

CHAPTER 3

RESIDUE ANALYSIS AND FAUNAL REMAINS AS DATA FOR FOOD CULTURE

The study of food culture, in all its complexity, is inherently constrained by the nature of the available evidence. This limitation is particularly pronounced in prehistoric analyses, where the scarcity of archaeological remains and the absence of oral and written sources impose significant interpretative challenges. Nevertheless, examining the early development of food culture during the advent of farming in Southeast Europe remains a viable endeavor. Given our limited understanding of this distant past, such an inquiry necessitates drawing upon a broad and diverse range of data.

For the purposes of this study, two primary lines of evidence have been selected: (1) lipid residue analysis of potsherds and (2) zooarchaeological data.³⁵ First, residue analyses were conducted on samples collected from Bulgaria, Serbia, Romania, and Hungary. As one of the more recent methodological advancements, lipid residue analysis has seen limited application in these regions, making it imperative to expand the existing dataset. Second, published zooarchaeological data from Early Neolithic sites were compiled to provide a broader perspective and facilitate inter-regional comparisons (Figure 10).

The integration of faunal remains and residue analysis represents one of the most effective approaches for evaluating food habits related to animal consumption. This dual-method strategy not only addresses economic questions but also sheds light on sociocultural developments. In Chapter 5, these lines of evidence will be further enriched by additional archaeological sources, including human isotope analysis and artefactual discoveries, to deepen our understanding of food culture in the North Balkans and Hungary.

35. As the primary objective of this study is to examine the development of food culture in relation to animal consumption, archaeobotanical remains are only briefly addressed, and a comprehensive analysis is unfortunately beyond the scope of this thesis. While archaeobotanical data are indeed central to studies of food culture, it is only in recent years that the field has received the scholarly attention it deserves. For a long time, archaeological excavations in the Balkans and the Carpathian Basin either minimized or entirely neglected archaeobotanical research (e.g. Budja 2004a; Greenfield and Jongsma-Greenfield 2014; Colledge and Conolly 2007), leading to notable gaps in the data. Beyond excavation strategies, additional factors such as settlement types, soil composition, and the rarity of charred plant remains may have also contributed to the limited recovery of plant-based evidence (Bogaard and Halstead 2015; Bogaard 2005).

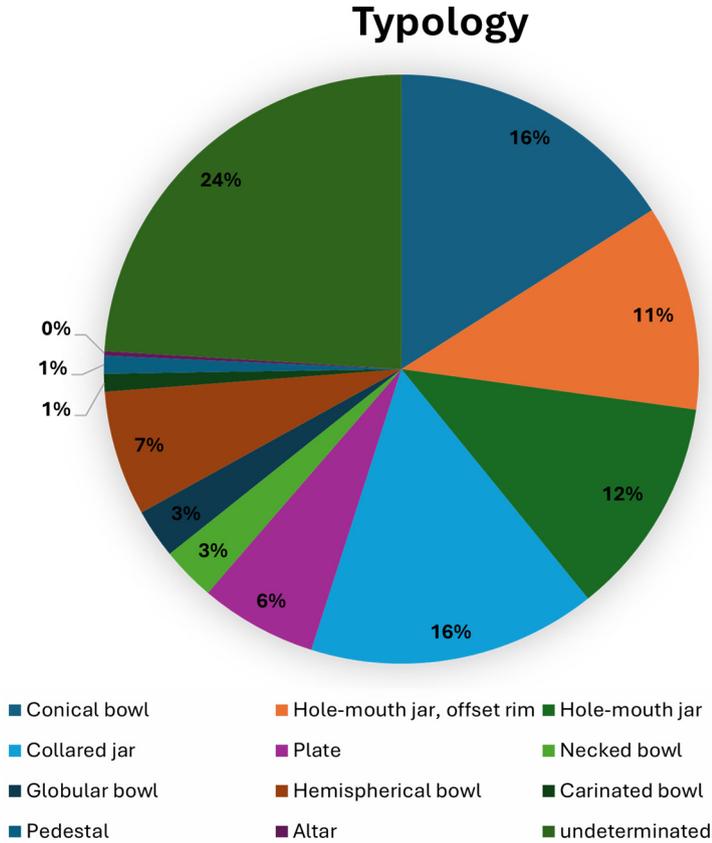


Figure 10. Typological representation of vessel forms for this study.

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Lipid residue analysis is one of the most recent and powerful analytical methods available for investigating past food habits, as well as sociocultural, economic, political, and technological developments in prehistoric contexts (e.g. Salque et al. 2013; Salque et al. 2012; Evershed, Payne, et al. 2008; Evershed 2008b; Dudd

36. The data presented in here—excluding those from Szakmár-Kisülés—have previously been published in two separate articles (Ethier et al. 2017; Cramp et al. 2019), each focusing on distinct regions. However, beyond offering a new interpretative framework centered on food culture, this book marks the first time that all these data have been brought together and analyzed within a single comprehensive study.

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and Evershed 1998; Evershed, Heron, and Goad 1990; Evershed, Heron, and Goad 1991; Heron, Evershed, and Goad 1991). This method is based on the principle that unglazed domestic vessels, used in food preparation, absorb lipids and waxes into the clay matrix or retain carbonized residues on their surfaces. These organic compounds become entrapped and preserved for thousands of years, offering valuable insights into past dietary practices (e.g. Evershed 2008b, 1993). By applying advanced analytical techniques, researchers can now recover and interpret this hidden information, reconstructing food behaviors that might otherwise have been lost.

The identification of lipid residues involves various solvent extraction methods combined with advanced analytical techniques that allow for a closer examination of biomarkers, their distributions, and their quantifications. This process enables the determination of lipid origins. In archaeological contexts, the primary evidence consists of residues of palmitic (C16) and stearic (C18) fatty acids, derived from the use of animal and plant-based products in food preparation. However, due to the degradation of these compounds and current technological limitations, their identification is largely restricted to a few broad subcategories, such as ruminant adipose fat, ruminant dairy fat, and non-ruminant adipose fat (e.g. Nieuwenhuys et al. 2015; Evershed 2008c; Evershed et al. 2002; Evershed 1993; Evershed, Heron, and Goad 1990; Regert 2010). Moreover, while dairy fats can be identified, distinguishing between dairy subproducts—such as cheese, butter, yogurt, or raw milk—remains beyond the method's current capabilities.

Recent advancements in organic chemistry and residue analysis have significantly improved the accuracy of lipid identification. In recent years, researchers have been able to better differentiate non-ruminant adipose fats from aquatic resources, thus integrating this data more effectively into archaeological interpretations (e.g. Cramp et al. 2019; Cramp and Evershed 2014). This progress is not limited to animal fats; the range of identifiable residues continues to expand. Today, it is possible to detect a diverse array of products, including leafy vegetables (e.g. Evershed et al. 1994; Evershed, Heron, and Goad 1991), specific plant oils (e.g. Formenti and Condamin 1978; Condamin et al. 1976; Copley et al. 2005; Evershed et al. 1999; Evershed, Heron, and Goad 1991), beeswax (e.g. Evershed et al. 2003; Regert et al. 2001; Evershed et al. 1997; Heron et al. 1994; Roffet-Salque et al. 2015), birch bark tar (e.g. Hayek et al. 1990; Charters et al. 1993; Urem-Kotsou et al. 2002), palm kernel oil (e.g. Copley et al. 2005; Garnier et al. 2009), resins (Eerkens 2002; Stern et al. 2003; Regert et al. 2008), and aquatic commodities (e.g. Cramp et al. 2019; Cramp and Evershed 2014; Hansel and Evershed 2009; Evershed, Copley, et al. 2008; Copley et al. 2004; Hansel et al. 2004; Craig, Forster, et al. 2007).

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As a result, residue analysis offers an invaluable tool for reconstructing past diets by identifying a wide range of substances used in food preparation. It allows researchers to differentiate between terrestrial and aquatic resources, distinguish between various animal fats, and recognize the use of C3 plants (commonly associated with cool-season or short-day crops such as wheat and oats) versus C4 plants (typically tropical or warm-season crops such as maize). By making these distinctions, lipid residue analysis provides yet another crucial piece of evidence for reconstructing past socio-economic structures and the evolution of food culture.³⁷

3.1.1 Case Studies and Samples

Lipid residue analysis in the Balkan regions remains relatively scarce. Although the method has become increasingly accessible to archaeologists, studies of this type have predominantly focused on the Mediterranean, the Near East, North Africa, and Western and Central Europe (e.g. Dunne et al. 2018; Kherbouche et al. 2016; Dunne et al. 2016; Debono Spiteri et al. 2016; Salque et al. 2013; Dunne et al. 2012; Carrer et al. 2016; Craig 2005; Craig et al. 2004; Evershed 2008a). Notably, Debono Spiteri et al. (2016) and Evershed et al. (2008a) synthesized a substantial amount of data in their search for the earliest dairying practices during the Neolithic period, encompassing regions such as the Levant, Anatolia, and the European Mediterranean, along with some sites in Central Europe. While they referenced Southeast Europe, their studies did not include any results from the Starčevo-Körös-Criş complex. One of the few analyses conducted in the region was performed by Craig et al. (2007) at the site of Ecsefalva 23, examining 41 samples.

Given the limited data available, interpretations of food habits in Southeast Europe have long relied primarily on faunal remains. Consequently, one of the principal objectives of this study is to provide an initial comprehensive overview of food patterns in the region. As such, 409 potsherds, dating to approximately 6000–5700 calBC, were selected from ten sites across the Balkans and the Carpathian Basin. These sites, excavated and published in well-documented studies, include locations in Bulgaria (Yabalkovo and Nova Nadezhda), Serbia (Blagotin, Divostin, Grivac, and Lepenski Vir), Romania (Schela Cladovei), and Hungary (Alsónyék, Ecsefalva 23, and Szakmár). The site selection corresponds

37. For further information on the archaeological applications of residue analysis and the techniques involved, the online platform Historic England—developed in collaboration with leading experts—offers a freely accessible document and accompanying supplement that cover all the fundamental aspects of the subject. (<https://historicengland.org.uk/advice/technical-advice/archaeological-science/materials-science-and-industrial-processes/>).

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to major cultural groups associated with the emergence of farming lifestyles in the region, specifically Karanovo, Starčevo, and Kőrös.³⁸ The selection of samples was guided by two primary criteria: (a) an undisturbed stratigraphic context and (b) a diverse range of ceramic wares and vessel shapes, including plates, bowls, and jars, which were likely used for cooking or food consumption (Figure 10). Additionally, specific vessel parts were prioritized, with a preference for rims over body fragments. Ethnoarchaeological and experimental cooking studies have demonstrated that rims tend to absorb greater amounts of lipids due to boiling and evaporation processes, thereby increasing the likelihood of lipid detection (e.g. Charters et al. 1997; Stacey 2009; Roffet-Salque 2012).

3.1.1.1 Northern Thrace

Serving as a bridge between the Balkans, the Aegean, and Anatolia, the Thracian region is regarded as one of the key entry points for the first farmers in Europe. Today, this area encompasses southern Bulgaria, northern Greece, and the north-western part of Turkey. It features a diverse mountainous landscape interwoven with a complex system of river valleys, which historically provided various opportunities for settlement. The southern Bulgarian region, in particular, exhibits significant climatic and vegetative variation due to its mountainous terrain. Between the Stara Planina and the Rhodope Mountains lie the Upper Thracian Lowland and the middle part of the Tundja Valley, where a Mediterranean ecosystem thrives. This area experiences warm summers (approximately 23–24°C in July), mild winters (around 0.5–2°C in November), and an annual Mediterranean-influenced precipitation level of roughly 500 mm (e.g. Grunewald et al. 2009; Velikov and Stoyanova 2007).

As elevation increases, the composition of forests shifts, tree sizes change, and precipitation becomes heavier, with prolonged snowfalls. Given these extreme conditions, most human settlements have historically been concentrated in the lowlands, where environmental conditions were more favorable for the adoption of farming. These circumstances made the region attractive to early settlers seeking to exploit its agricultural potential. This study focuses on the Karanovo I group, which, despite its distinctive characteristics, exhibits clear influences from

38. The data presented in this section derive from the DFG-funded project (DFG-IV 101/5-1), led by Maria Ivanova in collaboration with Richard Evershed. The analyses were carried out by myself under the supervision of Evershed. Although this work primarily focuses on the Starčevo-Kőrös complex, the scope of the DFG project also included sites belonging to the Karanovo complex in Bulgaria. Nonetheless, the comparative integration of these data with those from Serbian and Hungarian sites significantly strengthens the overall interpretation. For this reason, the data are fully presented here rather than being merely referenced.

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the Aegean and Anatolia. As discussed in Chapter 2.2.3.2, this group established permanent settlements, which, through cycles of destruction, reconstruction, and expansion, led to the formation of numerous tell-like sites. They built rectilinear surface structures with wattle-and-daub walls, adopted a sedentary lifestyle, and implemented domestication patterns similar to those of their southern neighbors (e.g. Sherratt 1982; Chapman 1990, 1997; Bailey 2000, 1999; Brami 2014). As we will explore, this pattern contrasts with other regions of the Balkans, where food habits were more variable and regionally distinct.

3.1.1.1.1 Yabalkovo

Situated in the heart of the Maritsa Valley in southern Bulgaria, the site of Yabalkovo was uncovered through archaeological rescue operations conducted between 2000 and 2012 in response to infrastructure projects. However, the site had been known to scholars since the 19th century, having been initially discovered during the construction of the Plovdiv-Edirne railway (Leshtakov et al. 2007). Unfortunately, due to the constraints of rescue archaeology and external pressures from planned infrastructure projects, the investigation was limited in scope, making a comprehensive analysis difficult (Leshtakov 2014a, 25). Despite these challenges, Yabalkovo quickly became a key site for understanding the transition to a farming economy in Bulgaria, particularly given the scarcity of studied Early Neolithic sites in the region.

