Subsistence Practices in Central and Eastern Europe

László Bartosiewicz and Malcolm Lillie

The Oxford Handbook of Neolithic Europe
Edited by Chris Fowler, Jan Harding, and Daniela Hofmann

Print Publication Date: Mar 2015 Subject: Archaeology, Archaeology of Europe
Online Publication Date: Apr 2014 DOI: 10.1093/oxfordhb/9780199545841.013.021

Abstract and Keywords

This paper integrates multiple strands of evidence for Neolithic subsistence economies in central and eastern Europe, with a focus on Hungary, Poland, Switzerland, Ukraine and the Baltic region. The relatively sudden dominance of domestic animals and plants of the 'Neolithic package' in south-eastern and central European farming cultures such as Starčevo/Körös/Criş beginning *c*. 7000 BC is followed by occasional reversions to the exploitation of local wild resources during the subsequent Linearbandkeramik (LBK) and Lengyel cultures. In contrast, in Ukraine, there is continuity in subsistence strategies across the Mesolithic to Neolithic periods, with the exception of the Tripolye culture which has links to Neolithic developments in central Europe. Throughout the Ukraine wild resources are exploited, including freshwater fish and molluscs, and domesticated resources are integrated to varying degrees into subsistence strategies. The situation is very similar in the Baltic, where domestic resources only become more visible during the middle Neolithic, and dominant in the Bronze Age. Overall, the proportions of wild versus domesticated species in Neolithic assemblages vary in space and time in relation to numerous factors, including cultural, socio-economic, and ritual causes.

Keywords: Central and eastern Europe, Baltic region, subsistence, Neolithic, wild and domesticated resources

> Subsistence is production without major surplus, when 'people … grow what they eat'
>
> (Waters 2007, 2).

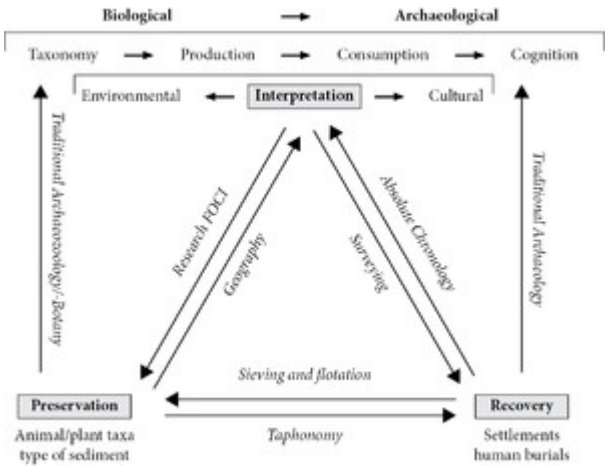

Fig. 21.1. Selective processes and feedback systems determining the interpretation of bioarchaeological evidence. Note the interrelatedness of preservation, recovery, and interpretation and the way they link traditionally disparate biological and archaeological reasoning.

BIOARCHAEOLOGICAL evidence results from multiple feedback mechanisms between differential preservation, selective recovery, and ideologically determined interpretation (Fig. 21.1). Consequently, the different techniques employed by bioarchaeologists throughout the Near East and Europe make it difficult to develop a nuanced understanding of the transition to agriculture (e.g. Conolly et al. 2008). Beyond these technical differences, the Neolithic in central and eastern Europe shows considerable diversity in subsistence strategies. Historically, the spread of agriculture across Europe was viewed as a process of population diffusion from the Balkans (see Bogaard and Halstead, this volume), where agriculture had flourished under Near Eastern influences. However, subsequent research has revealed complex alternatives (e.g. Barker 1985; Colledge et al. 2004, 2005; Richards et al. 2000; Whittle 1996; Zvelebil 1986). Hunting, fishing, and gathering clearly varied in importance, depending on location and socio-economic conditions. As Bogucki (2004, 202) notes, the spread of agriculture across Europe combined colonization and local adoption.

Mixed agriculture reached central Europe from the south-east and south. The available domesticated crops, and most animals, originated in the Near East. The earliest domesticated animals—caprines (sheep/goat), cattle, and pig—in Europe occur in Greece by *c*. 7000 BC (e.g. Price 2000). Across Europe, many factors influenced the rate (p. 412) of spread, integration, and ultimate adoption of these new/alternative subsistence strategies as ‘farming’ was disseminated (Thomas 2004). Hence, the timing of the onset of the Neolithic varies throughout Europe. This chapter contrasts three areas. In central Europe, an early focus on caprines gives way to an emphasis on cattle, with regionally varying contributions of wild resources. In Ukraine, indigenous groups gradually adopt domesticates, and a similarly piecemeal and protracted process is also evident in the Baltic, our final case study (e.g. Zvelebil and Dolukhanov 1991; Zvelebil and Lillie 2000). Throughout the area, summers are cooler and precipitation heavier than in the Balkans or the middle

Danube Basin, and winters are colder in general (Barker 1985, 135). Postglacial foragers exploited the rich fauna in mixed forests and open woodland and grassland habitats on loess soils.

Central Europe

Central Europe shows little evidence of ‘complex’ foragers (Milisauskas 2002, 153–155), and the archaeological record suggests that early farming cultures, such as the Starčevo/Körös/Criş and Linearbandkeramik (LBK), are intrusive. This section contrasts sequences from Hungary, Poland, and Switzerland to illustrate the variability in the uptake of domesticates.

The Danube valley probably served as a key Neolithic ‘gateway’ between the Balkans and the Carpathian Basin. One of the best studied sites, Lepenski Vir on the Serbian side (p. 413) of the Iron Gates, with its unusual deposits of wild animal remains (Dimitrijević 2008), does not look typical of cultural developments at the Mesolithic–Neolithic transition. Whilst Mesolithic evidence is extremely scarce in the Carpathian Basin, Neolithization here probably expanded from the Balkans, as variants of the Starčevo/Körös/Criş culture reached the middle Danube at *c*. 6200–6000 BC (Whittle et al. 2002, 107–117), during a presumed climatic optimum. Caprines were definitely introduced, as domestic sheep and goat had no wild ancestors in Europe (Bökönyi 1978).

It has been suggested that husbandry and hunting were of similar importance in Körös culture subsistence. However, assemblages with over 1,000 identifiable bones from Hungary and Serbia almost invariably contain 60–80% caprine remains, some cattle, but only little pig, dog, or game (Bartosiewicz 2005, 52). Romanian Criş assemblages reinforce this impression (El Susi 2007, 30; Bindea 2008). In contrast, the importance of hunting is often argued on the basis of small, atypical assemblages. Apparently, Körös herders lived in dispersed hamlets and maintained near-monocultural sheep husbandry for some 300 years, although sheep may have been ill adapted to the marshy environment. These early communities hardly ever hunted and rarely even gathered shed antler for tools (Makkay 1990; Choyke 2007). Opportunistic fowling, including the probable use of feathers and the gathering of eggs, was a constant feature of Neolithic subsistence in the floodplains of Hungary and Romania (Gál 2007), and aquatic resources were consistently exploited. Early Neolithic communities gathered small carp-like fish, pike, and mussels in residual flood pools (Bartosiewicz 2007), whilst by the late Neolithic bone and boar tusk hooks and antler harpoons indicate active fishing (Choyke and Bartosiewicz 1994).

