vor- und frühgeschichtlichen Schweinen. – Kühn-Archiv, 83: 3, 237–292.
- Teichert, M.** 1975. Osteometrische Untersuchungen zur Berechnung der Widerristhöhe bei Schafen. – Archaeozoological Studies. Papers of the Archaeozoological Conference, Groningen, 1974. Ed. A. T. Clason. North-Holland Publishing Company, Amsterdam, 51–69.
- Tornberg, R.** 1997. Prey selection of the Goshawk *Accipiter gentilis* during the breeding season: the role of prey profitability and vulnerability. – Ornis Fennica, 74, 15–28.
- Tsalkin, V. I.** 1960 = Цалкин В. И. Изменчивость метаподий и ее значение для изучения крупного рогатого скота древности. – Бюллетень московского общества испытателей природы. Отдел биологии, 65: 1, 109–125.
- Tyrberg, T.** 2002. The archaeological record of domesticated and tamed birds in Sweden. – Acta Zoologica Cracoviensia, 45, 215–231.
- Vaičiūnienė, D.** 2000. Kernavės viršutinio miesto tyrinėjimai. – Archeologiniai tyrinėjimai Lietuvoje 1998 ir 1999 metais. Lietuvos archeologijos draugija, Vilnius, 131–134.
- Vasks, A., Visocka, V., Daugnora, L., Ceriņa, A. & Kalniņa, L.** 2019. Krievu Kalns hillfort: new data on the Late Bronze Age and Pre-Roman Iron Age in western Latvia. – Archaeologia Baltica, 26, 80–107. <https://doi.org/10.15181/AB.V26I0.2024>
- Vasks, A., Zariņa, G., Legzdina, D. & Plankājs, E.** 2021. New data on funeral customs and burials of the Bronze Age Reznas cemetery in Latvia. – Estonian Journal of Archaeology, 25: 1, 3–31. <https://doi.org/10.3176/arch.2021.1.01>
- Vėlius, G., Vengalis, R., Piličiauskienė, G., Minkevičius, K. & Pilkauskas, M.** 2025. Kernavės piliakalniai. Vilniaus universiteto leidykla, Vilnius.
- Vengalis, R.** 2010. Kernavės senovės gyvenvietėje (16316), Kernavės senojo miesto vietoje (24567) ir Semeniškių senovės gyvenvietėje II (24574) (Širvintų r.) 2010 m. vykdytų archeologinių tyrinėjimų ataskaita. – Unpublished excavation report, KPC archive 39-1-3185.
- Vengalis, R.** 2012. Geležies amžiaus gyvenvietė Kernavėje: ilgalaikio apgyvendinimo atspindžiai archeologinėje medžiagoje. – Lietuvos archeologija, 38, 175–220.
- Vengalis, R.** 2014. Tyrimai Kernavės viršutiniame mieste. – Archeologiniai tyrinėjimai Lietuvoje 2013 metais. Lietuvos archeologijos draugija, Vilnius, 309–313.
- Vengalis, R.** 2016. Old and Middle Iron Age settlements and hillforts. – A Hundred Years of Archaeological Discoveries in Lithuania. Eds G. Zabiela, Z. Baubonis & E. Marcinkevičiūtė. Lietuvos archeologijos draugija, Vilnius, 160–181.

- Vengalis, R.** 2020. Kernavės piliakalnių ir jų aplinkos (Širvintų r. sav., Kernavės sen.) archeologinių tyrimų 2018 m. ataskaita. – Unpublished excavation report, archive of the Lithuanian Institute of History, f. 1, b. 10327.
- Vengalis, R. & Vėlius, G.** 2019. Kernavės piliakalnių funkcinė raida geležies amžiuje: naujos senų duomenų interpretacijos. – *Archaeologia Lituana*, 20, 75–115. <https://doi.org/10.15388/ArchLit.2019.20.4>
- Vengalis, R., Volungevičius, J., Vėlius, G., Kuncevičius, A., Poškienė, J. & Prapiestienė, R.** 2020. Žmogus prieš gamtą: reljefo transformavimas įrengiant XIII–XIV a. Kernavės pilį ir jo sukelti eroziniai procesai. – *Lietuvos archeologija*, 46, 207–253. <https://doi.org/10.33918/25386514-046008>
- Vitkūnas, M.** 2005. Kernavės miestas XIII–XIV amžiuje. – *Musinkai. Kernavė. Čiobiškis*. Ed. S. Buchaveckas. Versmė, Vilnius, 63–124.
- Volkaitė-Kulikauskienė, R.** 1984. Kernavės piliakalnio „Mindaugo sostas“ tyrinėjimai. – *Archeologiniai tyrinėjimai Lietuvoje 1982 ir 1983 metais*. Vilnius, 35–38.
- White, T. E.** 1953. A method of calculating the dietary percentage of various food animals utilized by aboriginal peoples. – *American Antiquity*, 18: 4, 396–398. <https://doi.org/10.2307/277116>
- Whitmore, K.** 2014. Diet at Medieval Alytus, Lithuania: Stable Carbon and Nitrogen Isotope Analysis of Bone and Dentin Collagen. Master's thesis. University of Central Florida, Orlando.
- Whitmore, K. M., Dupras, T. L., Williams, L. J., Skipitytė, R., Schultz, J. J. & Jankauskas, R.** 2019. Stable carbon and nitrogen isotope inter- and intra-individual dietary reconstruction from the late 14th to early 18th century site of Alytus, Lithuania. – *American Journal of Physical Anthropology*, 168: 2, 279–291. <https://doi.org/10.1002/ajpa.23742>
- Zarankaitė-Margienė, T.** 2018. Laukiniai žvėrys Lietuvos Didžiosios Kunigaikštystės valdovo aplinkoje XIV–XVII amžiuje. – *Vilniaus pilių fauna: nuo kepsnio iki draugo*. Eds P. Blaževičius, N. Dambrauskaitė, H. Luik, G. Piličiauskienė, S. Rumbutis & T. Zarankaitė-Margienė. Vilniaus universiteto leidykla, Vilnius, 246–273.