Unlike the typical tell settlements of Upper Thrace, Yabalkovo is characterized as a “flat” settlement, with a vast inhabited area estimated, based on geomagnetic surveys, to extend approximately 1.5 km × 2 km (Leshtakov 2014a). Excavations revealed multiple phases of occupation, spanning from the Early Neolithic of the 6th millennium BC through various later occupations in the Chalcolithic, Bronze Age, Iron Age, and even into the Middle Ages, with activity documented as late as the first quarter of the 13th century CE. The settlement sequence indicates periods of abandonment, suggesting that the site was not continuously occupied. Geophysical surveys and excavations identified two distinct settlement areas, each enclosed by a series of concentric ditches. The Early Neolithic occupation at Yabalkovo is associated with the Karanovo I group, with radiocarbon dating (¹⁴C) placing its use within the first three centuries of the 6th millennium BC.

In addition to its well-stratified archaeological layers, Yabalkovo has yielded an extensive array of artifacts, including over 790 flint tools, as well as small finds such as amulets, disks, sling bullets, arrowheads, and figurines. These objects bear strong similarities to assemblages found at other Early Neolithic sites ranging from Upper Thrace to Western Anatolia (e.g. Petrova and Leshtakov 2014a; Hadzhipetkov 2014; Vasileva and Hadzhipetkov 2014). The site has also

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produced a diverse collection of Early Neolithic pottery, including distinctive bowls characterized by tall, hollow pedestal bases, plain profiles, and upper perforations designed for suspension (Leshtakov 2014b). However, painted pottery was notably absent from the excavations. According to Leshtakov (2014b, 124–125), this absence may be attributed to poor preservation, as surface surveys in the northeastern sector uncovered fragments of white-on-red painted pottery. Consequently, it remains uncertain whether the unpainted pottery belongs to the initial phase of the Karanovo period or its later developmental stages.

For this study, 42 samples were selected from the excavation campaigns conducted in 2010, 2011, and 2012 (see catalogue plates 1–5).³⁹ These samples consist of potsherds from various unpainted vessels associated with food practices, including collared jars, hole-mouth jars, necked bowls, conical bowls, hemispherical bowls, and even a pedestal. To obtain a comprehensive overview of general trends, the sherds were sourced from two distinct areas: (1) Ditches A and A1, House 1, and Pit 1 in Sector Southwest, and (2) a concentration of finds in Square N35 in Sector North, representing a large area of refuse deposition.

3.1.1.1.2 Nova Nadezhda

Situated on a low-lying terrace within the fertile floodplain of the Middle Maritsa Valley, approximately 300 meters from the river's right bank, Nova Nadezhda was strategically positioned to support the establishment of a farming economy in the region. Its fluvial environment provided a reliable water source, an essential factor for human settlement. However, while access to water has always been a key consideration for human habitation, in this case, proximity to the river also introduced significant challenges (Yaneva et al. 2017). Excavations revealed traces of water damage, indicating that the local population contended with periodic flooding events. Despite these difficulties, the site expanded to a considerable size, covering over 5 hectares, with two tell-like formations separated by a stream.

Between 2013 and 2014, the construction of a railway necessitated rescue excavations on the northern edge of the northwest mound, covering an area of 7,500 m². These investigations revealed a sequence of continuous occupation, beginning in the earliest phase of the Neolithic (c. 6000 calBC) and extending through the Final Chalcolithic (c. 4000 calBC). The site experienced a brief revival during the Early Iron Age (11th–9th centuries calBC) and later served as a cemetery for a nearby Muslim community in the 17th and 18th centuries (Yaneva et al. 2017).

39. See the book's imprint for the link to the online catalogue on Propylaeum-DOK.

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For the Early Neolithic phase, key archaeological features include five concentric ditches, at least one enclosure wall composed of wooden posts, and the remains of a burnt house, all concentrated in the eastern part of the northwest tell. However, for the earliest phase of the Neolithic, the absence of clear settlement features complicates interpretations of the occupation history. It has been suggested that either the primary settlement area lies within the unexcavated southern section or that the southeastern tell functioned as the main residential area, while the northwestern tell was designated for other, as yet undetermined, activities (Bacvarov et al. 2016, 155).

In addition to structural remains, the site has yielded 18 burials containing 24 individuals, primarily adults, alongside a substantial collection of faunal remains.⁴⁰ Unfortunately, the ceramic assemblage has yet to be fully published, and little is known about the collection in its entirety. Despite this, 45 ceramic samples were gathered during the 2013 excavation campaign from the house (F01) and from various contexts within four enclosure ditches (F03, F53, F54, F55). These samples consist of cooking vessels similar in form to those found at Yabalkovo, with slight variations in color (see plates 6–8). The selected vessel types include collared jars, hole-mouth jars, necked bowls, conical bowls, globular bowls, hemispherical bowls, and a plate.

3.1.1.2 Šumadija in Serbia

As a subregion of Peripannonian Serbia, Šumadija occupies the central part of the country. It is characterized by dense forests—hence its name—along with low mountains, expansive valleys, and fertile soil that supports remarkable fruit production. While some regional variations exist, the climate is predominantly continental, featuring peak rainfall in summer, drier winters, and an average annual temperature of approximately 11°C (Milanović Pešić and Milovanovic 2016).

These favorable environmental conditions undoubtedly provided significant opportunities for early Neolithic communities. However, the settlement patterns in the Šumadija region, represented here by the Starčevo culture, differ notably from those observed in the Near East, Thrace, or Central Europe. As previously discussed, and as seen in the Criș culture of Romania and the Körös culture of Hungary, Starčevo communities appear to have employed more mobile

40. Unfortunately, the site was excavated only recently, and most of the data remain unpublished. Of particular importance is the fact that the zooarchaeological material is also unavailable in published form and therefore could not be integrated into this study. Nevertheless, I will return to the discussion of faunal remains later, as some insights can be drawn from personal communication with John Gorczyk, the lead zooarchaeologist at Nova Nadezhda, who provided an overview of the site's general tendencies (see Chapter 3.2 for further details).

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settlement strategies. Rather than establishing large tell-like settlements, they tended toward small, nonpermanent sites, often comprising circular pits and semi-subterranean dwellings, suggesting a seasonal economy.

The reasons for these settlement patterns remain debated, with potential explanations including sociocultural factors, challenges in adapting to a new climatic regime, or resistance from indigenous hunter-gatherer populations to agricultural practices (e.g. Greenfield and Jongsma-Greenfield 2014; Tringham 2000; Whittle et al. 1996). Greenfield and Jongsma-Greenfield (2014, 26) have ruled out environmental constraints as the primary factor behind the appearance of pit houses, given that Central Europe, which features a similar temperate climate, saw the development of stable, sedentary settlements. Nonetheless, climatic and environmental differences between the homeland of early farmers and their new surroundings may have influenced their approach to farming and, consequently, their sociocultural development. As the Mediterranean climate gives way to longer, colder winters, adaptation strategies become more necessary. The Šumadija region, however, experiences a relatively brief snow period—between 35 and 40 days—which must be considered when assessing the adaptive requirements of early farming communities (e.g. Allcock and Poulsen 2007; Greenfield and Jongsma-Greenfield 2014; Greenfield 1986; Halpern 1970; Chapman 1981; Furlan 1977; Pounds 1969).

3.1.1.2.1 Blagotin

Blagotin is located on the northern outskirts of the village of Poljna, near the foothills of its namesake mountain, south of the Danube. The site was already known before the First World War, having been documented by Miloje M. Vasić (1936), who linked its material to the Poljna complex of the Eneolithic. Decades later, in the summer of 1984, test trenches supervised by Emilija Tomić led to the rediscovery of the site, culminating in systematic excavations by a team from the University of Belgrade in 1989. In 1991, excavations continued in collaboration with a Canadian team, and between 1989 and 2000, extensive research at Blagotin uncovered approximately 300 m². Following the death of its principal investigator, Svetozar Stanković, large-scale excavations ceased, and subsequent work has been limited to smaller-scale investigations (Greenfield and Jongsma-Greenfield 2014; Nikolić and Zečević 2001).

Positioned at a key juncture between the Western Morava River valley and the Šumadija region, Blagotin was part of a significant corridor within the Starčevo cultural complex (Greenfield and Jongsma-Greenfield 2014, 4). Radiocarbon dating (14C) places the primary occupation phase between 6200–6000 calBC. The site was later reoccupied twice—once during the Eneolithic (Baden-Kostolac culture) and again during the Early Iron Age (Hallstatt culture).

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Across its various occupation phases, Blagotin remained a small settlement, covering approximately 0.4 ha during the Starčevo period, expanding slightly to 1.2 ha in later phases, before shrinking to 0.25 ha in its final occupation (Greenfield and Jongsma-Greenfield 2014). Compared to other Starčevo sites, its relatively modest size suggests that it may have held minor importance during the Early Neolithic. Nevertheless, Blagotin has provided valuable insights into settlement life and architectural development, with excavations revealing seven semi-subterranean dwellings, refuse areas, and numerous pits.

Faunal and floral remains from the site have been extensively analyzed, and a rich assemblage of artifacts has been recovered, including zoomorphic and anthropomorphic figurines, altars, amulets, and a prolific lithic industry. The stone tool repertoire comprises blades, scrapers, mallets, hammers, palettes, and ground axes (Greenfield and Jongsma-Greenfield 2014; Nikolić and Zečević 2001). Of particular interest is a clay fragment discovered in the largest pit house (ZM07), which, according to Greenfield and Jongsma-Greenfield (2018), may represent the oldest known map in Europe. The fragment features a pattern of circles resembling the spatial arrangement of pit houses at the site.

The pottery assemblage is also substantial, predominantly linked to the earliest phase of the Starčevo complex, as indicated by the absence of grey and black pottery associated with the later Starčevo IIa–b phase (Vuković 2004, 111). For the purposes of this study, 43 ceramic samples were selected from the 1995 excavations, covering various stratigraphic levels and contexts within the fill of Structure 03, a semi-subterranean dwelling.⁴¹ The samples include a range of food-related vessel forms, such as hemispherical bowls, conical bowls, collared jars, and hole-mouth jars, all displaying the characteristic brownish-orange hues of the earliest Starčevo phase (see plates 9–11).

3.1.1.2.2 Divostin

Discovered in 1952 during a survey conducted by the Archaeological Institute in Belgrade, Divostin is regarded as one of the major settlements of the Starčevo culture (McPherron and Srejović 1988). Located in the Šumadija region, the site lies near the modern city of Kragujevac. Although its initial discovery occurred in 1952, it was only after the unearthing of seven ceramic figurines in a buried house—during the construction of a cellar—that its significance was fully recognized. In light of these findings, systematic archaeological excavations

41. As of today, Structure 03 represents the only fully studied and published pottery assemblage at Blagotin (Vuković 2011, 2004). The study (Vuković 2004) includes a comprehensive statistical and typological analysis of 15,883 potsherds and complete vessels. This thorough documentation was a key factor in selecting this sector for sampling, as it fulfills the primary requirement of a well-established and clearly defined archaeological context.

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commenced in 1967 under the direction of Milenko Bogdanović, followed by further investigations between 1968 and 1974, led by Dragoslav Srejšović and Alan McPherron, covering an area of approximately 2,400 m² (McPherron 1988).

Radiocarbon dating of five wood charcoal samples places the initial occupation of Divostin (Divostin I) at approximately 6000–5700 calBC, suggesting that the settlement was inhabited by Starčevo groups for about a century. Excavations of this phase revealed semi-subterranean huts, surface-level houses, fireplaces, hearths, ovens, rubbish pits, and refuse areas (Bogdanović 1988). Following a period of abandonment lasting over a thousand years, the site was reoccupied during the Late Neolithic by groups associated with the Late Vinča culture (Divostin II) (McPherron and Srejšović 1988).

For this study, 43 ceramic samples were selected from the pottery assemblage recovered from a pit in Sector D, associated with the Divostin I phase, during Bogdanović's 1967 excavation (see plate 12). The assemblage consists of various vessel forms, including hole-mouth jars, collared jars, hemispherical bowls, conical bowls, globular bowls, necked bowls, and plates.

3.1.1.2.3 Grivac

Located approximately 20 km west of Divostin, Grivac is situated on a plateau near the modern village of Grivac, at the confluence of multiple water sources, including Cesma Creek, Slana Bar Creek, and the Great Morava River (Bogdanović 2004). Excavations at the site, which began in the 1950s, have revealed a well-stratified archaeological sequence spanning several millennia. Systematic trenching in different areas of the site occurred in 1953–1954, 1957, 1969, and again in 1989–1994, leading to the discovery of habitation remains from both the Early Neolithic (Grivac I–III) and Late Neolithic (Grivac IV–VI) periods. The site covers a total area of approximately 25 ha.

The Early Neolithic occupation at Grivac yielded evidence of semi-subterranean and above-ground houses, an extensive production of monochrome ceramics, zoomorphic and anthropomorphic figurines, cult-related objects, polished stone tools, jewelry, and a series of burials (Bogdanović 2004). The monochrome pottery, characteristic of the period, exhibits dark and light red, brown, or black tones and features a variety of decorative styles, including imprints and barbotine treatments.

For this study, 33 ceramic samples were selected from two separate areas of the site: (1) the western sector, including Trench IV and V (1957), Trench A and B (1969),⁴² and Trench A (1990); and (2) the eastern sector, including Trench

42. One radiocarbon date from this phase, obtained from Trench B, places the context around 6200–6000 cal BC.

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1954 and Trench A (1994) (see plates 13–14). As with other sites, the selection focused on vessel forms associated with food preparation and consumption, including hole-mouth jars, collared jars, conical bowls, globular bowls, and plates.

3.1.1.3 Iron Gates in Serbia and Romania

Situated at the border between Serbia and Romania, the Iron Gates region encompasses a 230 km stretch at the beginning of the Lower Danube. It is defined by the Đerdap, commonly known as the Iron Gates Gorge, which features a confluence of steep-sided canyons and wide valleys on its western side. Further downstream, the landscape transitions into a gentler terrain marked by alluvial plains extending through the Wallachian Plain toward the Black Sea (Figure 11) (Bonsall, Boroneant, and Radovanović 2008). Despite its relatively small size, this region holds immense significance for understanding the development of Mesolithic and Neolithic communities in Southeast Europe.