During the middle Neolithic (*c*. 5600–5000 BC), the contribution of pig remains becomes comparable to that of caprines in the Hungarian Plain (Bartosiewicz 2005, table 6.1). This may indicate a late trend towards local domestication of wild pigs, as mtDNA analyses suggest for other parts of Europe (Larson et al. 2007, 15276). Bökönyi (1985) hypothesized a late Neolithic cattle ‘domestication fever’ in Hungary around 5250–4250 BC, but mtDNA shows that the Körös aurochs population was genetically separate from domestic cattle of Near Eastern origins (Edwards et al. 2007, 329). Aurochs hunting be-

came significant during the late Neolithic, although animal keeping was already well-established. Contemporary settlement structures, including tells, reflect a complex social organization, possibly making hunting an important way of confirming social status. Prestige objects (Siklósi 2004) such as boar tusks and stag canine pendants, and the bone imitations of the latter (Choyke 2001), also show the increasing cultural importance of game in the south-eastern Carpathian Basin.

Early farming communities of the LBK (*c*. 5600–4900 BC) may have been very mobile, and cattle dominate faunal assemblages (see Bickle and Hofmann 2007 and references therein). This shift away from caprines towards cattle and pig is probably an adaptation to differing environmental zones (i.e. Balkans versus central Europe), but may also be determined by varying attitudes towards available species, differing management requirements, and differences in meat yields and secondary products.

In the lowlands of northern Poland and north-eastern Germany, less substantial post-built structures take the place of the characteristic longhouses of the loess (seen (p. 414) as related to storage). Subsistence is based primarily on cattle, with pig and caprines occurring at significant frequencies. Cereals are dominated by emmer and a proportion of the diet is obtained from wild resources (terrestrial and aquatic) (Bogucki and Grygiel 1993). Milisauskas (2002, 162) suggests that the role of hunting has been underplayed. LBK studies in Germany have long benefited from the analysis of subsistence (Lüning 1991, 2000), with ground-breaking general work by Müller (1964) followed by more detailed analyses in the upper Danube catchment (Pucher 1987; Uerpmann and Uerpmann 1997).

Later LBK faunal assemblages in the German and Polish lowlands, as well as in the Eneolithic of Slovakia (Ambros 1986) and Hungary (Bökönyi 1961–1963), are discussed under the general heading of the Lengyel culture. Long-term agricultural settlements, with the characteristic trapezoidal longhouses, do not occur until *c*. 4400 BC in central Poland (Bogucki and Grygiel 1993, 414). In contrast to the conventional wild/domestic dichotomy, Marciniak (2005, tables 7.1 and 8.1) has studied differences in carcass treatment between domesticates at LBK sites in Kujavia and Małopolska. He observed differences between cattle and pigs on the one hand and sheep and goats on the other. Lengyel culture sites in Kujavia and Wielkopolska show a different pattern and more hunting, a trend seen elsewhere in central Europe. In the north, animal exploitation by people of the Funnel Beaker (TRB) culture is discussed in general terms by Midgley (1992, 369–384). She has shown that hunting played an important role in the economy, but this was more pronounced in the north than in the TRB's more southern and south-eastern areas. Environmental (predominance of loess in southern regions) and possibly even cultural factors influenced this situation. Midgley (1992, 375–376) characterizes the TRB economy as based on mixed farming, supplemented by hunting and gathering. In general, red deer dominate the wild fauna and cattle the domesticated element, but as might be anticipated there are inter-regional and inter-site differences, and the relative proportion of wild resources decreases towards the later TRB (Midgley 1992, 377). More recently, Marciniak (2005) has traced the dynamic development of middle Neolithic farming and its stabilization in the Funnel Beaker territory from an ethnologically informed perspective, wherein

interpretations of animal exploitation are embedded in a theoretical discourse on the role of animals in the everyday social structuring of farming communities. This work has moved beyond the fundamental aspects of animals as elements of subsistence strategies and explores amongst other things themes of agency, identity, and space and place. Fundamentally, however, it provides a similar, albeit more nuanced picture of the TRB culture as developed by Midgley. Both offer important insights into the nature of continuity and change from the earlier Neolithic to the cultural developments that characterize the TRB.

In late Mesolithic Switzerland (6700–5500 BC), there is no evidence of domesticated animals, but pollen data and macrofossils suggest minor pre-Neolithic agricultural activity on the Swiss Plateau (Haas 1996; Tinner et al. 2007). The lack of high resolution scanning in the identification of *cerealia* in earlier work means caution should be exercised here (Edwards and McIntosh 1988). However, responding to Behre (2007), (p. 415) Tinner et al. (2008, 1468) argue that 'relying uniquely on the pollen signal, the onset of the Neolithic in Switzerland would be placed at *ca*. 6700 cal. BC, which indeed is in contradiction with the conventional paradigm in archaeology', which dates the onset of the Swiss Neolithic to *c*. 5500–5200 BC (Tinner et al. 2007). Imported sea shells indicate Mediterranean contacts along the Rhône (Nielsen 1997), and the concept of agriculture could have arrived along the same route. Domesticates occur from 5500 BC, whilst pollen diagrams show 'conventional' Neolithic cultivation at *c*. 5400–5000 BC. On the Swiss Plateau, Neolithic deforestation is evident in the palynological record at around 4400–4000 BC, as lakeshores were being settled (Erny-Rodmann et al. 1997; Nielsen 1997, 2003). Agriculture dominates subsistence only after *c*. 4500 BC (Stöckli 1998). Waterlogged deposits at pile-dwellings have enriched this picture, and were key for developing archaeozoology and archaeobotany as disciplines (Rütimeyer 1861; Heer 1866), but these sites date mostly to the late Neolithic (*c*. 4300 BC).

Whilst proportions between domestic animals vary between eastern and western Switzerland, at around 3900 BC and after 3750[1] BC red deer bone reaches around 60% in food refuse (Schibler et al. 1997, 178–179), apparently due to an agricultural crisis visible in declining grain harvests and the increasing contribution of wild plants (Jacomet 2007). This is also reflected in raw material management in occupation layers dendro-dated to 4300–2571 BC. At earlier settlements (4300–3100 BC) bone tools were common, and antler originated from both hunting and gathering. Antler sleeves, used as shock absorbers between the stone axe blades and wooden handles, attained importance during the fourth millennium BC. Later inhabitants increasingly gathered shed antler (Schibler et al. 1997; de Capitani et al. 2002), a sign of systematic raw material management. Juvenile deer significantly contributed to assemblages around 3600 BC, possibly indicating over-hunting. By 3100 BC, even small antler tines were manufactured into sleeves and commonly curated (Schibler 2001, 85–87). Corded Ware levels (*c.* 2750 BC) yielded significantly more antler sleeves, but red deer bone became minimal. These changes show the subtle interplay between technical innovation, shifting subsistence patterns, and environmental change.

As a long-term trend throughout central Europe, Sherratt (1983) suggested a shift to the 'secondary' production of milk, wool, and animal labour, supporting increasing social complexity. However, the earliest use and functions of these products represent different motivations. Milk and wool utilization seemingly began earlier than animal traction (Lüning 1979/80). Caprine or cow milk residue has been detected on sherds from early Neolithic Ecsegfalva in Hungary and Schela Cladovei in Romania (Craig et al. 2005), and whilst the diffusion of dairying into the rest of Europe remains debated, biochemical evidence is available from middle Neolithic France (Chasséen Septentrional culture; early fourth millennium BC) (Balasse et al. 1997) and late Neolithic Switzerland (3384–3370 BC) (Spangenberg et al. 2006). By the end of the Neolithic, finds from waterlogged contexts, such as a yoke fragment from Switzerland (Jacomet and Schibler 2006, 142, fig. 1) and a wheel with axle from Slovenia (Velusček 2006), coincide with the increase of articular disorders in cattle, partly related to draught exploitation (Bartosiewicz 2006). Ploughing and wheeled transport enabled (p. 416) increased agricultural production, facilitating the accumulation and redistribution of surplus.