Loomakasvatus ja jaht kahe aastatuhande jooksul Aukurase mäe linnamäel Kernavė arheoloogilisel alal Leedus: lindude, kalade ja imetajate zooarheoloogiline andmestik (u 800 kal eKr–1400 kal pKr)

Giedrė Piličiauskienė, Saulius Rumbutis,
Karolis Minkevičius, Rokas Vengalis
ja Gintautas Vėlius

RESÜMEE

Kernavė arheoloogiline ala Leedu idaosas on haruldane paik, kus saab uurida inimeste ja loomade suhteid pika perioodi jooksul. Käesolevas uurimuses analüüsiti Aukurase mäe linnamäelt leitud 15 339 loomaluud ja -hammast. Nendest õnnestus täpsemalt määrata 4207 luuleidu, mis pärinevad kahe aastatuhande pikkusest perioodist hilispronksiajast (u 800 eKr) hiliskeskajani (1400 pKr). Luukogum sisaldab imetajate, lindude ja kalade jäänuseid ja on üks paremini kirjeldatud zooarheoloogilisi andmestikke idapoolses Baltikumis. Kuigi eri perioodide andmestiku maht on erinev, annab luumaterjal loomakasvatuse ja jahi kohta siiski tervikliku pildi ning on võrreldav teiste Leedu arheoloogiliste muististega.

Uurimistulemuste põhjal oli loomakasvatus hilispronksiajaks välja kujunenud. Määratud luumaterjalist moodustavad koduloomad ligikaudu 90%, kusjuures karjakasvatuse põhilise osa moodustasid sead ja lambad/kitsed. Metsloomade osakaal imetajaluude hulgas on vaid 10%, mis viitab jahiloomade vähestele majanduslikule olulisusele. Kalu ja linde on materjalis samuti vähe, seega ei olnud ka need inimeste toidulaua olulised.

Hilisel eelrooma rauaajal ja varasel rooma rauaajal (u 200 eKr–200 pKr) toimus suur muutus: veiste olulisus kasvas, nende luuleiud moodustavad koduloomadest ligikaudu 42%. See viitab tõenäoliselt põllumajanduse intensiivistumisele ja suurenenud vajadusele veojõu ja sõnniku järele. Samast

perioodist on teada varaseimad Leedust leitud kodukanade jäänused, mis täiendavad seniseid tõendeid kodukana saabumise kohta Baltikumi kaguossa.

Keskaja luumaterjalis on näha kõrgemale sotsiaalsele klassile omaseid tarbimismustreid. Võrreldes Kernavė üla- ja all-linnaga, kus elasid tavalised linnaelanikud, tarvitati Aukurase mäel suuremas koguses sea- ja linnuliha, kala ning ulukiliha.

Keskaegses luukogumis on tähelepanuväärsed tõendid spetsialiseerunud jahipidamise kohta. Kui paljudes teistes Leedu paikades jahtis eliit suurulukeid, nagu põtra ja punahirve, siis Aukurase mäe elanikud keskendusid peamiselt väikeimetajate jahile, eriti jänestele ja oravatele. Kuna materjalis on ka palju kanakulli luid, viitab see jahikullide kasutamisele. Arvukad rongaluud võivad samuti olla selle tegevusega seotud.

Ka kalaluud võivad viidata kõrgema sotsiaalse klassi tarbimisharjumustele. Kokku määrati kuusteist kalaliiki, sh lõhe, tuur ja angerjas. Suurt kasvu lõhed, haugid, sägad ja karplased on materjalis tavalised. Kalaliikide mitmekesisus on suurem kui paljudes teistes Leedu suuremates keskaegsetes paikades.

Linnuluudki näitavad eliidile omaseid toitumisharjumusi. Enamasti söödi kana, aga ka jahilinde, nagu tetre, metsist ja laanepüüd. Viimatinimetatute suhteliselt suur osakaal on kooskõlas linnamäe muude eliidile viitavate leidudega.

Kokkuvõttes näitab Aukurase mäe zooarheoloogiline materjal, et loomade kasvatust ja kasutust Kernavės kujundasid nii loomakasvatuse kui ka sotsiaalse staatuse areng, kõrgema ühiskonnakihi tarbimisharjumused ja spetsialiseerunud jahitraditsioonid. Kuigi määratud luuleidude arv on periooditi erinev ja seetõttu tuleb mõnesse järeldusse suhtuda asjakohase ettevaatlikkusega, pakub uurimus siiski olulisi uusi teadmisi pikaajsete majanduslike ja kultuuriliste arengusuundumuste kohta Baltikumi idaosas.

ISSN 1406-2933 (print)
ISSN 1736-7484 (electronic)