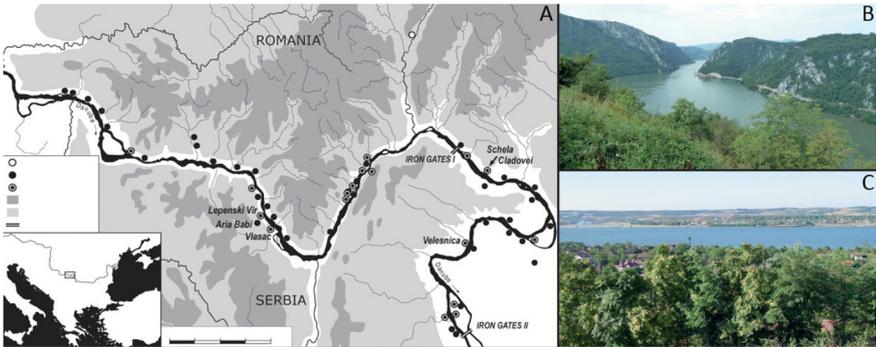


Figure 11. A) Map of the Iron Gates region, including important sites of the Mesolithic and Neolithic period. B) Pictures of the Đerdap and C) the downstream area (Cramp et al. 2019: fig. 1).

For over a century, classical archaeologists have studied the Iron Gates, recognizing its strategic economic, political, and military importance, as evidenced by its early exploitation by the Romans (Bonsall, Boroneant, and Radovanović 2008). Archaeological investigations in the region have revealed military camps, Roman canals, and Trajan's Bridge, constructed in the first century BC. However, prehistoric settlements in the area received comparatively less attention until the 1960s, when the construction of the Iron Gates Dams I and II prompted large-scale archaeological investigations.

Rescue excavations were first conducted between 1960 and 1971 in areas affected by the construction of Iron Gates Dam I, focusing primarily on the gorge section, as well as sites such as Schela Cladovei and Ostrovul Banului. A second phase of excavations followed between 1977 and 1984 in response to the con-

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struction of Iron Gates Dam II, covering sites in the downstream area (Bonsall, Boroneant, and Radovanović 2008). Across both campaigns, more than 200 sites spanning the Mesolithic, Neolithic, Bronze Age, and Iron Age were identified. However, it was the Mesolithic and Early Neolithic phases that garnered the most scholarly attention.

A pivotal moment in prehistoric research came with the discovery of Lepenski Vir by Srejović and his team during these rescue operations. Lepenski Vir remains one of the earliest and most significant sites documenting an uninterrupted sequence from the Mesolithic to the Neolithic (Srejović 1969, 1966). Many additional sites corresponding to either the Mesolithic or Neolithic periods were also uncovered, making the Iron Gates region a crucial area for studying the transition to farming economies in the Balkans.

3.1.1.3.1 Schela Cladovei

Situated in the downstream area of the Iron Gates, Schela Cladovei is located on a terrace adjacent to the Danube, near the modern city of Drobeta Turnu-Severin in Romania. The site, known for its recurrent floodplain, was first excavated in 1965 as part of the rescue operations associated with the construction of two hydroelectric dams. Subsequent investigations were conducted twelve times until 1990, and since 1991, a collaborative project between Romanian and British archaeologists has continued research at the site (Boroneant and Bonsall 2013). Although Schela Cladovei was occupied irregularly over time, it preserves well-documented remains from the Late Mesolithic (ca. 7200–6300 calBC) and the Early Neolithic (ca. 6000 calBC), providing invaluable insights into regional cultural developments (Bartosiewicz, Bonsall, and Stallibrass 2006).

Considered part of the Starčevo-Criș complex, Schela Cladovei was initially inhabited by Late Mesolithic groups, who left behind stone and bone tools, numerous burials, and architectural remains (Boroneant et al. 1995). The transition to the Early Neolithic is marked by a hiatus of approximately 300 years, after which the site was reoccupied by a population that appears to represent a mixture of local Mesolithic inhabitants and newcomers. These new groups introduced Starčevo-Criș-style pottery, architecture, and burial practices while maintaining certain Mesolithic traditions, such as dietary habits, architectural techniques, and tool production (Bonsall et al. 2002).

For this study, 49 potsherds were selected for residue analysis. The selection criteria followed the same principles applied to other sites, prioritizing vessels associated with food-related activities. The sample set includes a variety of forms, such as necked bowls, globular bowls, hemispherical bowls, conical bowls, hole-mouth jars, collared jars, and plates (see plates 18–21). The sherds originated from Early Neolithic pits in Area VII. As no direct radiocarbon dating

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was available for this area, the chronological framework was inferred from comparable ceramic assemblages in Area VI, which have been dated to between 6000 and 5700 calBC.

3.1.1.3.2 Lepenski Vir

Situated within the Đerdap section of the Iron Gates, Lepenski Vir is located on the Serbian side of the Danube, near the village of Boljetin, close to Donji Milanovac (Srejović 1969, 1966). The site was first identified by archaeologists from the Belgrade Archaeological Institute while surveying land owned by a local farmer. Initial discoveries included pottery fragments linked to the Starčevo culture, but no further investigations were carried out at the time. Like many sites in the Iron Gates region, Lepenski Vir was revisited a few years later as part of the rescue operations necessitated by the construction of the first Iron Gates dam and its reservoir. Excavations revealed an unexpectedly rich and well-preserved archaeological record, distinguishing Lepenski Vir from other sites such as Schela Cladovei by offering a continuous sequence encompassing the Mesolithic occupation, a transitional period, and the full Neolithization process (Srejović 1972).

As discussed in Chapter 2.2.3.3, Lepenski Vir quickly became central to archaeological discourse, serving as a key reference for both the Mesolithic-Neolithic transition and the broader advent of Neolithic lifestyles in the Balkans (e.g. Rusu 2016). Beyond its chronological significance, the site is notable for the sociocultural dynamics it reveals, particularly regarding resistance to Neolithic transformations. This resistance need not be interpreted as violent opposition to farming communities but rather as the continuation of Mesolithic traditions in response to the introduction of agricultural lifeways. Studies of food culture may help to elucidate aspects of this complex cultural interplay, as will be explored in subsequent chapters.

While the broader archaeological context of Lepenski Vir has been thoroughly examined earlier in this work, the focus here is on the technical aspects of residue analysis. A total of 41 ceramic samples were selected from contexts attributed to Lepenski Vir Phase III, representing common vessel forms such as conical bowls, hole-mouth jars, collared jars, and plates (see plates 15–17). It is noteworthy that many of the potsherds acquired for analysis were in poor condition, with adhesive materials such as glue and nail polish used for cataloguing. Given that excavations at Lepenski Vir date back to the 1960s, and the materials have been stored and previously studied in a museum setting, such conditions were anticipated. While this did not hinder the analysis, extra precautions were taken during the cleaning process to prevent sample contamination.

3.1.1.4 Transdanubia and Alföld in Hungary

As we move northward beyond the Balkans into Peripannonian Hungary, two key regions emerge as focal points of early Neolithic development. The first is Transdanubia, a fertile expanse of diverse landscapes, including mountains, hills, valleys, plains, and basins. This region played a crucial role in the Early Neolithic, as the Starčevo culture extended its reach to the surroundings of Lake Balaton, ultimately becoming a pivotal influence in the evolution of the Linearbandkeramik (LBK) culture in Central and Western Europe (Bánffy 2013a, 2004, 2001, 2000). Unlike conventional models of linear migration, this process appears to have been more complex, involving what Bánffy (2013a, 157) describes as “[...] successive waves of immigration and blends with different indigenous groups”.

The second region, the Alföld or Great Hungarian Plain, situated in the southern and eastern parts of Hungary, offers significant advantages as a vast, fertile flatland with seasonal flooding—ideal conditions for agriculture, which remains a dominant practice in the region today. However, the Starčevo groups did not appear to expand further east into this region, leaving it instead to be settled by the Körös culture (Bánffy 2013c, a).

Interestingly, despite their geographical proximity, there is no clear evidence of direct interaction between the Starčevo and Körös groups (Bánffy 2012, 2004; Brukner 1966; Kalicz 2000). The Körös complex appears to have remained relatively isolated, with no concrete signs of cultural exchange. However, given their shared reliance on mobile economies, both cultures are considered part of the broader Starčevo-Körös-Criş cultural formation, which contrasts with the more sedentary settlement strategies observed in Anatolia, the Aegean, and Thrace. Another crucial point is that both Transdanubia and the Alföld fall within the temperate continental climate zone, much like the Šumadija region. This provides an excellent opportunity for comparative analysis of food habits in similar environmental conditions.

3.1.1.4.1 Alsónyék

The site of Alsónyék is located near the Danube in the southern part of the Sárköz region in Tolna County, at the border between the Transdanubian Hills and the Great Hungarian Plain. Like many sites in this study, it was subject to rescue excavations between 2006 and 2009 due to construction work along the M6 motorway. Covering an area of approximately 80 ha, the excavations revealed a long and complex occupational history spanning from the Early Neolithic to the Early Chalcolithic. The site witnessed successive phases of occupation, abandonment, and reoccupation, with settlements linked to the Starčevo, LBK, Sopot, and Lengyel cultures.

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Significantly, Alsónyék represents the first large-scale excavation of a Starčevo site in Hungary, yielding the most extensive Starčevo assemblage discovered in the region to date. Radiocarbon dating places the arrival of the Starčevo groups at around 5775–5740 calBC—approximately two centuries after their emergence in Serbia—before the settlement was ultimately abandoned around 5575–5505 calBC (Bánffy et al. 2016). This timeline aligns with broader trends in Transdanubia and suggests that the expansion of the Starčevo complex into the region occurred later rather than as a simultaneous development (Bánffy et al. 2016; Szécsényi-Nagy et al. 2015; Kalicz, Biró, and Virag 2002).

Excavations at Alsónyék identified two primary foci of Starčevo habitation, designated as 10B and 5603. The larger area, 5603, contained approximately 500 features associated with the Starčevo period, including numerous Early Neolithic structures such as well-preserved ovens, wells, and accumulations of burnt daub (Bánffy et al. 2016; Oross et al. 2016). Among the significant finds were figurines, approximately 20 graves—frequently associated with oven contexts—jewelry, zoomorphic and rectangular altarpieces, and a diverse array of stone and bone tools. Notably, the site also produced a substantial collection of faunal remains, further contributing to its significance in studies of early food economies.

The ceramic assemblage at Alsónyék is extensive, comprising an enormous quantity of potsherds. The collection includes unpainted pottery, barbotine-decorated surfaces, and fine painted ceramics, with deep carinated bowls being particularly well represented. As observed at other Starčevo sites, the pottery is predominantly red, brown, or black in color. The black-painted bowls display various decorative motifs, including vertical patterns, grid-like designs, and small chevrons.

For this study, 43 ceramic samples were selected from the fills of eleven pits in Area 5603, the primary zone of Starčevo occupation at Alsónyék (see plates 22–26). The sample set includes fragments of hole-mouth jars, collared jars, hemispherical bowls, conical bowls, globular bowls, plates, pedestals, and an altar.

3.1.1.4.2 Ecsegfalva 23

The site of Ecsegfalva 23 was discovered in 1998 during large-scale archaeological surveys along an old meander of the Hortobágy-Berettyó River, a northern tributary of the Körös River, locally known as Kiri-Tó (Whittle 2010a, 2007). Excavations were conducted between 1999 and 2001, focusing on three key locations: Ecsegfalva 16, 18, and 23. These investigations included an in-depth analysis of faunal and floral remains, aiding in the reconstruction of food habits and behaviors at these sites. In addition to standard excavations, small surveys were carried out along the meander to identify further sites.

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Geophysical surveys indicated that Ecsegfalva 23 extends over 100 meters along the meander and is approximately 40 meters in width (Whittle 2007, 27). However, proximity to the river had eroded parts of the site, obscuring its original extent. To mitigate this, three trenches were excavated away from disturbed areas. The findings suggest that the site was occupied for a relatively short duration, with initial habitation around 5800 calBC and peak activity between 5750 and 5650 calBC (Whittle 2007).

As part of the Körös complex, Ecsegfalva 23 yielded a substantial collection of archaeological finds despite its brief period of occupation. Among the discoveries were figurines and other clay objects, including the characteristic Körös steatopygous anthropomorphic figurines, spindle whorls, discs, small and large weights, beads, studs, and clay balls (e.g. Oross and Whittle 2007; Choyke 2007). Bone tools, primarily derived from caprine, cattle, and unidentified sources, were also found, along with stone tools made from various raw materials such as obsidian, limnic quartzite, and radiolarite (e.g. Choyke 2007; Mateiciucová 2007).

The ceramic assemblage at Ecsegfalva 23 was particularly significant, with over 11,000 individual potsherds recovered (Oross 2007). For this study, 41 samples were selected from the excavation campaigns conducted between 1999 and 2001, representing all three trenches at the site: Area 23A (2 samples), Area 23B (31 samples), and Area 23C (8 samples) (see plates 27–29). The selected forms include conical bowls, hemispherical bowls, necked bowls, carinated bowls, globular bowls, collared jars, and hole-mouth jars.

3.1.1.4.3 Szakmár-Kisülés

Known to scholars since the mid-20th century, Szakmár-Kisülés is located at the interfluvium of the Danube and Tisza rivers in Hungary, marking the northernmost extent of the Körös complex (Bognárné Kutzián 1977, 1976; Bánffy 2012). The first archaeological investigations at the site were conducted in the 1970s under the supervision of Ida Bognár-Kutzián, whose primary objective was to refine the stratigraphic framework of the region rather than to engage in detailed reflections on the Early Neolithic and the development of the Körös culture (Bánffy 2012).

Despite the site's potential significance for understanding the Körös complex, archaeological investigations at Szakmár-Kisülés were complicated by contamination from later human activities. As a result, research was concentrated on two or three areas where Early Neolithic material remained relatively undisturbed. Within these areas, possible structural remains were identified, alongside fragments of characteristic Körös pottery and animal bones. Burials of both adults and children were also uncovered. The selection of this site for study was driven by its under-researched status. As Bánffy noted:

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Evaluating the surviving documentation and find material of the excavations at the early neolithic settlement of Szakmár-Kisülés is in progress. However, our general knowledge of early neolithic settlements in the Danube-Tisza Interfluvium remains scarce. This may be attributed to the low intensity of archaeological research in the area.

(Bánffy 2012, 64)

To address this research gap, 29 ceramic samples were gathered from well-documented contexts. These samples include various vessel forms typically associated with Körös sites, such as plates, hole-mouth jars, collared jars, and conical bowls (see Vol. II, pages 67–72). Unfortunately, all analyzed potsherds exhibited a total absence of residue (for further discussion, see Sections 3.1.3 and 3.1.4).