Ukraine

It is still valid that often 'the first appearance of pottery and polished stone tools is taken as automatic evidence that hunting and gathering had been replaced by farming' (Dennell 1985, 153; see also Telegin 1987; Jacobs 1993; Lillie 1996). Yet generally in Ukraine there is continuity between the Mesolithic and early Neolithic.

Thus, the sixth millennium BC Bug-Dniester culture, originating in the forested valleys of the Bug, Dniester, and Prut rivers (Zvelebil and Dolukhanov 1991, 252) and extending across Moldova and into Ukraine (Dergachev et al. 1991), continued using Mesolithic lithic industries. Hunting, fishing and gathering constitute the main subsistence elements. Remains of wild pig, red and roe deer, fish, and edible molluscs (riverine mussel) are common. In addition to collected food, there is evidence for the extensive use of grasses and some exploitation of domesticates (Zvelebil and Dolukhanov 1991, 260). Subsistence data have been recovered from 11 sites in the southern Bug and Dniester valleys (Zvelebil and Lillie 2000, 74). Domestic animals are probably imported in the earlier stage of the culture (accounting for <20% of faunal assemblages), sheep and goat are generally absent (Tringham 1971, 98), and wild plants are gathered (possibly with some management/cultivation?) (Zvelebil and Lillie 2000). The incorporation of domesticates into subsistence strategies is uneven and piecemeal between *c*. 5700–5000 BC. Even in the latest stages of the Bug-Dniester culture, domesticates seldom exceed 50% of the assemblages (Telegin et al. 2003), although Milisauskas (2002, 150) suggests an agricultural component from as early as *c*. 6000 BC.

Artefacts and economic evidence indicate contacts with the Körös-Criş and LBK farming communities to the west and north-west (Dolukhanov 1984, 341) during the second stage of the Bug-Dniester culture, whilst early Bug-Dniester sites are contemporary with pre-Körös-Criş groups (Kotova 2003). At *c*. 6200 BC, Körös-Criş sites in Romania and Moldova

exhibit features with Mesolithic antecedents in stone and bone tool technology, domestic architecture, and economy (Zvelebil and Lillie 2000, 72). In general, the numbers of domesticates on these sites are somewhat lower than in areas further south and south-west (Tringham 1971; Demoule and Perlès 1993; Perlès 2001) or within the Carpathian Basin, and wild plants, and occasionally animals, are significant components of the subsistence economy. Faunal assemblages at the Criş site of Sakarovka on the right bank of the Solonets, which ultimately drains into the Dniester, include pig, red deer, and cattle, with some caprines, roe deer, elk, and wild horse as subsidiary components. Whilst cereals were not recovered, sickles suggest possible cultivation, or at least the harvesting of wild grasses (Dergachev et al. 1991, 10).

East of the Bug-Dniester cultural area, the Dnieper-Donets culture also developed from Mesolithic groups (Telegin and Titova 1998; Telegin et al. 2002). At later Mesolithic (p. 417) sites in the Dnieper region (e.g. Kukrek culture), ceramics are associated with Mesolithic type lithics, indicating that Mesolithic groups are influential in the development of the ‘Neolithic’ here (Zaliznyak 1997). The earliest Neolithic element is the Surskaia culture (also sometimes spelled Sursko or Surskii) dated to *c*. 6200 BC (Telegin et al. 2003), which extensively exploits the rich fish resources of the Dnieper, along with some domesticated cattle and pig (Telegin 1987, 318). Kotova (2003) offers a detailed reconsideration of culture groupings in the Ukraine.

The Dnieper-Donets culture (including its Mesolithic precursors and its variants) has been the subject of a considerable number of new dating, dietary isotope, and palaeopathological analyses aimed at understanding subsistence throughout its development (*c*. 5500–4000 BC) (Telegin et al. 2002, 2003; Lillie 1996, 1998; Lillie and Richards 2000; Lillie et al. 2003, 2011; Lillie and Jacobs 2006). Of the over 800 Mesolithic and Neolithic skeletons recovered (Konduktorova 1974, 12), the *c*. 300 suitably preserved examples have provided important insights into chronology, diet, and subsistence across the Mesolithic-Eneolithic periods (between *c*. 7000–3700 BC). Recent dating work (Lillie et al. 2009) has also included evidence from mammalian and fish remains from middle and lower Dnieper basin sites. This has shown that freshwater resources (e.g. carp and pearl roach) are influencing the radiocarbon determinations obtained on human bone, with preliminary evidence of a freshwater reservoir effect across the Mesolithic–Neolithic transition (similar to the Danubian Iron Gates; Bonsall et al. 2000) and across the Neolithic to Eneolithic periods. At *c*. 5100 BC, sites such as Dereivka I and Yasinovatka show a marked offset between terrestrial mammal, human, and fish samples from the same burial context. Offsets between human and red deer samples span *c*. 250 radiocarbon years at Dereivka I and *c*. 470 years at Yasinovatka (Lillie et al. 2009). Thus, previous dates on human remains from the cemeteries of the Dnieper Basin could be several centuries too old at the onset of the Neolithic, a situation also observed at Schela Cladovei, downstream from the Danubian Iron Gates in Romania (Cook et al. 2002, 81).

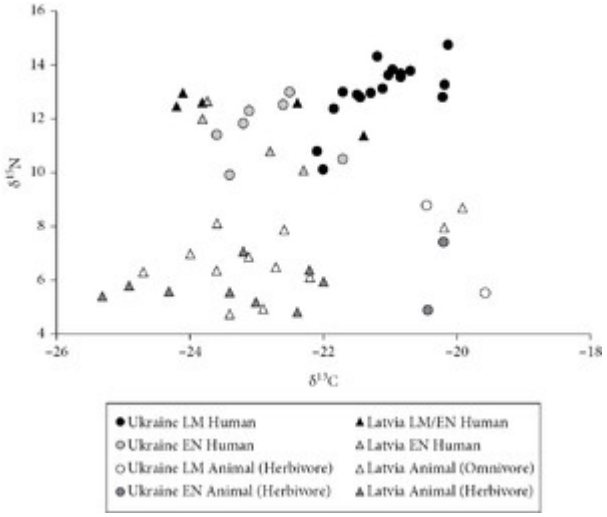

Fig. 21.2. Stable isotope analysis of Ukrainian (Vasilyevka II, Marievka, Dereivka, and Yasinovatka) and Latvian (Zvejnieki) late Mesolithic (LM) and early Neolithic (EN) human and faunal remains

(after Lillie and Jacobs 2006; Budd et al. in press; Eriksson 2006; Eriksson et al. 2003).

The increased levels of freshwater resource consumption by the hunter- fisher-gatherers in the valleys of the Dnieper and Donets systems could be a socio-economic 'buffering' reaction against the new resources (i.e. domesticates) becoming available at this time through, for instance, population movements along the Black Sea coast and the expansion of agricultural communities (Anthony 2007; Dolukhanov and Shilik 2007). At the Dnieper Rapids cemeteries—similarly to those in the Iron Gates—later Mesolithic populations consumed a greater proportion of freshwater resources compared to early Neolithic groups (Fig. 21.2). The late Mesolithic population consumed terrestrial resources (e.g. red deer, roe deer, horse, wild boar) with a significant input from freshwater fish, with the contribution of the latter lessening slightly in the early Neolithic, although the broad range of wild animal species continued to be exploited into the Neolithic period, alongside cattle, caprines and pig. There is evident variability in individual diets, but this is not unusual, as different subsistence regimes are to be expected where social situations may have been mediated through the procuring, allocating, and controlling of resources (Lillie 2003).

(p. 418) During the Neolithic period, the stable isotope ratios for Yasinovatka (Lillie et al. 2009, table 5) demonstrate higher $\delta^{15}N$ values than those from Dereivka I. At 11.4–13‰, these ratios are closer to those from the Danubian Iron Gates sites ($\delta^{15}N$ at *c*. 14 or 15‰, and $\delta^{13}C$ at *c*.−23‰), which for Bonsall et al. (1997) indicate a diet based heavily on river fish. Stable isotope analyses on the populations of the middle and lower Dnieper basin are ongoing, but significantly, the freshwater reservoir effect so far seems dissipated towards the Neolithic–Eneolithic transition (*c*. 4500–3700 BC) (Lillie et al. 2009), perhaps reflecting the increasing importance of domesticates (predominantly animals, i.e. cattle, pig, and caprines). Recent debate regarding the adoption of domesticated cereals in Dnieper-

Donets stage II primarily revolves around seed impressions (wheat and barley) in pottery fabrics (e.g. Kotova 2003). However, at present, the available evidence is insufficient to indicate that domesticated cereals formed an important element in subsistence during the earlier Neolithic period (see e.g. Motuzaite Matuzeviciute et al. 2009; Motuzaite Matuzeviciute 2012).

Towards the middle Neolithic, and the Eneolithic/Copper Age in Ukraine, Moldova, and Romania, the Tripolye culture (Trypillia in Ukrainian) develops through a combination of initial influences from the Balkan-Danube region and later Neolithic contacts with the Körös and Turdaş cultures (Lillie 2008; Korvin-Piotrovskiy 2008). The Trypillia (p. 419) subsistence economy is based on the husbandry of cattle, caprines, and pigs, alongside cultivation of wheat, barley, millet, and legumes. Gathering, hunting, and fishing occur everywhere, and at some sites, such as Kolomyïshchina II, wild animals make up a significant proportion of the assemblage (Lillie 2008, 14). This situation resonates with the idea of the hybridization of mixed hunter-gatherer/farming groups at frontier zones during the initial expansion of agriculture (e.g. Thomas 2004; Zvelebil 2006), although the Trypillia culture is relatively unique due to the development of ‘mega-sites’, such as Nebelivka, Talljanki, and Maydanetskoe, which contain up to 1000 buildings (Kruts 2008a, 2008b). The central European TRB also occurred in Ukraine at this time, and, as with many central European middle Neolithic communities, its economy is characterized by mixed agro-pastoralism with wild fauna contributing to varying degrees (Milisauskas and Kruk 2002, 209).

The Baltic Region

Recent research in the Baltic Sea area, particularly Lithuania, Latvia, and Estonia, has provided significant insights into the development of Neolithic agriculture (Antanaitis-Jacobs et al. 2009). In the Mesolithic, similar hunter-fisher-gatherer economies persisted around the Baltic, with some regional differentiation in the later Mesolithic. The larger cemetery sites, such as Skateholm, Vedbæk, Zvejnieki, and Oleneostroviskii Mogilnik, appear at this time (Timofeev 1998, 44).

One of the cemeteries, Zvejnieki in Latvia, has recently been investigated in relation to prehistoric diets (Eriksson et al. 2003). The 2,446 tooth pendants recovered indicate that elk dominates, with wild boar, red deer, dog, aurochs, and seal also present. These species are just part of the range of fauna from the Zvejnieki complex, where beaver, marten, badger, wild horse, otter, brown bear, fox, wolf, wild cat, wildfowl, fish, and caprines are all attested. For instance, the settlement produced pike, perch, a range of cyprinids (bream, tench, asp, carp), wels, eel, and some salmon (Eriksson et al. 2003, 5–7). Stable isotope analyses show considerable variability in diets across the late Mesolithic to the end of the middle Neolithic (*c*. 5600–3500 BC), with an emphasis on terrestrial/freshwater animals (Fig. 21.2). Human isotope values cluster in two groups, one with a diet similar to that of the otters analysed in this study, the other displaying a mixed fresh-

water fish and hunted animal diet (Eriksson et al. 2003, 12). Overall, Mesolithic and early Neolithic populations consumed more freshwater fish than individuals in later periods.

Antanaitis-Jacobs et al.'s work (2009) reinforces the observation that hunter-fisher-gatherer subsistence strategies persist into the Neolithic, and in general, the only defining Neolithic 'signature' in the east Baltic is the appearance of pottery at *c*. 5600–5400 BC in Lithuania and Latvia (Antanaitis 1999, 89). Domestic cattle, caprines, and pigs are present at middle Neolithic sites in Lithuania and Latvia, although at relatively low levels of *c*. 6–18% in terms of the number of identified species (Antanaitis-Jacobs et al. **(p. 420)** 2009). The Lithuanian record indicates that the hunting of elk, red deer, aurochs, boar, marten, and beaver, alongside seal, persisted into the Neolithic (when seal exploitation actually increases) (Antanaitis-Jacobs et al. 2009, 13). Only in the Bronze Age do domesticates begin to dominate faunal and floral assemblages (Antanaitis 1999, 2001).

Evidence for cereals is generally sparse in the east Baltic, although there are single finds of oat, barley, *Cerealia*, and hemp/hops from middle Neolithic contexts (Rimantienė 1992, 98). Indeed, the first domesticated plant recorded in western Lithuania at *c*. 3300–2000 BC is hemp (Antanaitis et al. 2000, 49). Overall, the most prolific plants on Mesolithic and Neolithic sites are the 'ubiquitous' hazelnuts and water chestnut (Antanaitis-Jacobs et al. 2009, 15). Later Neolithic finds additionally include cultivars such as emmer, barley, and millet. To enhance the resolution of the Lithuanian palaeobotanical record, Antanaitis et al. (2000; Antanaitis and Ogrinc 2000) investigated two habitation sites, Kretuonas in north-eastern Lithuania and Turlojiškė, located *c*. 250 km to the south-west. Both of these sites represent a palimpsest of activity, with habitation and burial features and some partially waterlogged elements. A combination of subsistence strategies is also in evidence (Antanaitis-Jacobs, pers. comm. 2012). There are both Neolithic and Bronze Age contexts at each site, and these predominantly yielded wild species such as raspberry, apple (?), and hazelnuts. Unfortunately, of the 166 samples analysed only one contained evidence for domesticated plants, this being millet from Turlojiškė (Antanaitis et al. 2000, 56–57). In general, wetland/aquatic species dominated these assemblages, reflecting the surrounding natural environments, although at least a proportion of the material was likely gathered by the groups occupying these sites (e.g. Nicholas 2007). Whilst the sampling methodology needs further refinement, Antanaitis et al. (2000) note that these data support the late introduction and small-scale exploitation of domesticates in Lithuania.