3.1.2 Methodology

In the course of this research, all ceramic sherds were subjected to direct acidified methanol extraction, following the protocol outlined by Marisol Correa-Ascencio and Evershed (2014),⁴³ and subsequently analyzed using various gas chromatography (GC) techniques. Approximately 2 g of material was extracted from each sherd, and to minimize contamination from modern sources (e.g. soil burial, excavation and post-excavation handling, plastic bags, or adhesives), a fine surface layer was carefully removed using a modeling drill. The drill was cleaned between each sample to prevent cross-contamination. After surface cleaning, the sherds were crushed into a fine powder using a glass mortar and pestle, weighed (ca. 2 g), and transferred into a culture tube. An internal standard of n-tetratriacontane (20 µl, 1.0 mg ml⁻¹ solution) was then added to each sample.

Lipid extraction was carried out by adding 5 ml of a sulfuric acid-methanol (H₂SO₄-MeOH, 4 % sulfuric acid/methanol) solution (with δ¹³C measured) to the powdered sherds. The mixture was heated at 70°C for one hour and whirled every ten minutes to ensure thorough contact between the solvent and powdered material. Following extraction, the H₂SO₄-MeOH solution was transferred to a second clean culture tube, where 2 ml of DCM-extracted double-distilled water was added. To maximize lipid recovery, two additional extractions with 2 ml of hexane were performed on the treated sherds, followed by three hexane extractions of the diluted methanol solution.

The total lipid extract (TLE) was then concentrated in a 3.5 ml vial, and an aliquot (one-quarter of the vial) was taken for instrument analysis. If the aliquot contained n-alkanols, the TLE was derivatized using N,O-bis(tri-

43. The extraction method described in this Chapter was chosen over alternative procedures due to its proven effectiveness in recovering lipids.

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methylsilyl)trifluoroacetamide (BSTFA containing 1 % trimethylsilyl chloride) at 70°C for one hour to trimethylsilylate free alcohols. Once derivatized, the TLEs were dried and subsequently diluted with hexane before undergoing GC analysis.⁴⁴ This initial screening allowed for the preliminary identification of lipid components based on the internal standard and enabled the quantification of lipid concentrations in the ceramic samples. However, as GC alone does not provide detailed structural information on the detected compounds, GC-mass spectrometry (GC-MS) was employed on samples exhibiting significant organic compounds of interest.

Samples containing biomarkers associated with food consumption—specifically palmitic acid (hexadecanoic acid; C16:0) and stearic acid (octadecanoic acid; C18:0)—were further analyzed using GC-combustion-isotope ratio mass spectrometry (GC-C-IRMS). This technique was applied to determine individual $\delta^{13}\text{C}$ values, which are essential for distinguishing between different sources of

⁴⁴ The instruments used for the analyses were an Agilent 7890a or an Agilent 7820 GC-FID for the GC. The former was fitted with a fused silica capillary column with a 100 % dimethyl polysiloxane stationary phase (Agilent J & W, DB1-HT, 15 m x 0.32 mm i.d., 0.1 μm film thickness) using He as carrier gas. The oven temperature program consisted of an isothermal at 50°C for 2 min, ramping to 350°C at 10°C min⁻¹, followed by a 10 min isothermal at 350°C. The Agilent 7820 GC-FID was fitted with a fused silica capillary column with a 100 % dimethylpolysiloxane stationary phase (Agilent J & W, DB1-HT, 15 m x 0.32 mm i.d., 0.1 μm film thickness) using He as carrier gas. The oven temperature program consisted of an isothermal at 50°C for 2 min, ramping to 300°C at 10°C min⁻¹, followed by a 10 min isothermal at 300°C. Data were analyzed using Agilent Chemstation software. For the GC-MS, a ThermoFinnigan single quadrupole TraceMS run in EI mode (electron energy 70 eV) with a PTV injector in splitless mode fitted with a fused silica capillary column with a high cyano-modified cyanopropyl polysilphenylenesiloxane stationary phase (Agilent J & W, VF-23ms, 60 m x 0.32 mm i.d., 0.15 μm film thickness) was used. The oven temperature program consisted of an isothermal at 50°C for 2 min, ramping to 100°C at 10°C min⁻¹ followed by a second ramp to 240°C at 4°C min⁻¹ and an isothermal at 240°C for 15 min. The GC/MS was operated in both full scan (m/z 50–650) and selected ion monitoring (m/z 105, 262, 290, 318 and 346) mode with a scan time of 0.6 sec⁻¹ to detect the presence of C16–C22 APAAs at high sensitivity. The MS was set to operate in selected ion monitoring (SIM) mode, acquiring at m/z 159, 187, 215, 231, 259, 287, 431, 443, 459, 471, 487, 499, 515 at 0.757 scans s⁻¹. To read and analyze the data, the Xcalibur software was used. Finally, the conduct GC-C-IRMS analyses, an Agilent 7890A GC coupled to an Isoprime 100 MS via an Isoprime GC5 combustion interface. The GC was fitted with a fused silica capillary column with a non-polar 100 % dimethylpolysiloxane stationary phase (Agilent J & W, HP-1, 50 m x 0.32 mm i.d., 0.17 μm film thickness). Samples were introduced via a split/splitless injector in splitless mode at 300°C. The temperature program consisted of a 2 min isothermal at 40°C, ramping to 300°C at 10°C min⁻¹ followed by a 10 min isothermal at 300°C. The combustion reactor consisted of a quartz tube filled with copper oxide pellets which was maintained at a temperature of 850°C. Faraday cups were used to detect ions of m/z 44 (12C16O2), 45 (13C16O2 and 12C17O16O) and 46 (12C18O16O).

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lipids, such as non-ruminant adipose fats, ruminant adipose fats, and ruminant dairy fats. During GC-C-IRMS analyses, an external standard was measured every fourth run to ensure calibration accuracy.

This methodological approach was applied to all samples analyzed in this study. However, for samples from Lepenski Vir and Schela Cladovei, an additional step was required to determine whether non-ruminant adipose fats were derived from aquatic resources. To achieve this, the method described by Cramp and Evershed 2014 was followed, which involved reanalyzing the samples using GC-MS-SIM. This technique facilitates the high-sensitivity detection of ω -(*o*-alkylphenyl)alkanoic acids (APAAs) and dihydroxy acids, key biomarkers for differentiating between terrestrial non-ruminant and aquatic animals.

Finally, samples containing detectable lipids underwent further processing for data analysis. The first step in this process was to calculate the concentration of lipids in each sample. This was achieved by determining the TLE concentration based on the peak areas observed in the gas chromatograms, using the following formula:

$$C_{lipids} = \frac{(100 - A_{IS} - A_{cont}) \times m_{IS}}{A_{IS} \times m_{sherd}}$$

Here, A_{IS} represents the peak area of the internal standard in percentage, A_{cont} denotes the sum of the peak areas of visible contamination (also in percentage), m_{IS} refers to the mass of the internal standard (20 μ l), and m_{sherd} corresponds to the mass of the powdered sherds extracted.

The next step involves calculating the difference in $\delta^{13}C$ values between stearic acid (C18:0) and palmitic acid (C16:0), expressed as $\delta^{13}C_{18:0} - \delta^{13}C_{16:0}$. These values are reported relative to the international VPDB (Vienna Pee Dee Belemnite) standard:

$$\delta^{13}C_{sample} = \frac{R_{sample} - R_{standard}}{R_{standard}}$$

Here, R_{sample} represents the $^{13}C/^{12}C$ ratio in the sample, while $R_{standard}$ denotes the $^{13}C/^{12}C$ ratio in the standard. This adjustment is necessary to account for environmental variations, particularly those resulting from the post-Industrial Revolution effects of fossil fuel combustion (Friedli et al. 1986).

Once the $\delta^{13}C$ values are determined, statistical analyses are performed using Mstat software, and the data are subsequently imported into a template for visualization in Illustrator. The results are presented in two formats: (a) $\delta^{13}C$ values in comparison with modern reference fats, and (b) the difference in $\delta^{13}C$ values between stearic acid (C18:0) and palmitic acid (C16:0), also in reference to modern fat sources.

3.1.3 Results⁴⁵

Lipid residue analysis was conducted on a total of 408 potsherds, revealing that over 20 percent of the samples contained identifiable lipid residues, with concentrations ranging from 49 $\mu\text{g g}^{-1}$ to 5679 $\mu\text{g g}^{-1}$ (Figures 12 to 13). This percentage aligns with previous studies conducted in the Mediterranean region (Debono Spiteri et al. 2016) but remains significantly lower than the 50 percent detection rate observed in Central Europe (Evershed, Payne, et al. 2008). The disparity in lipid preservation across regions is influenced by multiple factors, including differences in environmental preservation conditions and past food processing activities. Nonetheless, the majority of sites examined in this study yielded results within a range of 20 percent to 35 percent positive detection.

While lipid residue analysis can identify a range of organic compounds, including beeswax and resins, the results of this study predominantly indicated the presence of fatty acids derived from animal fats—specifically palmitic acid (C16:0) and stearic acid (C18:0). As a result, all identified residues were attributed to ruminant and non-ruminant sources, with the notable exception of samples from the Iron Gates region, where evidence of aquatic resource utilization was detected.

The sites of Divostin and Szakmár-Kisülés yielded less promising results. At Divostin, only 7 percent of the analyzed sherds (3 out of 43) contained identifiable lipid residues, while Szakmár-Kisülés did not produce any positive results (see Table 2 to 5). Several factors may account for the lack of lipid preservation at Szakmár-Kisülés, which could have provided valuable insights into the periphery of the Körös cultural sphere. However, determining the precise causes remains challenging. One possibility is the age of the excavation, as older collections are often stored in suboptimal conditions, leading to degradation of organic residues. However, this factor alone cannot fully explain the absence of lipids, as samples from Lepenski Vir—also retrieved from an older excavation—produced highly successful results. Additional variables such as the small sample size (29 fragments), past food preparation behaviors, or even random preservation biases may have played a role. Future research in the region, along with an expansion of the sample set for Szakmár-Kisülés, may help clarify the reasons behind these patterns and provide further insights into early food consumption practices. Beyond these two sites, the results offer valuable insights into regional patterns of food consumption (Figure 12).

45. The chromatographs and $\delta^{13}\text{C}$ value graphs for each individual site are provided in the catalogue. This subchapter presents only the graphs displaying the cumulative results by region.

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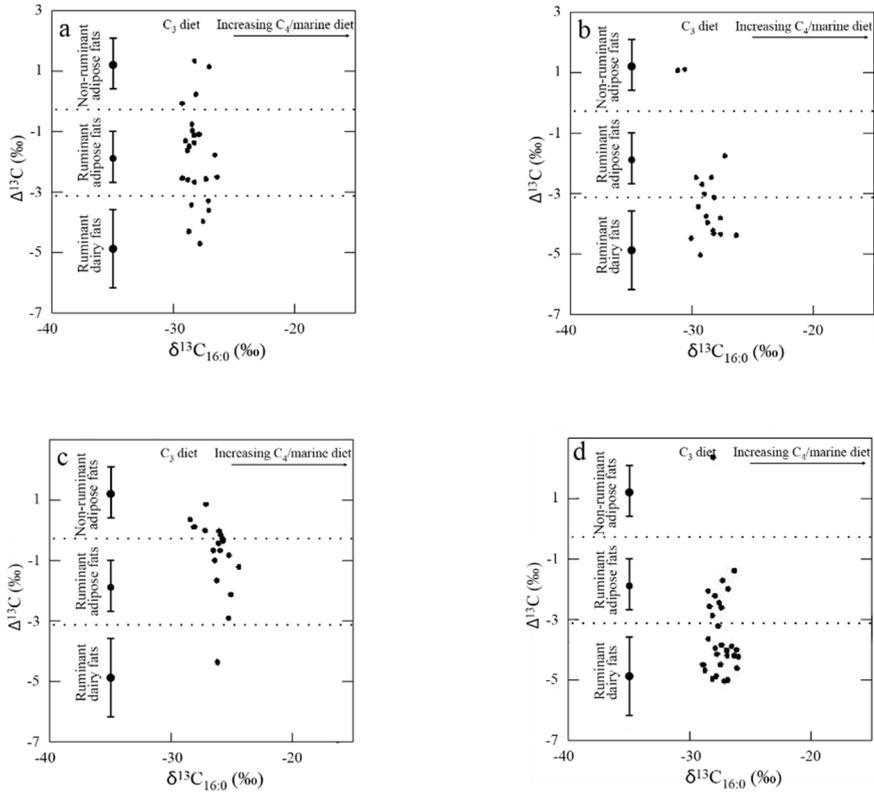


Figure 12. Plots of the $\delta^{13}\text{C}$ values for animal residue in archaeological site from Early Neolithic Balkans and Carpathian Basin. A) South Balkans: Yabalkovo and Nova Nadezhda; B) North Balkans: Blagotin, Grivac, and Divostin; C) Iron Gates: Lepenski Vir and Schela Cladovei; D) Carpathian Basin: Alsónyék and Ecsegfalva 23 (including results from Craig et al. 2007).

In the South Balkans, the sites of Yabalkovo and Nova Nadezhda exhibited similarities, particularly in the dominance of ruminant adipose fats, which accounted for 53 percent (8 sherds) and 89 percent (8 sherds), respectively, of the lipid-positive samples. Notably, among the two, only Yabalkovo contained ruminant dairy fats, reaching 27 percent (4 sherds). Non-ruminant adipose fats were found in only one sherd at Nova Nadezhda and in three sherds at Yabalkovo (see Table 2 and 3).

In contrast, the North Balkans and Hungarian sites display some divergences from their southern counterparts. First, in Šumadija and Hungary, there is a noticeable increase in the percentage of dairy adipose fats. Excluding Divostin

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and Szakmár-Kisülés, three out of four sites exhibited percentages exceeding 55 percent, with Blagotin reaching 78 percent (7 sherds). At Grivac, only 33 percent (2 sherds) of the lipid-positive samples were associated with dairy consumption. Second, ruminant adipose fats represented the next most frequently detected commodity, averaging 38 percent. As in the South Balkans, non-ruminant adipose fats were the least common among the detected lipids. Unlike Yabalkovo and Nova Nadezhda, where non-ruminant adipose fats were present in small proportions, four out of six sites—Blagotin, Grivac, Alsónyék, and Szakmár-Kisülés—yielded no traces of non-ruminant adipose fats. Among all analyzed samples, only two (one from Divostin and one from Grivac) presented mixed lipid signatures, most likely containing both ruminant adipose fats and ruminant dairy fats (see Tables 3 and 4).

The pattern is entirely reversed in the Iron Gates. At Lepenski Vir and Schela Cladovei, non-ruminant adipose fats dominate the lipid spectrum, representing 63 percent (5 sherds) and 82 percent (9 sherds) of the total lipid-positive samples, respectively (see Table 5). Although this category often pertains to terrestrial animals, the Iron Gates region presents a mixture of both terrestrial and aquatic resources. Given that aquatic fats exhibit low C18:0 content, their detection can be challenging, particularly when mixed with terrestrial animal fats. For aquatic lipids to be identifiable, they must have been the primary component in the cooking process to ensure their biomarkers were not overshadowed by other lipid sources.

As previously discussed, in addition to detecting C16:0 and C18:0, samples containing non-ruminant adipose fats were screened for ω -(*o*-alkylphenyl)alkanoic acids (APAAs) and dihydroxy acids to confirm the presence of aquatic resources. At Lepenski Vir, four out of five non-ruminant adipose fat samples contained APAAs, while at Schela Cladovei, five out of nine samples tested positive for aquatic resources. Ruminant adipose fats and dairy fats were notably underrepresented in this region, with dairy fats being entirely absent at Lepenski Vir.

Table 2: Summary of pots/herds containing lipid residues: Yabalkovo.

Site	Lab number	Vessel part	Context type and location	Lipids classes	$\delta^{13}C_{6:0}$ (‰)	$\delta^{13}C_{8:0}$ (‰)	$\Delta^{13}C$ (‰)	Lipid concentration ($\mu\text{g g}^{-1}$)	Predominant commodity
Yabalkovo	YAB 05	Rim	Pit fill, Pfr 1	FA	-27.2	-27.1	0.1	82	Non-Ruminant Adipose Fats
	YAB 07	Body	Ditch fill, A1/10	FA	-27.3	-26.0	1.3	1356	Non-Ruminant Adipose Fats
	YAB 11	Body	Ditch fill, A/01	FA	-27.4	-29.0	-1.6	89	Ruminant Adipose Fats
	YAB 22	Rim	Concentration of finds, N35	FA	-28.0	-32.6	-4.6	54	Ruminant Dairy Fats
	YAB 24	Base	Concentration of finds, N35	FA	-28.8	-29.0	-0.2	49	Non-Ruminant Adipose Fats
	YAB 27	Base	Concentration of finds, N35	FA	-26.8	-31.8	-5.1	545	Ruminant Dairy Fats
	YAB 30	Rim	Concentration of finds, N35	FA	-25.1	-27.0	-2.0	151	Ruminant Adipose Fats
	YAB 31	Rim	Concentration of finds, N35	FA	-27.7	-31.4	-3.7	765	Ruminant Dairy Fats
	YAB 32	Body	Concentration of finds, N35	FA	-26.8	-28.1	-1.3	2632	Ruminant Adipose Fats
	YAB 33	Body	Concentration of finds, N35	FA	-26.1	-28.9	-2.8	3843	Ruminant Adipose Fats
	YAB 35	Rim	Concentration of finds, N35	FA	-24.8	-27.6	-2.8	266	Ruminant Adipose Fats
	YAB 37	Base	Concentration of finds, N35	FA	-27.6	-28.7	-1.1	5956	Ruminant Adipose Fats
	YAB 38	Body	Concentration of finds, N35	FA	-25.8	-29.7	-3.9	768	Ruminant Dairy Fats
	YAB 39	Base	Concentration of finds, N35	FA	-27.3	-30.3	-2.9	1169	Ruminant Adipose Fats
	YAB 40	Base	Concentration of finds, N35	FA	-28.0	-29.6	-1.7	726	Ruminant Adipose Fats

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Table 3. Summary of the potsherds containing lipid residues: Nova Nadezhda, Blagotin, and Divostin.

Site	Lab number	Vessel part	Context type and location	Lipids classes	$\delta^{13}C_{650}$ (‰)	$\delta^{13}C_{850}$ (‰)	$\Delta^{13}C$ (‰)	Lipid concentration ($\mu\text{g g}^{-1}$)	Predominant commodity
Nova Nadezhda	NNA 02	Rim	House, 001	FA	-28.8	-31.5	-2.8	53	Ruminant Adipose Fats
	NNA 07	Rim	House, 001	FA	-26.4	-30.8	-4.3	453	Ruminant Adipose Fats
	NNA 13	Body	Ditch fill, 003	FA	-27.7	-28.6	-0.9	146	Ruminant Adipose Fats
	NNA 20	Rim	Ditch fill, 054/2	FA	-28.2	-30.0	-1.8	138	Ruminant Adipose Fats
	NNA 21	Rim	Ditch fill, 054/2	FA	-25.7	-24.6	1.1	63	Non-Ruminant Adipose Fats
	NNA 23	Base	Ditch fill, 054/3	FA	-28.4	-29.9	-1.5	54	Ruminant Adipose Fats
	NNA 32	Rim	Ditch fill, 003	FA	-28.1	-31.0	-2.8	353	Ruminant Adipose Fats
	NNA 33	Rim	Ditch fill, 003	FA	-25.8	-29.4	-3.6	146	Ruminant Adipose Fats
	NNA 38	Rim	Ditch fill, 055	FA	-27.4	-28.7	-1.3	254	Ruminant Adipose Fats
	BLA 17	Body	Pit fill, QI/12	FA	-27.4	-31.8	-4.5	463	Ruminant Dairy Fats
Blagotin	BLA 20	Rim	Pit fill, QI/18	FA	-24.7	-29.4	-4.6	572	Ruminant Dairy Fats
	BLA 23	Rim	Pit fill, Q _g /09	FA	-28.4	-31.6	-3.2	5679	Ruminant Adipose Fats
	BLA 28	Body	Pit fill, QI/12	FA	-28.9	-34.2	-5.3	783	Ruminant Dairy Fats
	BLA 29	Rim	Pit fill, Q _d /11	FA	-28.0	-32.2	-4.2	235	Ruminant Dairy Fats
	BLA 30	Rim	Pit fill, Rb/14	FA	-29.3	-31.9	-2.6	752	Ruminant Adipose Fats
	BLA 32	Rim	Pit fill, Rb/14	FA	-29.9	-34.6	-4.7	1937	Ruminant Dairy Fats
	BLA 34	Rim	Pit fill, QI/11	FA	-27.3	-31.9	-4.6	93	Ruminant Dairy Fats
	BLA 36	Body	Pit fill, QI/09	FA	-26.5	-30.6	-4.0	409	Ruminant Dairy Fats
	DIV 13	Rim	Pit fill, D-2/V- ⁶⁷	FA	-30.6	-29.4	1.2	102	Non-Ruminant Adipose Fats
	DIV 21	Rim	Pit fill, D ₁ -2/V- ⁶⁷	FA	-31.4	-30.3	1.2	264	Non-Ruminant Adipose Fats
Divostin	DIV 40	Rim	Pit fill, D-1/V- ⁶⁷	FA	-29.1	-32.7	-3.6	367	Mixture Ruminant Adipose/Ruminant Dairy Fats

Table 4. Summary of the pots/herds containing lipid residues: Grivac, Alsónyék, and Ecségfalva 23

Site	Lab number	Vessel part	Context type and location	Lipids classes	$\delta^{13}\text{C}_{\text{lipid}}$ (‰)	$\delta^{13}\text{C}_{\text{chole}}$ (‰)	$\Delta^{13}\text{C}$ (‰)	Lipid concentration ($\mu\text{g g}^{-1}$)	Predominant commodity
Grivac	GRI 03	Rim	1969/A/VI	FA	-26.5	-31.1	-4.6	1673	Ruminant Dairy Fats
	GRI 06	Rim	1969/B/VI	FA	-27.3	-30.6	-3.3	232	Mixture Ruminant Adipose/Ruminant Dairy Fats
	GRI 17	Rim	1969/B/IV	FA	-28.6	-31.5	-2.9	1257	Ruminant Adipose Fats
	GRI 18	Rim	An 10/41	FA	-26.1	-27.9	-1.8	541	Ruminant Adipose Fats
	GRI 26	Rim	1969/A/V, 14	FA	-27.6	-30.2	-2.6	233	Ruminant Adipose Fats
	GRI 32	Rim	1994/A/VIIc	FA	-28.5	-32.1	-4.0	219	Ruminant Dairy Fats
Alsónyék	ALS 01	Rim	Pit fill, 704	FA	-27.1	-5.1	-5.1	1352	Ruminant Dairy Fats
	ALS 10	Rim	Pit fill, 617	FA	-26.1	-32.2	-4.6	503	Ruminant Dairy Fats
	ALS 11	Rim	Pit fill, 617	FA	-27.9	-31.8	-4.0	624	Ruminant Dairy Fats
	ALS 12	Rim	Pit fill, 617	FA	-27.7	-31.9	-4.2	881	Ruminant Dairy Fats
	ALS 18	Rim	Pit fill, 720	FA	-28.9	-33.4	-4.5	903	Ruminant Dairy Fats
	ALS 22	Rim	Pit fill, 720	FA	-28.5	-30.5	-2.1	2265	Ruminant Adipose Fats
	ALS 23	Body	Pit fill, 720	FA	-28.1	-33.1	-5.0	1398	Ruminant Dairy Fats
	ALS 24	Rim	Pit fill, 720	FA	-28.7	-33.4	-4.7	774	Ruminant Dairy Fats
	ALS 25	Base	Pit fill, 687	FA	-27.9	-30.1	-2.2	548	Ruminant Adipose Fats
	ALS 30	Rim	Pit fill, 687	FA	-28.5	-32.1	-3.7	259	Ruminant Dairy Fats
	ALS 31	Rim	Pit fill, 687	FA	-27.3	-30.0	-2.6	487	Ruminant Adipose Fats
	ALS 34	Rim	Pit fill, 708	FA	-27.8	-32.7	-4.9	672	Ruminant Dairy Fats
Ecségfalva 23	ALS 36	Rim	Pit fill, 1078	FA	-27.3	-29.0	-1.7	152	Ruminant Adipose Fats
	ALS 38	Rim	Pit fill, 1078	FA	-28.3	-30.9	-2.6	1393	Ruminant Adipose Fats
	ECS 08	Rim	23C/515	FA	-26.0	-30.2	-4.2	177	Ruminant Dairy Fats
	ECS 16	Rim	23B/475	FA	-27.3	-31.2	-3.9	912	Ruminant Dairy Fats
	ECS 17	Rim	23B/376	FA	-28.0	-25.7	2.3	1298	Non-Ruminant Adipose Fats
	ECS 19	Rim	23B/376	FA	-28.1	-31.0	-2.9	119	Ruminant Adipose Fats
	ECS 21	Rim	23B/430	FA	-27.4	-31.9	-4.5	347	Ruminant Dairy Fats
	ECS 26	Rim	23B/464	FA	-27.5	-30.0	-2.5	113	Ruminant Adipose Fats
	ECS 28	Rim	23B/301	FA	-27.6	-30.9	-3.2	75	Ruminant Dairy Fats
	ECS 32	Rim	23B/301	FA	-26.9	-31.0	-4.0	151	Ruminant Dairy Fats

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Table 5. Summary of the potsherds containing lipid residues: Lepenski Vir and Schela Cladovei.

Site	Lab number	Vessel part	Context type and location	Lipids classes	$\delta^{13}C_{16:0}$ (‰)	$\delta^{13}C_{18:0}$ (‰)	$\Delta^{13}C$ (‰)	Lipid concentration ($\mu g\ g^{-1}$)	Predominant commodity
Lepenski Vir	LV 04	Rim	Block F	FA	-26.2	-27.9	-1.7	178	Ruminant Adipose Fats
	LV 07	Rim	Block F	FA	-26.0	-26.0	0	489	Non-Ruminant Adipose Fats
	LV 08	Body	Block F	FA	-25.7	-26.0	-0.3	831	Non-Ruminant Adipose Fats
	LV 10	Rim	Block H I	FA	-25.7	-26.0	-0.4	1312	Non-Ruminant Adipose Fats
	LV 13	Rim	Quad A V	FA	-25.0	-27.2	-2.1	72	Ruminant Adipose Fats
	LV 30	Rim	Quad c II	FA	-25.2	-28.1	-2.9	356	Non-Ruminant Adipose Fats
	LV 32	Body	Quad c II	FA	-26.3	-27.3	-1.0	420	Non-Ruminant Adipose Fats
	LV 35	Rim	Quad c II	FA	-27.1	-26.2	0.9	1298	Ruminant Adipose Fats
	SCL 01	Rim	VII/Q510b		-26.1	-26.1	0.0	3672	Non-Ruminant Adipose Fats
	SCL 02	Rim	VII/Q513a		-28.4	-28.0	0.4	834	Non-Ruminant Adipose Fats
Schela Cladovei	SCL 12	Rim	VII		-25.9	-26.6	-0.7	241	Non-Ruminant Adipose Fats
	SCL 16	Rim	VII/R512d		-26.1	-30.5	-4.4	562	Ruminant Dairy Fats
	SCL 18	Rim	VII/R509d		-25.2	-26.0	-0.8	68	Non-Ruminant Adipose Fats
	SCL 21	Rim	VII/T512d		-28.6	-28.5	0.1	703	Non-Ruminant Adipose Fats
	SCL 22	Rim	VII/T512d		-28.0	-27.9	0.1	376	Non-Ruminant Adipose Fats
	SCL 24	Rim	VII		-25.9	-26.0	-0.2	123	Non-Ruminant Adipose Fats
	SCL 31	Rim	VII		-26.5	-27.1	-0.7	161	Non-Ruminant Adipose Fats
	SCL 37	Rim	VII		-26.0	-26.5	-0.4	812	Non-Ruminant Adipose Fats
	SCL 39	Body	VII/R511a		-24.3	-25.5	-1.2	495	Ruminant Adipose Fats

3.1.4 Discussion

This study identifies three distinct lipid residue patterns corresponding to the regions under investigation (Figure 13 and Table 6). First, in the Thracian region of Bulgaria, the results align closely with patterns observed in Greece and Anatolia, where ruminant adipose fats dominate, with only a few instances of non-ruminant and ruminant dairy fats (Figure 13). Similar trends were noted by Evershed et al. (2008), who documented comparable dietary practices across sites in Central Anatolia, Eastern Anatolia, the Levant, Southeast Europe, and Northern Greece. The primary exception was northwestern Anatolia, where ruminant dairy residues were more prevalent.