Whilst palaeoenvironmental research in Estonia continues to develop, the study of early agriculture is still relatively under-developed (Poska and Saarse 2002). However, in north Estonia there is evidence for cereals in pollen records at *c*. 4500 BP, and barley and wheat were integral to the economy by *c*. 2300/2200 to 1600/1500 BC (Poska and Saarse 2002, 555). This suggests that 'primitive' agriculture occurred on Saaremaa Island as early as *c*. 4500 BC, at the onset of the Neolithic. In Neolithic inland Estonia, much as in the Mesolithic, elk, wild boar, and aurochs were hunted, whilst at coastal sites marine resources were exploited (Lõugas et al. 1996, 399f). Later Neolithic subsistence practices are mixed, with seal hunting and fishing on the coast, and some use of domestic cattle alongside crop cultivation. The diversity of environmental and ecological characteristics

around the Baltic clearly results in a protracted and piecemeal adoption of the agricultural economy across the Neolithic through to the Iron Age period (e.g. Zvelebil 2006).

(p. 421) Discussion

As might be anticipated, many factors influence the rate of spread, integration, and ultimate adoption of domestic animals and plants across Europe as 'farming' was disseminated. The evidence presented here reinforces this observation and highlights the fact that even at the intra-regional level, significant variation in Neolithic economies can occur.

To some degree, regional variation in topography, soils, drainage, etc. influenced the choices of domesticates exploited in the earlier Neolithic. However, it is now generally accepted that socio-political aspects and even cultural beliefs and practices came into play when individuals and groups chose to adopt parts of the new farming package. As a consequence of domestication, it appears that animals and plants became integrated into material culture inventories as artefacts. Domestication itself is an artificial process. As such, the choice to 'opt in to' a particular combination of species, alongside decisions on how to tend, display, and consume them, reflect the needs, tastes, and aspirations of incipient farmers. However, various cultures also developed their own cognitive, linguistic, and cultural systems to deal with the non-physical world, and these general attitudes would also have impinged on the significance of animals in a given society. These elements tend to be unique, and often virtually impossible to compare due to the diversity of forms of expression, whether this be verbal, behavioural, or concerning material culture. The diversity that is evident in the spread and adoption of farming practices and products is, most probably, embedded in metaphorical connotations that are intangible today.

Overall, however, diversity in subsistence practices unquestionably increased and the material consequences of the choices made need to be documented in a rigorous and scientific manner. Additionally, in order to facilitate a holistic understanding of Neolithic subsistence strategies, detailed regional knowledge is also required. Fortunately, the available literature has expanded considerably in recent years, and researchers can now further develop an inductive overview, as has been attempted here.

Finally, in addition to the increased political opening-up of central and eastern Europe since the 1990s, enhancing international academic exchange, the twenty-first century has also brought a flurry of methodological innovations and analytical techniques, such as serial AMS dating, isotope studies, and DNA analysis (e.g. Ambrose 1993; Bonsall et al. 1997; DeNiro 1985; Lubell et al. 1994; Richards 1998; Schoeninger et al. 1983), which offer new insights into ancient subsistence strategies. Whilst there are still inherent limitations and areas in need of further refinement, it is obvious that integrating multiple strands of evidence will enhance our understanding of past diets through development of a holistic and nuanced perspective on the transition to agriculture throughout Europe.

(p. 422) # Acknowledgements

As always, ML would like to thank colleagues in Ukraine and Russia for all their help since 1994, especially Inna Potekhina for continued collaboration on the Ukrainian material. Indre Antanaitis-Jacobs is thanked for access to unpublished material. Vladimir Timofeev and Ken Jacobs both helped me (ML), in varying ways, during my early research years in eastern Europe. As ever, this paper is dedicated to their memory. In addition, since writing the original draft of this paper Dmitri Telegin and Pavel Dolukhanov have passed away—they were both colleagues, advisors, and friends, and their loss is immeasurable (ML). Pál Raczky and Jörg Schibler contributed valuable critical comments to the section on central Europe, although responsibility for the final version rests with the authors.

References

Ambros, C. 1986. Tierknochenfunde aus Siedlungen der Lengyeler-Kultur in der Slowakei. In B. Chropovský (ed.), *Internationales Symposium über die Lengyel-Kultur, Nové Vozokany 5.-9. November 1984*, 11–17. Nitra: Archäologisches Institut der Slowakischen Akademie der Wissenschaften.

Ambrose, S.H. 1993. Isotopic analysis of palaeodiets: methodological and interpretive considerations. In M.K. Sandford (ed.), *Investigations in ancient human tissue: chemical analyses in Anthropology*, 59–130. Langhorne, PA: Gordon & Breach Science Publishers.

Antanaitis, I. 1999. Concerning the transition to farming in the East Baltic. *Documenta Praehistorica* 26, 89–100.

Antanaitis, I. 2001. *Eastern Baltic economic and social organization in the late Stone and early Bronze Ages*. Unpublished PhD thesis summary, Vilnius University.

Antanaitis, I. and Ogrinc, N. 2000. Chemical analysis of bone: stable isotope evidence of the diet of Neolithic and Bronze Age people in Lithuania. *Istorija* 45, 3–12.

Antanaitis, I., Riehl, S., Kisieliené, D., and Kelertas, K. 2000. The evolution of the subsistence economy and archaeobotanical research in Lithuania. *Lietuvos archeologija* 19, 47–67.

Antanaitis-Jacobs, I., Richards, M., Daugnora, L., Jankauskas, R., and Ogrinc, N. 2009. Diet in early Lithuanian prehistory and the new stable isotope evidence. *Archaeologia Baltica* 12, 12–30.

Anthony, D.W. 2007. Pontic-Caspian Mesolithic and early Neolithic societies at the time of the Black Sea flood: a small audience and small effects. In V. Yanko-Hombach, A.S. Gilbert, N. Panin, and P.M. Dolukhanov (eds), *The Black Sea flood question: changes in coastline, climate, and human settlement*, 345–370. Dordrecht: Springer.

Balasse, M., Bocherens, H., Tresset, A., Vigne, J-D., and Mariotti, A. 1997. Emergence de la production laitière au Néolithique? Contribution de l'analyse isotopique d'ossements de bovins (p. 423) archéologiques. Comptes rendus de l'Académie des Sciences de Paris. *Sciences de la Terre et des Planètes* 325, 105–110.

Barker, G. 1985. *Prehistoric farming in Europe*. Cambridge: Cambridge University Press.

Bartosiewicz, L. 2005. Plain talk: animals, environment and culture in the Neolithic of the Carpathian Basin and adjacent areas. In D. Bailey, A. Whittle, and V. Cummings (eds), *(Un)settling the Neolithic*, 51–63. Oxford: Oxbow.

Bartosiewicz, L. 2006. Mettre le chariot devant le boeuf. Anomalies ostéologiques liées à l'utilisation des boeuf pour la traction. In P. Pétrequin, R.-M. Arbogast, A.-M. Péterquin, S. van Willigen, and M. Bailly (eds), *Premiers chariots, premiers araires. La diffusion de la traction animale en Europe pendant les IVe et IIIe millénaires avant notre ère*, 259–267. Paris: CNRS Editions.

Bartosiewicz, L. 2007. Fish remains. In A. Whittle (ed.), *The early Neolithic on the Great Hungarian Plain: investigations of the Körös culture site of Ecsegfalva 23, County Békés I*, 377–394. Budapest: Archaeological Institute.

Behre, K.-E. 2007. Evidence for Mesolithic agriculture in and around central Europe? *Vegetation History and Archaeobotany* 16, 203–219.

Bickle, P. and Hofmann, D. 2007. Moving on: the contribution of isotope studies to the early Neolithic of central Europe. *Antiquity* 81, 1029–1041.

Bindea, D. 2008. *Archeozoologia Transilvaniei în pre- şi protohistorie (The archaeozoology from Transylvania in pre- and protohistory)*. Cluj-Napoca: Editura Teognost.

Bogucki, P. 2004. Introduction. In P. Bogucki and P. Crabtree (eds), Ancient Europe. Encyclopedia of the Barbarian world, 8000 **BC–AD** 1000. Volume 1: The Mesolithic to Copper Age (c. 8000–2000 **BC**), 201–203. New York: Scribners.

Bogucki, P. and Grygiel, R. 1993. The first farmers of central Europe: a survey article. *Journal of Field Archaeology* 20, 399–426.

Bökönyi, S. 1961–1963. A lengyeli kultura gerinces faunája (Vertebrate fauna of the Lengyel culture). I-III. *Janus Pannonius Múzeum Évkönyve 1960–1962*, 85–113; 91–104; 73–101.

Bökönyi, S. 1978. The introduction of sheep breeding to Europe. *Ethnozootechnie* 21, 65–70.

Bökönyi, S. 1985. Environmental and cultural effects on the faunal assemblages of four large 4th millennium **BC** sites. *A Szekszárdi Béri Balogh Ádám Múzeum Évkönyve (Szekszárd)* 13, 69–88.

Bonsall, C., Lennon, R., McSweeney, K., Stewart, C., Harkness, D., Boroneant, V., Bartosiewicz, L., Payton, R., and Chapman, J. 1997. Mesolithic and early Neolithic in the Iron Gates: a palaeodietary perspective. *Journal of European Archaeology* 5, 50–92.

Bonsall, C., Cook, G.T., Lennon, R., Harkness, D., Scott, M., Bartosiewicz, L., and McSweeney, K. 2000. Stable isotopes, radiocarbon and the Mesolithic-Neolithic transition in the Iron Gates. *Documenta Praehistorica* 27, 119–132.

Budd, C.E., Lillie, M.C., and Potekhina, I.D. In press. Radiocarbon dating and isotope analysis of hunter-fisher-gatherers in Ukraine. In *From the Baltic to the Black Sea*. Frankfurt: Römisch-Germanische Kommission des Deutschen Archäologischen Instituts.

Choyke, A.M. 2001. Late Neolithic red deer canine beads and their imitations. In A.M. Choyke and L. Bartosiewicz (eds), *Crafting bone—skeletal technologies through time and space*, 251–266. Oxford: BAR.

Choyke, A.M. 2007. Objects for a lifetime—tools for a season: the bone tools from Ecsegfalva 23. In A. Whittle (ed.), *The early Neolithic on the Great Hungarian Plain: investigations of the Körös culture site of Ecsegfalva 23, County Békés I*, 641–665. Budapest: Archaeological Institute.

(p. 424) Choyke, A.M. and Bartosiewicz, L. 1994. Angling with bone. In W. Van Neer (ed.), *Fish exploitation in the past. Koninklijk Museum voor Midden-Afrika, Annalen, Zoologische Wetenschappen* 274, 177–182.

Colledge, S., Conolly, J., and Shennan, S. 2004. Archaeobotanical evidence for the spread of farming in the eastern Mediterranean. *Current Anthropology* 45(S), 35–58.

Colledge, S., Conolly, J., and Shennan, S. 2005. The evolution of Neolithic agriculture: from SW Asian origins to NW European limits. *European Journal of Archaeology* 8, 137–156.

Conolly, J., Colledge, S., and Shennan, S. 2008. Founder effect, drift, and adaptive change in domestic crop use in early Neolithic Europe. *Journal of Archaeological Science* 35, 2797–2804.

Cook, G.T., Bonsall, C., Hedges, R.E.M., McSweeney, K., Boroneanţ, V., Bartosiewicz, L., and Pettitt, P. 2002. Problems of dating human bones from the Iron Gates. *Antiquity* 76, 77–85.

Craig, O.E., Chapman, J., Heron, C., Willis, L.H., Bartosiewicz, L., Taylor, G., Whittle, A., and Collins, M. 2005. Did the first farmers of central and eastern Europe produce dairy foods? *Antiquity* 79, 882–894.

de Capitani, A., Deschler-Erb, S., Leuzinger, U., Marti-Grädel, E., and Schibler, J. 2002. *Die Jungsteinzeitliche Seeufersiedlung Arbon Bleiche 3. Funde*. Frauenfeld: Veröffentlichung des Amtes für Archäologie des Kantons Thurgau.

Demoule, J-P. and Perlès, C. 1993. The Greek Neolithic: a new review. *Journal of World Prehistory* 7, 355–416.

DeNiro, M.J. 1985. Post-mortem preservation and alteration of in vivo bone collagen isotope ratios in relation to paleodietary reconstruction. *Nature* 317, 806–809.

Dennell, R. 1985. *European economic prehistory: a new approach*. London: Academic Press.

Dergachev, V., Sherratt, A., and Larina, O. 1991. Recent results of Neolithic research in Moldovia (USSR). *Oxford Journal of Archaeology* 10, 1–16.

Dimitrijević, V. 2008. Lepenski Vir animal bones. What was left in the houses? In C. Bonsall, V. Boroneanţ, and I. Radovanović (eds), *The Iron Gates in prehistory. New perspectives*, 117–130. Oxford: BAR.

Dolukhanov, P.M. 1984. Upper Pleistocene and Holocene cultures of the Russian Plain and Caucasus: ecology, economy and settlement pattern. In F. Wendorf and A.E. Close (eds), *Advances in world archaeology. Volume 1*, 323–358. New York: Academic Press.

Dolukhanov, P.M. and Shilik, K.K. 2007. Environment, sea-level changes, and human migrations in the northern Pontic area during late Pleistocene and Holocene times. In V. Yanko-Hombach, A.S. Gilbert, N. Panin, and P. Dolukhanov (eds), *The Black Sea flood question: changes in coastline, climate, and human settlement*, 297–318. Dordrecht: Springer.

Edwards, C., Ceiridwen, J., and Bradley, D.G. 2007. Ancient DNA analysis of aurochsen. In A. Whittle (ed.), *The early Neolithic on the Great Hungarian Plain: investigations of the Körös culture site of Ecsegfalva 23, County Békés I*, 327–329. Budapest: Archaeological Institute.

Edwards, K.J. and McIntosh, C.J. 1988. Improving the detection rate of cereal-type pollen grains from Ulmus decline and earlier deposits from Scotland. *Pollen et Spores* 30, 179–188.

El Susi, G. 2007. Archaeozoological records about domestic species farmed by early neolithical communities from Banat and Transilvania. *Acta Terrae Septemcastrensis* 6, 25.

Eriksson, G. 2006. Stable isotope analysis of human and faunal remains from Zvejnieki. In L. Larsson and I. Zagorska (eds), *Back to the origin: new research in the Mesolithic-Neolithic Zvejnieki cemetery and environment, northern Latvia*, 183–215. Stockholm: Almqvist & Wiksell.

Eriksson, G., Lõugas, L., and Zagorska, I. 2003. Stone age hunter-fisher-gatherers at Zvejnieki, northern Latvia: radiocarbon, stable isotope and archaeozoology data. *Before Farming* 2003/1, 1–25.

(p. 425) Erny-Rodmann, C., Gross-Klee, E., Haas, J.N., Jacomet, S., and Zoller, H. 1997. Früher 'human impact' und Ackerbau im Übergangsbereich Spätmesolithikum-Frühneolithikum im schweizerischen Mittelland. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 80, 27–56.

Gál, E. 2007. *Fowling in lowlands. Neolithic and Chalcolithic bird exploitation in southeast Romania and the Great Hungarian Plain*. Budapest: Archaeolingua.