Nearly a decade later, Debono Spiteri et al. (2016) revisited and expanded upon the findings of Evershed et al., extending the research to the northern Mediterranean. Their results remained consistent, with two additional regions—southwestern France/Spain and Italy/Slovenia/Croatia/Malta—exhibiting a predominance of dairy adipose fats. More recently, Whelton et al. (2018) further corroborated the dominance of ruminant adipose fats in northern Greece, while also conducting a diachronic analysis that highlighted a shift toward more diverse subsistence strategies in later periods. Notably, despite the coastal proximity of some sites in their study, no biomarkers indicative of aquatic resources were detected. Given that food habits evolved over time, as demonstrated by Whelton et al. (2018), a cautious approach is necessary when interpreting the results from Evershed et al. (2008) and Debono Spiteri et al. (2016). Both studies include sites spanning from the Early to the Late Neolithic without clearly differentiating temporal phases in their lipid residue analyses.

In the present book, only Yabalkovo exhibited evidence of dairy product usage, with dairy residues surpassing non-ruminant fats by one sample. In contrast, Nova Nadezhda was almost exclusively characterized by ruminant adipose fats, with only a single sherd containing non-ruminant lipids. In both cases, ruminant animals formed the foundation of the diet, while other animal by-products appear to have played only a complementary role.

In contrast to the southern Balkan region, sites from Šumadija, Transdanubia, and the Alföld present a markedly different dietary pattern. As Neolithic lifeways expanded beyond the Mediterranean environment into temperate regions, a shift in food habits becomes evident, at least in lipid residue analyses, with a growing dominance of dairy products (Table 6). With the exception of Divostin, all sites exhibit a consistent proportion of approximately 20 percent of analyzed samples containing identifiable lipid residues, which aligns with the expected standard for the region. In Šumadija, the distribution of ruminant dairy fats varies from 33 percent at Grivac to 78 percent at Blagotin. Notably, neither site yielded any evidence of non-ruminant adipose fats. Divostin, however, presents an anomaly within this

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regional framework, and its results must be interpreted with caution. With only 7 percent of samples containing identifiable lipid residues—significantly lower than the regional average of 20 percent—the dataset remains statistically weak. Moreover, the lipid profile at Divostin deviates from the broader pattern observed in the Starčevo-Körös complex outside of the Iron Gates. The presence of two sherds associated with non-ruminant fats and only one with ruminant fats reflects a lipid signature more reminiscent of the Iron Gates region, which will be examined in detail below.

Table 6. Summary of lipid residue analysis: samples and results.

Sites	Sam- ples		Residue De- tected		Non-Rumi- nant adipose fats		Ruminant adipose fats		Ruminant dairy fats	
	Number	%	Number	%	Number	%	Number	%		
Thrace										
<i>Nova Nadežhda</i>	45	9	20	1	11	8	89	0	0	
<i>Yabalkovo</i>	42	15	35	3	20	8	53	4	27	
Šumadija										
<i>Blagotin</i>	43	9	21	0	0	2	22	7	78	
<i>Divostin</i>	43	3	7	2	67	1	33	0	0	
<i>Grivac</i>	33	6	18	0	0	4	66	2	33	
Transdanubia/ Alföld										
<i>Alsónyék</i>	43	14	32	0	0	5	36	9	64	
<i>Ecségfalva 23</i>	41	9	20	1	11	3	33	5	56	
<i>Szakmár-Kisülés</i>	29	0	0	0	0	0	0	0	0	
Iron Gates										
<i>Schela Cladovei</i>	49	11	22	9	82	1	9	1	9	
<i>Lepenski Vir</i>	40	8	20	5	63	3	37	0	0	

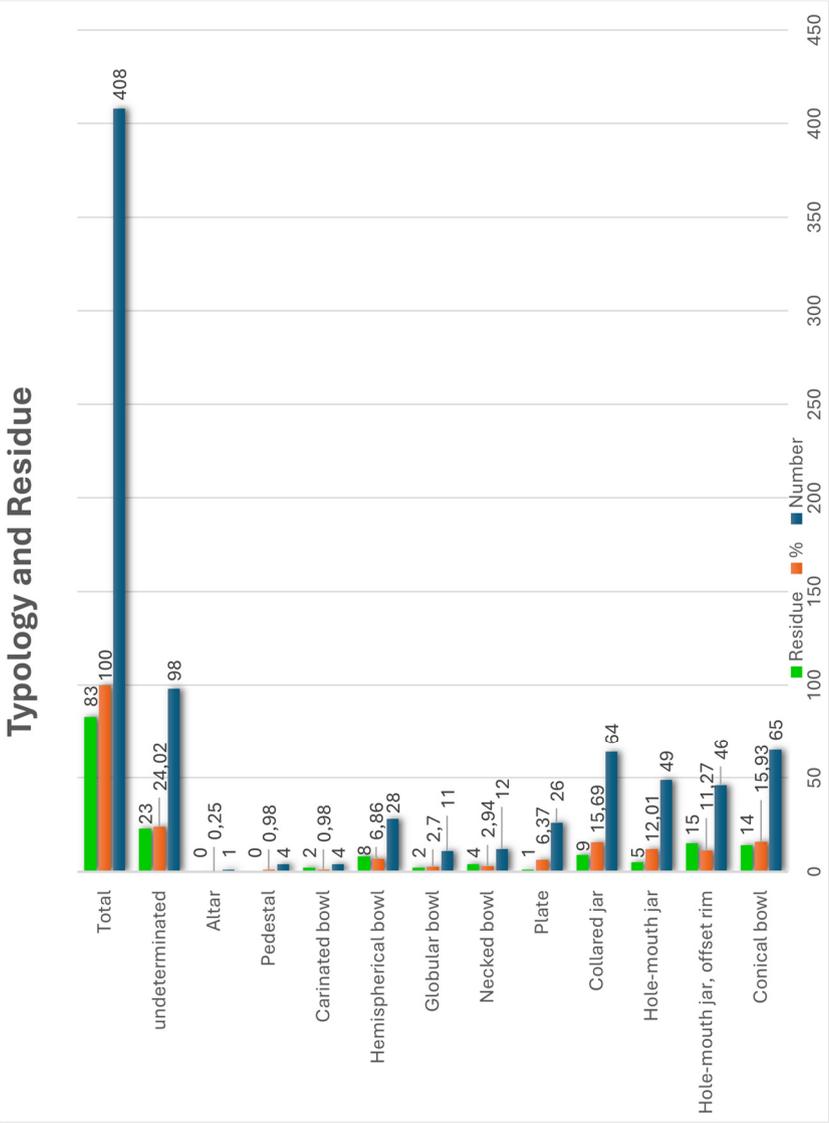


Figure 13. Animal residues found in vessels according to their typology.

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In Transdanubia and the Alföld region, the Starčevo site of Alsónyék exhibited a dietary pattern nearly identical to that of its southern counterparts. With over 33 percent of the analyzed samples containing animal fats, dairy products accounting for up to 64 percent and no detectable traces of non-ruminant adipose fats, the results reaffirm the strong preference for dairy among Starčevo groups. Slightly further northeast, Ecsegfalva 23, representing the Körös culture, was similarly dominated by dairy adipose fats, comprising 56 percent of the positive results. However, unlike the Starčevo sites, Ecsegfalva 23 yielded one sample containing non-ruminant adipose fats. A previous study at the site conducted by Craig et al. (2007) reported similar findings, with milk fats and their derivatives comprising 71 percent of the lipid residues, while ruminant fats accounted for 29 percent. Notably, that study did not detect any traces of non-ruminant adipose fats, suggesting that the current research has identified a rare case of non-ruminant animal use in the cooking process. This finding reinforces the idea that Ecsegfalva 23, and by extension the Körös culture, aligns closely with the dietary habits of the Starčevo culture.

While the Starčevo and Körös cultures exhibit substantial similarities in lipid residues, the Iron Gates region—often described as part of the broader Starčevo-Criș complex—presents a stark contrast. Whereas dairy products dominate dietary patterns outside the Danube, they appear only in rare instances within the Iron Gates. In this study, only Schela Cladovei provided evidence, via a single sample, that dairy products may have been consumed locally. This result aligns with expectations, as the region is known for retaining certain Mesolithic cultural behaviors and demonstrating a reliance on aquatic resources. These characteristics persisted even as the economy transitioned from hunting and gathering to farming (see Chapter 4). While faunal remains have long suggested a strong dependence on aquatic resources, the hypothesis had not been fully substantiated until recently. Advances in residue analysis now enable the detection of lipids originating from aquatic sources, providing definitive insights into these dietary practices (e.g. Cramp et al. 2019; Cramp and Evershed 2014; Craig, Forster, et al. 2007).

This study unequivocally confirms the use of aquatic resources at both Lepenski Vir and Schela Cladovei. Across the Iron Gates sites, more than 50 percent of the detected organic residues were attributed to non-ruminants. Specifically, Lepenski Vir yielded 63 percent non-ruminant residues, while Schela Cladovei reached 82 percent. At Schela Cladovei, the initial results revealed a predominance of non-ruminant adipose fats, with nine samples testing positive, compared to only one sample each for ruminant adipose and ruminant dairy fats. Further investigation identified five of the nine non-ruminant samples as originating from aquatic sources, accounting for 45 percent of the total organic residues. A similar trend was observed at Lepenski Vir, where four out of five non-

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ruminant samples were linked to aquatic resources, while the remaining three samples were associated with ruminants. However, in contrast to Schela Cladovei, no dairy residues were detected at Lepenski Vir. Interestingly, stable isotope values from both sites ranged from depleted values typical of freshwater ecosystems to higher values associated with anadromous fish species—organisms that are born in freshwater, migrate to the ocean, and return to freshwater for spawning, such as sturgeon (e.g. Cramp et al. 2019; Alexandru 2010; Bartosiewicz, Bonsall, and Şişu 2008).

In a collaborative study by Cramp et al. (Cramp et al. 2019), which included the present research, three additional sites from the Iron Gates—Vlasac, Aria Babi, and Velesnica—were analyzed. The first two sites are situated in the Đerdap region near Lepenski Vir, while Velesnica is located further downstream, between the Iron Gates Dams I and II. The results from these sites align with those of Schela Cladovei and Lepenski Vir, with 50 percent, 40 percent, and 47 percent of analyzed samples containing aquatic-related lipids, respectively. However, similar to Divostin, Vlasac yielded a lower proportion, with only 5 percent ($n=2$) of the collected samples containing organic residues.

It is important to acknowledge the challenges in identifying lipids derived from aquatic sources. As aquatic lipids typically produce lower C18 values than their mammalian counterparts, they can be masked when both sources are present in a cooking process. Nevertheless, the results obtained from Schela Cladovei, Lepenski Vir, Vlasac, Aria Babi, and Velesnica provide undeniable evidence that aquatic resources played a significant role in the diet of the Iron Gates population. Despite being part of the broader Starčevo-Körös-Criş cultural complex, the dietary habits in the Iron Gates region were markedly distinct, as will be further discussed in Chapter 4.

Finally, a statistical comparison between technological innovation and food habits is unfeasible in this case. The primary limitation lies in the sample selection, as the distribution of pottery types was not uniform, preventing an accurate correlation between specific vessel types and residue presence. Consequently, any attempt to link lipid residues to specific ceramic forms could lead to misleading interpretations. With this consideration in mind, Figure 13 presents the number of identified organic residues relative to pottery types and their overall representation purely for informational purposes.

Although direct comparisons between vessel type and residue results are inconclusive, a general trend can be observed: vessel forms with substantial sample sizes (at least more than 10) exhibit proportions of organic residue detection ranging between 20 percent and 30 percent, consistent with the regional pattern. However, plates, with only 4 percent positive results, appear to contain fewer identifiable residues. This observation may relate to food preparation practices

and absorption rates. As discussed earlier, for lipids to be preserved in ceramic matrices, vessels must have undergone extensive and prolonged use. Storage and cooking vessels, which are frequently reused and continuously exposed to food commodities, are therefore more likely to retain detectable lipid residues compared to vessels primarily used for consumption.

Unfortunately, this is the extent of what can be inferred from Figure 13. However, this limitation is common in lipid residue analysis, a field that remains in its early stages. Many fundamental questions remain unanswered, and current research priorities are largely focused on identifying commodities in relation to regional dietary patterns or reconstructing site-specific subsistence strategies. Future studies should consider integrating typological analyses, ensuring that sampling strategies account not only for context and diversity but also for representativeness. Such an approach would allow for a deeper understanding of food behavior in relation to ceramic use, providing insights into which vessel types were preferred for particular food choices. As the first comprehensive study of lipid residues in the Balkans and the Hungarian Plains, the present research did not address this aspect, but it represents an important avenue for future investigation.

3.2 Faunal Remains

Zooarchaeological analysis has long been central to discussions on subsistence strategies and food habits, offering an invaluable source of data. While lipid residue analysis provides critical insights into past consumption practices, faunal remains complement and enhance these interpretations, filling in gaps that residue analysis alone cannot address. This subchapter presents a summary of faunal remains from Southeast European sites, with a particular focus on the Mesolithic and Early Neolithic periods. As discussed earlier, dating many of these sites poses significant challenges; therefore, when possible, the sites included in this summary are dated to approximately 6000 BC.

3.2.1 Materials and Methods

The data used in this study result from a compilation of zooarchaeological findings from sites in the Aegean, South Balkans, North Balkans, and the Carpathian Basin. These data are derived from published excavations and encompass various methods of recovery and analysis. While zooarchaeology has produced a wealth of high-quality studies, inconsistencies in excavation techniques, analytical approaches, and publication standards have introduced biases that may impact interpretative scope (e.g. Orton, Gaastra, and Vander Linden 2016; Payne 1972;

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Shaffer 1992; van der Veen and Fieller 1982).⁴⁶ One of the primary concerns relates to recovery methods, particularly in older excavations. When systematic sieving and detailed recording are not employed, smaller species—including aquatic, terrestrial, and aerial fauna—are often underrepresented. This can lead to an overestimation of larger species such as aurochs, cattle, goats, or sturgeon (e.g. Orton, Gaastra, and Vander Linden 2016). Since detailed records of excavation procedures are often unavailable—especially for older digs—the interpretations presented here acknowledge these limitations.

A persistent issue in zooarchaeology is the difficulty in distinguishing between sheep (*Ovis aries*) and goats (*Capra hircus*), as both species share similar skeletal characteristics (e.g. Zeder and Lapham 2010; Zeder and Pilaar 2010; Halstead, Collins, and Isaakidou 2002; Rowley-Conwy 1998; Boessneck 1969). This challenge is evident in publications, where these species are frequently grouped together or even divided into three separate categories: sheep, goats, and sheep/goat. In this study (Table 7–8), a four-category subdivision—sheep, goat, sheep/goat, and caprine—has been applied to mitigate classification ambiguities.⁴⁷

The problem of species identification extends beyond sheep and goats. Many sites contain substantial quantities of unidentified or only partially identified remains. While degradation accounts for some of these cases, the issue is further compounded by the way certain species are treated within zooarchaeological research. As Orton et al. highlight:

Fish, birds, reptiles, amphibians, and ‘micromammals’ are often treated as specialisms within zooarchaeology, and only sporadically included alongside the main ‘macromammals’ – often at lower taxonomic resolution. Moreover, where these groups are omitted from reports it is rarely clear whether they were absent or simply not studied.

(Orton, Gaastra, and Vander Linden 2016, 4)

To this, one might also add: “or simply discarded as unidentified.” These smaller species often require specialized expertise, and in cases where researchers lack the necessary background, they may be relegated to the unidentified category.

46. While some of the criticisms and limitations may apply to zooarchaeology more broadly or to other regions, the present biases pertain specifically to research conducted in Southeast Europe.

47. Caprine refers here to the subfamily that includes both sheep and goats. The distinction between ‘sheep/goat’ and ‘caprine’ is made for statistical purposes. Since ‘sheep/goat’ is often used to denote faunal remains that cannot be identified more precisely, a separate category was created to report the percentages of sheep, goat, and unidentified sheep/goat for each site.

Additionally, partial identification occurs when remains are classified into broad categories such as small, medium, or large mammals. The challenge here is defining these categories consistently across different sites, as individual researchers may apply varying interpretations. To avoid such discrepancies, this study includes only remains that have been explicitly identified to the taxonomic level.

Another obstacle in zooarchaeological research is the inconsistency in statistical methodologies and data presentation. For example, at Kovačevo, results are reported solely in terms of the number of individual specimens (NISP) as a percentage (Benecke 2006), whereas at Kremenik, only the minimum number of individuals (MNI) is provided (Ninov 1986). These differing approaches complicate cross-site comparisons and, as a result, such cases are excluded from broad statistical trend analyses, though they may still be referenced in specific contexts.

Similarly, the absence of detailed statistical analyses in many reports presents a further limitation. While NISP and MNI provide a general overview of species presence, more nuanced analyses—such as kill-off patterns used to infer subsistence and economic strategies—are often lacking. Following Bökönyi's recommendation (personal communication from Bökönyi to Bartosiewicz in Bartosiewicz and Bonsall 2018), only sites with a faunal assemblage of at least 500 identifiable bones have been considered for statistical comparison in this study. This threshold, applied in Tables 7 and 8, ensures a more reliable dataset for comparative analysis. However, as Bartosiewicz and Bonsall (2018) note, smaller assemblages should not be disregarded outright, as they may still provide valuable insights. In certain cases, smaller sites—such as temporary camps or short-term occupation sites—may contain relatively few bones, yet still contribute to the broader narrative of regional subsistence strategies. Thus, for regional comparisons, the dataset presented in Tables 7 and 8 serves as the primary reference for statistical analyses. While recognizing the inherent limitations and biases within zooarchaeological data, this study aims to provide a robust synthesis of faunal remains to enhance our understanding of food culture and subsistence strategies in Southeast Europe during the Mesolithic and Early Neolithic.

Table 7. Summary of faunal remains in Southeast Europe: Carpathian Basin and Northern Balkans.

Sites	Period/ Culture group	NISP **	Cattle %	Goat NISP	Sheep NISP	Sheep/ Goat NISP	Caprine %	Pig NISP	Pig %	Large game NISP	Large game %	References
Carpathian Basin												
<i>Alonyók</i>	Starčevo	428	28.97			81	18.92	17	3.97	188	44	Nyerges 2013
<i>Erogháta 23</i>	Körös	4337	10.05	9	408	3607	80.33	66	1.52	248	5.82	Bartoszewicz 2007
<i>Erdőd 119</i>	Körös	22366	51.39	298	2332	12717	68.62	140	0.63	1645	7.35	Bókányi 1992
<i>Fonyó-Győr</i>	Criș II	7561	26.00	34.39		3054	40.39	386	5.11	1489	19.7	El Sisi 2008
<i>Fonyó-Sátság</i>	Criș II	2563	8.95	34.92	77	270	668	39.60	99	536	21	Greenfield & Jongsma 2008
<i>Lányórák</i>	Starčevo	1068	20.9	19.57	21	103	85.67	16	1.50	51	4.77	Bókányi 1981
<i>Luda Badgák</i>	Körös	2450	28.4	11.59		1863	76.04	8	0.33	572	23.34	Bókányi 1974
<i>Ménamra Sítaljai</i>	Criș I-III	890	48.6	54.61		262	29.44	9	1.01	128	16	El Sisi 2011
<i>Péteri</i>												
<i>Nova</i>	Körös	911	9.5	10.42		115	12.62	18	1.97	736	80.79	Bókányi 1984
<i>Rédeke</i>	Körös	1397	15.3	10.95		631	45.17	14	1.00	525	38.69	Bartoszewicz 2012
<i>Szász-Cátracs-Merzi</i>	Criș IB-IIA	1086	33.5	30.85		620	57.09	77	7.09	51	4.7	El Sisi 2008
<i>Sziged</i>	Körös	1361	57.6	42.32		680	49.96	2	0.15	87	6.45	Bartoszewicz 2012
<i>Székely-Szendő</i>	Körös	6556	15.57	23.75	58	571	34.28	61.88	93	714	11.06	Bartoszewicz 2012
<i>Tiszváralja</i>	Körös	949	24.2	25.50	137		14.43	33	3.47	459	48.36	Domborozki 2010
Northern Balkans												
<i>Blagotin</i>	Proto- Starčevo	8706	26.84	30.83	281	1048	38.41	115	1.32	722	8.29	Greenfield et al. 2014
<i>Dinatin</i>	Proto- Starčevo	2398	11.17	46.58	14	92	87.5	84	3.50	200	8.54	Bókányi 1988
<i>Dunja Branjeva</i>	Proto- Starčevo	1926	40.4	11.20		1306	36.22	26	0.72	1856	33.63	Blažič 2005
<i>Gubok</i>	Starčevo	1160	26.0	22.41	2	6	11.8	10.86	23	1.98	747	Blažič 1985
<i>Koprivce</i>	Criș	2005	97.6	48.68	18	127	64.5	39.40	5	0.25	223	Manhart 1998
<i>Leposki Vrh</i>	Proto- Starčevo	1959	37.5	19.14		81	4.13	8	0.4	1355	69.16	Bókányi 1969
<i>Magers-Baldulin-Mog</i>	Criș I	8500	31				60		0.1		8	Balasse et al. 2013
<i>Ivanic*</i>												
<i>Mihaljanci</i>	Starčevo	2554	8.53	33.40	35	137	12.68	56.38	5	0.20	255	Bókányi 1992
<i>Oncharno-Gomata</i>	Karanovo II	1251	80.5	64.19	8	6	21.3	18.15	101	8.07	9.11	Nobis 1986
<i>Samarodun*</i>	Karanovo II	2170	80								35	Benecke 2006
<i>Schala Cladovei</i>	Criș	1569	40.0	25.49		35	29.2	20.84	66	4.20	747	Bartoszewicz et al. 2001
<i>Sursovo-Graf</i>	Starčevo	1159	50.5	43.57	4	213	18.72	31	2.67	403	34.77	Clason 1980

Table 8. Summary of faunal remains in Southeast Europe: Southern Balkans and Aegean.

Sites	Period/ Culture group	NISP **	Cattle NISP	Cattle %	Goat NISP	Sheep NISP	Sheep/ Goat NISP	Caprine %	Pig NISP	Pig %	Large game NISP	Large game %	References
Southern Balkans													
<i>Anzabegovo I-III</i>	Anzabegovo-Vrsnik I-III	3192	305	9.56			2476	77.57	288	9.02	80	2.5	Bökönyi 1976
<i>Kupitan Dimitriev</i>	Karanovo I	1650	512	31.03			932	56.48	127	7.70	72	4.4	Ninov 1999
<i>Karanovo I</i>	Karanovo I	4671	990	21	76	265	2234	55	374	8	630	13.48	Bökönyi & Barto-siewicz 1997
<i>Konovo*</i>	Karanovo I			14				65		21		3.5	Benecke 2006
<i>Madžari</i>	Anza-begovo-Vrsnik IV	2856	1104	38.65	33	145	1116	45.30	273	9.55	167	5.65	Moskalevska & Simev 1989
<i>Mirsalovo</i>	Karanovo I	2954	364	12.32	39	210	1452	57.58	488	16.51	394	13.33	Martnova et al. 2016
<i>Na Bug*</i>	Anzab-egovo-Vrsnik	1407		14.6			76.8			5.7		2.4	Orton 2012f
<i>Rakitzovo</i>	Karanovo I	4373	1944	44.45			897	20.51	214	4.89	1278	29.21	Kovachev & Georgiev 2002
<i>Slatina</i>	Karanovo I	3861	1637	42.40	33	202	1268	32.84	350	9.07	362	9.17	Bökönyi 1992
<i>Yabalovo</i>	Karanovo I	2086	513	24.59	12	31	1298	64.29	159	7.62	49	2.35	Spassov & Iliev 2014
Aegean													
<i>Atalibito II</i>	Ceramic EN	1489	61	4.09			1157	77.7	152	10.2	73	4.9	Bökönyi 1989
<i>Argissa</i>	Aceramic EN	2195	103	4.69		33	1820	84.42	216	9.84	52	2.37	Boessneck 1962
<i>Franchthi*</i>	Ceramic EN						70			30			Payne 1975
<i>Nvo, Nikaonidia</i>	Ceramic EN	450	64	14.44			310	68.89	65	14.44	11	2.44	Higgs 1962
<i>Protrama 1-2</i>	Ceramic EN	1299	388	29.86			718	55.27	171	13.16	22	1.69	Halstead & Jones 1980
<i>Revania-Korina</i>	Ceramic EN	2140	257	12			1470	68.69	363	16.96	30	1.40	Halstead & Isakidou 2013
<i>Servia*</i>	MIN			15				60		15		10	Watson 1979
<i>Sesklo</i>	Ceramic EN	721	92	13.80			427	64.1	144	21.6	21	2.9	Schwartz 1982
<i>Uluçtepe V/early</i>	Ceramic EN	2149	394	18.33	55	96	1215	63.65	289	13.44	63	2.9	Çakirlar 2012

3.2.2 Results and Discussion

To assess the faunal remains in the northern Balkans and the Carpathian Basin, it is first necessary to examine the Aegean and South Balkans, as these regions provide a comparative framework for understanding broader trends. While both areas exhibit some regional variations, they largely share key characteristics, particularly a strong reliance on caprines and an economy centered around domesticated animals. These patterns are also observed among their northern neighbors; however, a notable distinction lies in the degree of commitment to these specific domesticated species and a relative disinterest in wild game.

Figures 14 and 15 illustrate the predominance of sheep and goat consumption, which consistently exceeds 50 percent in the faunal assemblages analyzed. In contrast, the occurrence of cattle and wild game in the Aegean is notably low, ranging from 4 percent at Achilleion II to 18 percent at Ulucak V—except for Prodrornos 1–2, where cattle represent 30 percent of the assemblage. Wild game presence is even more limited, with percentages ranging from just 1 percent at Revenia-Korinou to 5 percent at Achilleion II. Pigs also appear at relatively low frequencies, averaging around 14 percent, though in certain contexts, such as at Sesklo, their representation can rise to 22 percent.

These findings underscore a dietary strategy that heavily favored domesticated sheep and goats, while other livestock, including cattle and pigs, played a secondary role. The minimal presence of wild game suggests a shift away from foraging-based subsistence practices, reinforcing the notion that early Neolithic communities in these regions were firmly embedded in an agricultural economy with an emphasis on controlled animal husbandry.

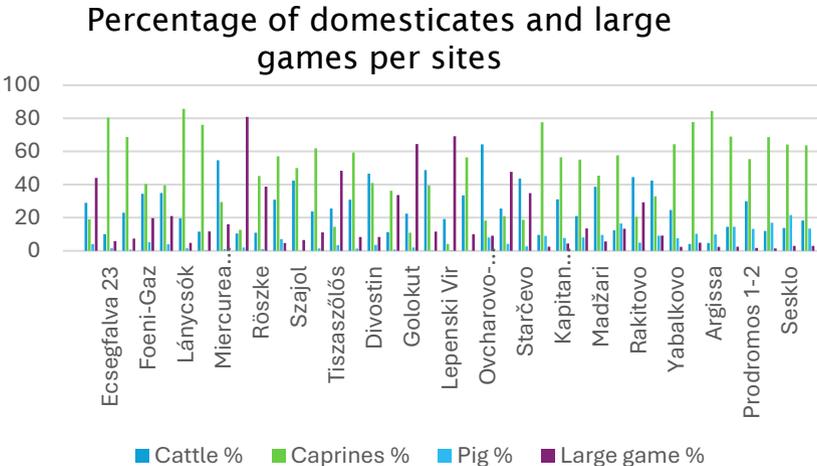
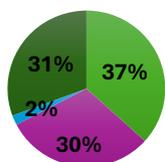


Figure 14. Percentage of domesticates and large game per sites.