Haas, J.N. 1996. Pollen and plant macrofossil evidence of vegetation change at Wallisellen-Langachermoos (Switzerland) during the Mesolithic–Neolithic transition 8500 to 6500 years ago. *Dissertationes Botanicae* 267, 1–67.

Heer, O. 1866. Die Pflanzen der Pfahlbauten. *Neujahrsblatt der Naturforschenden Gesellschaft in Zürich für das Jahr 1865*, 1–54.

Jacobs, K. 1993. Human postcranial variation in the Ukrainian Mesolithic-Neolithic. *Current Anthropology* 34, 417–430.

Jacomet, S. 2007. Neolithic plant economies in the northern alpine foreland (central Europe) from 5500–3500 **BC** cal. In S. Colledge and J. Conolly (eds), *The origins and spread of domestic plants in Southwest Asia and Europe*, 221–258. London: Left Coast Press.

Jacomet, S. and Schibler, J. 2006. Traction animale et données paléoenvironnementales au Néolithique dans le nord des Alpes. In P. Pétrequin, R.-M. Arbogast, A.-M. Pétrequin, S. van Willigen, and M. Bailly (eds), *Premiers chariots, premiers araires. La diffusion de la traction animale en Europe pendant les IVe et IIIe millénaires avant notre ère*, 141–155. Paris: CNRS Editions.

Konduktorova, T.S. 1974. The ancient population of the Ukraine: from the Mesolithic Age to the first centuries of our era. *Anthropologie (Brno)* 12, 5–149.

Korvin-Piotrovskiy, O.H. 2008. Trypilian culture in Ukraine. In K. Ciuk (ed.), *Mysteries of ancient Ukraine: the remarkable Trypillian culture 5400–2700 **BC***, 22–31. Toronto: Royal Ontario Museum.

Kotova, N.S. 2003. *Neolithization in Ukraine*. Oxford: BAR.

Kruts, V.O. 2008a. Giant Trypilian settlements. In K. Ciuk (ed.) *Mysteries of ancient Ukraine: the remarkable Tripilian culture 5400–2700 **BC***, 58–66. Toronto: Royal Ontario Museum.

Kruts, V.O. 2008b. The Talyanki site—a giant Trypilian settlement. In K. Ciuk (ed.) *Mysteries of ancient Ukraine: the remarkable Trypilian culture 5400–2700 **BC***, 67–74. Toronto: Royal Ontario Museum.

Larson, G., Albarella, U., Dobney, K., Rowley-Conwy, P., Schibler, J., Tresset, A., Vigne, J.-D., Edwards, C.J., Schlumbaum, A., Dinu, A., Bălăşescu, G., Dolman, G., Tagliacozzo, A., Manaseryan, N., Miracle, P., van Wijngaarden-Bakker, L., Masseti, M., Bradley, D.G., and

Cooper, A. 2007. Ancient DNA, pig domestication, and the spread of the Neolithic into Europe. *Proceedings of the National Academy of Sciences (USA)* 104, 15276–15281.

Lillie, M.C. 1996. Mesolithic and Neolithic populations of Ukraine: indications of diet from dental pathology. *Current Anthropology* 37, 135–142.

Lillie, M.C. 1998. The Mesolithic-Neolithic transition in Ukraine: new radiocarbon determinations for the cemeteries of the Dnieper rapids region. *Antiquity* 72, 184–188.

Lillie, M.C. 2003. Tasting the forbidden fruit: gender based dietary differences among prehistoric hunter-gatherers of eastern Europe? *Before Farming* 2, 1–16.

Lillie, M.C. 2008. The Trypilian culture in context. In K. Ciuk (ed.), *Mysteries of ancient Ukraine: the remarkable Trypillian culture 5400–2700* ***BC***, 11–16. Toronto: Royal Ontario Museum.

(p. 426) Lillie, M.C. and Jacobs, K. 2006. Stable isotope analysis of fourteen individuals from the Mesolithic cemetery of Vasilyevka II, Dnieper Rapids region, Ukraine. *Journal of Archaeological Science* 33, 880–886.

Lillie, M.C. and Richards, M.P., 2000. Stable isotope analysis and dental evidence of diet at the Mesolithic-Neolithic transition in Ukraine. *Journal of Archaeological Science* 27, 965–972.

Lillie, M.C., Richards, M.P., and Jacobs, K. 2003. Stable isotope analysis of twenty-one individuals from the Epipalaeolithic cemetery of Vasilyevka III, Dnieper rapids region, Ukraine. *Journal of Archaeological Science* 30, 743–752.

Lillie, M.C., Budd, C.E., Potekhina, I.D., and Hedges, R.E.M. 2009. The radiocarbon reservoir effect: new evidence from the cemeteries of the middle and lower Dnieper basin, Ukraine. *Journal of Archaeological Science* 36, 256–264.

Lillie, M.C, Budd, C.E., and Potekhina, I.D. 2011. Stable isotope analysis of prehistoric populations from the cemeteries of the Middle and Lower Dnieper Basin, Ukraine. *Journal of Archaeological Science* 38, 57–68.

Lõugas, L., Lidén, K., and Nelson, D.E. 1996. Resource utilisation along the Estonian coast during the Stone Age. In T. Hackens, S. Hicks, V. Lang, U. Miller, and L. Saarse (eds), *Coastal Estonia: recent advances in environmental and cultural history*, 399–420. Strasbourg: Conseil de l'Europe.

Lubell, D., Jackes, M., Schwarcz, H., Knyf, M., and Meiklejohn, C. 1994. The Mesolithic–Neolithic transition in Portugal: isotopic and dental evidence of diet. *Journal of Archaeological Science* 21, 201–216.

Lüning, J. 1979/80. Bandkeramische Pflüge? *Fundberichte Hessen* 19/20, 55–68.

Lüning, J. 1991. Frühe Bauern in Mitteleuropa im 6. und 5. Jahrtausend v. Chr. *Jahrbuch des Römisch-Germanischen Zentralmuseums Mainz* 35, 27–93.

Lüning, J. 2000. *Steinzeitliche Bauern in Deutschland. Die Landwirtschaft im Neolithikum*. Bonn: Habelt.

Makkay J. 1990. Knochen, Geweih und Eberzahngegenstände der frühneolithischen Körös-Kultur. *Communicationes Archaeologicae Hungariae* 38, 23–58.

Marciniak, A. 2005. *Placing animals in the Neolithic: social zooarchaeology of prehistoric farming communities*. London: UCL Press.

Midgley, M. 1992. *TRB culture*. Edinburgh: Edinburgh University Press.

Milisauaskas, S. 2002. Early Neolithic: the first farmers in Europe, 7000–5500/5000 **BC**. In S. Milisauaskas (ed.), *European prehistory: a survey*, 143–192. New York: Kluwer Academic.

Milisauskas, S. and Kruk, J. 2002. Middle Neolithic continuity, diversity, innovations, and greater complexity, 5500/5000–3500/3000 **BC**. In S. Milisauaskas (ed.), *European prehistory: a survey*, 193–246. New York: Kluwer Academic.

Motuzaite Matuzeviciute, G., Hunt, H.V., and Jones, M.K. 2009. Multiple sources for Neolithic European agriculture: geographical origins of early domesticates in Moldova and Ukraine. In P. Dolukhanov, G.R. Sarson, and A.M. Shukurov (eds), *The east European plain on the eve of agriculture*, 53–64. Oxford: Archaeopress.