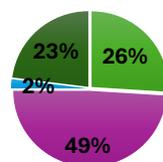
3.2 Faunal Remains

The faunal assemblage in the South Balkans continues to reflect the dominance of caprines; however, in contrast to the Aegean, this region exhibits a greater integration of cattle and wild game into its subsistence strategies (Figures 14 and 15). At sites such as Rakitovo, Slatina, Madžari, and Kapitan Dimitriev, cattle account for more than 30 percent of the total assemblage, reaching as high as 44 percent at Rakitovo. While some older excavations may have led to an overrepresentation of larger species, as discussed earlier, more recent and methodologically refined excavations—such as at Yabalkovo—continue to produce similar results, with cattle comprising 24 percent of the faunal remains.

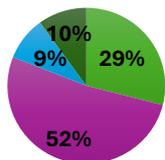
Northern Balkans



Carpathian Basin



Southern Balkans



Aegean

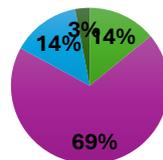


Figure 15. Pie charts of regional distribution of cattle, caprines, pigs, and large game in percentage.

Conversely, the use of pigs appears to have declined slightly compared to the Aegean, whereas wild game seems to have gained prominence, averaging around 10 percent. However, this figure may be misleading (Figures 15 and 16). While there is an overall increase in the remains of wild animals, this average is heavily influenced by site-specific variations.

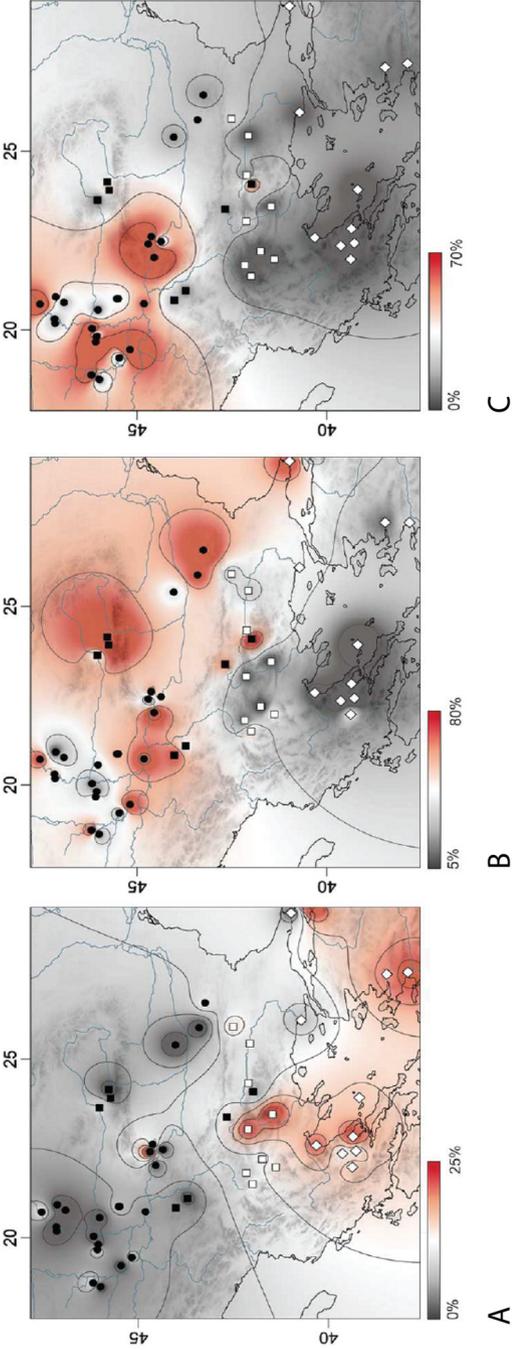


Figure 16. Animal frequencies at sites. A) Pig frequency; B) Cattle frequency; C) Large and medium-size game frequency (after Ivanova et al. 2018: fig. 4).

3.2 Faunal Remains

For instance, Rakitovo presents an exceptionally high proportion of wild game at 29 percent, whereas sites such as Anzabegovo I–III, Kapitan Dimitriev, and Yabalkovo record less than 5 percent. If Rakitovo is excluded from the calculation, and only sites with a moderate representation (13 percent) are included, the regional average drops to approximately 7 percent. This discrepancy could be attributed to differences in site function, adaptation strategies, or cultural interactions.

While clear parallels can be drawn between the Aegean and South Balkans, the northern Balkans present a starkly different picture (Figure 15). In Serbia and Romania, the proportion of caprines declines sharply to an average of 30 percent, with cattle and large game surpassing them in prevalence. However, this regional average can be misleading, as it includes data from the Iron Gates, where dietary patterns deviate significantly from other sites. For example, Blagotin maintains a high proportion of caprines at 59 percent, with wild game representing only 8 percent of the assemblage. In contrast, sites from the Iron Gates, such as Lepenski Vir and Schela Cladovei, exhibit markedly different proportions, with wild game comprising 64 percent and 48 percent of the faunal remains, respectively.

As illustrated in Figures 14 and 15, sites located outside of the Iron Gates generally maintain a wild game proportion between 8 percent and 10 percent. The primary exceptions are Golokut and Starčevo, where wild taxa exceed 30 percent. Interestingly, both of these sites are situated in close proximity to the Danube—approximately 6.5 km away—a geographical characteristic shared with the Iron Gates. This raises important questions regarding how riverine environments influenced food habits, a topic that will be explored in further detail later in this discussion.

While overestimation of wild animal remains can occur, the increased presence of cattle across many sites remains significant, often exceeding 25 percent and reaching as high as 64 percent at Ovčarovo-Gorata. Orton et al. (2016) noted a discrepancy in cattle—and to a lesser extent, wild taxa—between Adriatic and continental assemblages, a pattern attributed to inadequate recovery strategies, particularly the absence or inconsistency of sieving. As previously discussed, the caprine-to-cattle ratio is especially susceptible to such methodological biases, as cattle possess larger, more easily identifiable bones. In contrast, wild taxa, encompassing a broader size range, present a more complex challenge, though the increased identification of red deer and wild pigs may also be partially explained by these recovery issues.

It is crucial to remain aware of these biases. However, due to limited transparency or access to excavation methodologies, it is difficult to justify the complete exclusion of sites from broader analyses. One point of contention with Orton et al. concerns the following claim:

Chapter 3 Residue Analysis and Faunal Remains

The few well-sieved continental assemblages do fall closer to the Adriatic norm of more caprines and fewer cattle and wild animals, while the few poorly sieved Adriatic assemblages fit better with the continental group

(Orton, Gaastra, and Vander Linden 2016, 15)

Their definition of “continental” amalgamates sites from diverse cultural and environmental contexts, including the Iron Gates, and lacks the microscale inter-site analysis necessary for accurate interpretations. A more nuanced picture emerges when examining the distinct differences between Iron Gates sites—such as Lepenski Vir, Schela Cladovei, and Padina—and continental sites like Blagotin, Divostin, or Ovčarovo-Gorata. For example, Blagotin and Schela Cladovei were both excavated using systematic sieving by Haskel Greenfield and Clive Bonsall, respectively, yet yielded contrasting results: Blagotin shows a dominance of caprines (59 percent) and only 8 percent wild game, while Schela Cladovei presents 21 percent caprines and 48 percent wild game. Padina,⁴⁸ too, deviates from the Adriatic norm, with cattle, pigs, and dogs outnumbering caprines, and fish and red deer appearing in significant quantities.

Despite these differences, I agree with Orton et al.’s broader argument—particularly their suggestion that fish remains may also be underrepresented, given their susceptibility to destruction and the challenges of identification without proper sieving. In sum, the North Balkan region cannot be treated as a monolithic unit. Differentiating between continental and Iron Gates sites is essential to understanding the diversity in subsistence strategies.

Turning to the Carpathian Basin, we find a mix of similarities with both the North and South Balkans (Figures 15–16). As in the North, domesticated pigs appear to have been underutilized, averaging just 3 percent of the faunal assemblages. Meanwhile, wild game continues to play a prominent role, constituting roughly a quarter of the remains. In terms of caprine use, the Carpathian Basin aligns more closely with the South Balkans, with an average representation of around 50 percent. In some cases, such as at Lánycsók, caprines account for up to 86 percent of the assemblage—comparable to levels seen at Argissa in the Aegean.

However, caprine frequencies vary widely across sites, ranging from 13 percent at Nosa and 19 percent at Alsónyék to 80 percent at Ecsegfalva 23 and 76 percent at Ludas Budžak (Figure 15). These fluctuations cannot be attributed solely to cultural preferences, as both the Körös and Starčevo complexes exhibit similar irregularities. While differences in recovery methods may play a role, even well-documented sites such as Alsónyék and Ecsegfalva 23 yield divergent patterns.

48. Padina was not included in the above table as its NISP of domesticates was under 500.

3.2 Faunal Remains

Site location may help explain these discrepancies. A cluster of sites with high caprine values is concentrated in the northern part of the Carpathian Basin—specifically, Ludas, Ecsegfalva 23, Szajol, Szolnok, and Endröd 119. The only notable exception in this area is Tiszaszölös, where wild game and cattle dominate over caprines. In contrast, sites in the southwest show greater variability and generally higher reliance on wild taxa. When comparing the two zones, most northeastern sites contain less than 10 percent wild game, whereas southwestern sites typically exceed 20 percent. This distribution suggests a potential environmental influence: sheep may have been favored in grassland areas where hunting opportunities were limited, offering faster growth and reproduction than cattle (Bartosiewicz 2005).

Nevertheless, cattle presence across the Carpathian Basin fluctuates between 10 percent and 30 percent, with some outliers such as Szajol, where cattle account for 42 percent and wild taxa are underrepresented. Broadly, a correlation emerges: sites with high caprine frequencies often have wild game rates below 10 percent, while the opposite holds true at sites like Nosa and Alsónyék. Although not a strict rule, this trend can be useful as a general guideline. That said, exceptions exist—Röszke, for instance, presents a more balanced distribution, with 45 percent caprines and 39 percent wild game.

A recent study by Ivanova et al. (2018) further investigated these variations, correlating animal taxa with climatic zones.⁴⁹ To this end, the authors divided northern Greece, the Balkans, and the Carpathian Basin into four distinct climatic regions (Table 9). The results of their inquiry align closely with the patterns described above, revealing a distinct contrast in herding strategies between Mediterranean and continental environments. In the southern regions, a stronger reliance on pigs was noted, whereas in the northern zones, cattle use increased significantly (Figure 17). The composition of wild game also varied across climatic zones, showing a gradual rise in the occurrence of aurochs, roe deer, and wild pigs as one moves northward. Among the wild taxa, red deer stands out as the only species consistently present at all sites across all regions.

Although animal remains in Southeast Europe have been extensively studied and published, Ivanova et al. (2018) conducted one of the few large-scale investigations into how environmental conditions influence herding strategies. Their study clearly demonstrates that environmental factors play a significant role in shaping food choices, as available options are often constrained by the surrounding ecology. As previously emphasized, environmental context cannot be overlooked—it is an integral part of the broader narrative.

49. Plant taxa were also part of the study, but, for the purposes of this chapter, are left aside.

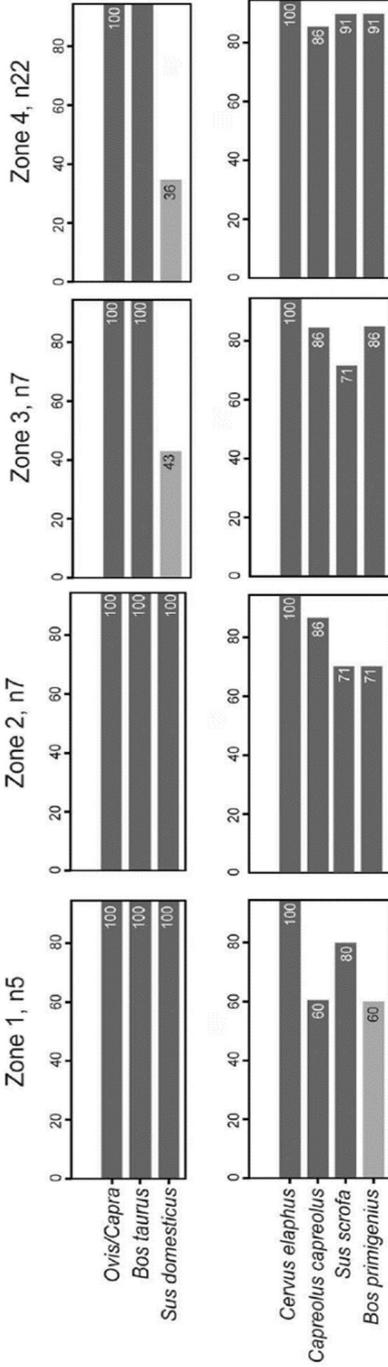


Figure 17. Presence of animal taxa at sites in percentage according to their NISP (after Ivanova et al. 2018: fig. 4).

3.2 Faunal Remains

Table 9. Grouping of archaeological sites into four climatic zones in relation to altitude and bioclimatic parameters (after Ivanova et al. 2018, tab. 5).

Zone	Conditions	Location of sites
1	Mediterranean conditions with hot dry summers and mild rainy winters	Littoral areas of Thessaly and Macedonia
2	Transitional sub-Mediterranean environments with lower annual mean temperature and stronger seasonality	River valleys of Vardar, Aliakmon, Lower Struma and Maritsa
3	Sub-continental environments, cooler temperatures	Higher altitude intra-mountain basins or valleys – the basins of Sofia, Zlatitsa-Pirdop and Kazanluk, the valleys of Mesta, Upper Struma, Middle Morava and its tributaries, and the Transylvanian high plateau
4	Continental climate with cold dry winters and moist early summers	Lowlands of the Pannonian plain and the Lower Danube

However, environment alone does not dictate subsistence strategies. Food choices are embedded within a more complex framework, shaped by sociocultural traditions, economic practices, and political conditions. In the next chapter, the findings from both lipid residue and zooarchaeological analyses will be integrated with additional lines of evidence to contribute to the broader discourse on food culture in Southeast Europe.