Motuzaite Matuzeviciute, G. 2012. The earliest appearance of domesticated plant species and their origins on the western fringes of the Eurasian steppe. *Documenta Praehistorica* 39, 1–21.

Müller, H.H. 1964. *Die Haustiere der mitteldeutschen Bandkeramik*. Berlin: Deutsche Akademie der Wissenschaften.

Nicholas, G.P. 2007. Prehistoric hunter-gatherers in wetland environments: theoretical issues, economic organisation and resource management strategies. In M.C. Lillie and S. Ellis (p. 427) (eds), *Wetland archaeology & environments: regional issues, global perspectives*, 47–62. Oxford: Oxbow.

Nielsen, E.H. 1997. Fällanden Zürich-Usseriet. Zum Übergangsbereich Spätmesolithikum-Frühneolithikum in der Schweiz. *Jahrbuch der Schweizerischen Gesellschaft für Ur—und Frühgeschichte* 80, 57–84.

Nielsen, E.H. 2003. Das Spätmesolithikum und die Neolithisierung in der Schweiz. *Archäologische Informationen* 26, 275–297.

Perlès, C. 2001. *The early Neolithic in Greece: the first farming communities in Europe*. Cambridge: Cambridge University Press.

Poska, A. and Saarse, L. 2002. Vegetation development and introduction of agriculture to Saaremaa Island, Estonia: the human response to shore displacement. *The Holocene* 12, 555–568.

Price, T.D. 2000. *Europe's first farmers*. Cambridge: Cambridge University Press.

Pucher, E. 1987. Viehwirtschaft und Jagd zur Zeit der ältesten Linearbandkeramik von Neckenmarkt (Burgenland) und Strögen (Niederösterreich). *Mitteilungen der Anthropologischen Gesellschaft in Wien* 117, 141–155.

Richards, M.P. 1998. *Palaeodietary studies of European human populations using bone stable isotopes*. Unpublished D.Phil. thesis, University of Oxford.

Richards, M., Macaulay, V., Hickey, E., Vega, E., Sykes, B., Guida, V., Rengo, C., Sellitto, D., Cruciani, F., Kivisild, T., Villems, R., Thomas, M., Rychkov, S., Rychkov, O., Rychkov, Y., Gölge, M., Dimitrov, D., Hill, E., Bradley, D., Romano, V., Calì, F., Vona, G., Demaine, A., Papiha, S., Triantaphyllidis, C., Stefanescu, G., Hatina, J., Belledi, M., Di Rienzo, A., Novelletto, A., Oppenheim, A., Nørby, S., Al-Zaheri, N., Santachiara-Benerecetti, S., Scozzari, R., Torroni, A., and Bandelt, H.-J. 2000. Tracing European founder lineages in the Near Eastern mtDNA pool. *American Journal of Human Genetics* 67, 1251–1276.

Rimantienė, R. 1992. The Neolithic of the eastern Baltic. *Journal of World Prehistory* 6, 97–143.

Rütimeyer, L. 1861. *Die Fauna der Pfahlbauten der Schweiz*. Neuchâtel: Allgemeine Schweizerische Gesellschaft für die Gesammten Naturwissenschaften.

Schibler, J. 2001. Red deer antler exploitation and raw material management in Neolithic lake dwelling sites from Zürich, Switzerland. In H. Buitenhuis and W. Prummel (eds), *Animals and man in the past*, 82–94. Groningen: ARC-Publicatie.

Schibler, J., Jacomet, S., Hüster-Plogmann, H., and Brombacher, C. 1997. Economic crash in the 37th and 36th century **BC** cal. in Neolithic lake shore sites in Switzerland. *Anthropozoologica* 25/26, 553–570.

Schoeninger, M., DeNiro, M., and Tauber, H. 1983. Stable nitrogen isotope ratios of bone collagen reflect marine and terrestrial components of prehistoric human diet. *Science* 220, 1381–1383.

Sherratt, A. 1983. The secondary exploitation of animals in the Old World. *World Archaeology* 15, 90–104.

Siklósi, Zs. 2004. Prestige goods in the Neolithic of the Carpathian Basin. Material manifestations of social differentiation. *Acta Archaeologica* 55, 1–62.

Spangenberg, J.E., Jacomet, S., and Schibler, J. 2006. Chemical analyses of organic residues in archaeological pottery from Arbon Bleiche 3, Switzerland: evidence for dairying in the late Neolithic. *Journal of Archaeological Science* 33, 1–13.

Stöckli, W.E. 1998. Die Erforschung des Neolithikums in der Schweiz (Stand 1998). In G. Kaenel (ed.), *Grossprojekte (30 Jahre Nationalstrassenbau). Bilanz und Perspektiven*, 35–37. Lausanne: Arbeitsgemeinschaft für die Urgeschichtsforschung in der Schweiz.

(p. 428) Telegin, D.Ya. 1987. Neolithic cultures of the Ukraine and adjacent areas and their chronology. *Journal of World Prehistory* 1, 307–331.

Telegin, D.Ya. and Titova, E.N. 1998. La zone des steppes. In J. Kosłowski, with P.-L. van Berg (eds), *Atlas du Néolithique européen. Vol.1, L'Europe orientale*, 463–494. Liège: ERAUL.

Telegin, D.Ya., Potekhina, I.D., Lillie, M.C., and Kovaliukh, M.M. 2002. The chronology of the Mariupol-type cemeteries of Ukraine re-visited. *Antiquity* 76, 356–363.

Telegin, D.Ya., Lillie, M.C., Potekhina, I.D., and Kovaliukh, M.M. 2003. Settlement and economy in Neolithic Ukraine: a new chronology. *Antiquity* 77, 456–470.

Thomas, J. 2004. Current debates on the Mesolithic-Neolithic transition in Britain and Ireland. *Documenta Praehistorica* 31, 113–130.

Timofeev, V.I. 1998. The east-west relations in the late Mesolithic and Neolithic in the Baltic region. *Baltic-Pontic Studies* 5, 44–58.

Tinner, W., Nielsen, E.H., and Lotter, A.F. 2007. Mesolithic agriculture in Switzerland? A critical review of the evidence. *Quaternary Science Reviews* 26, 1416–1431.

Tinner, W., Nielsen, E.H., and Lotter, A.F. 2008. Evidence for late-Mesolithic agriculture? A reply to Karl-Ernst Behre. *Quaternary Science Reviews* 27, 1467–1470.

Tringham. R. 1971. Hunters, fishers and farmers of eastern Europe, 6000–3000 **BC**. London: Hutchinson.

Uerpmann, M. and Uerpmann, H.-P. 1997. Remarks on the faunal remains of some early farming communities in central Europe. *Anthropozoologica* 25/26, 571–578.

Velusček, A. 2006. Une roue et un essieu néolithiques dans les marais de Ljubljana (Slovénie). In P. Pétrequin, R.-M. Arbogast, A.-M. Pétrequin, S. van Willigen, and M. Bailly (eds), *Premiers chariots, premiers araires. La diffusion de la traction animale en Europe pendant les IVe et IIIe millénaires avant notre ère*, 39–45. Paris: CNRS Editions.

Waters, T. 2007. *The persistence of subsistence agriculture: life beneath the level of the marketplace*. Lanham, MD: Lexington Books.

Whittle, A. 1996. *Europe in the Neolithic. The creation of new worlds*. Cambridge: Cambridge University Press.

Whittle, A., Bartosiewicz, L., Borić, D., Pettitt, P., and Richards, M. 2002. In the beginning: new radiocarbon dates for the early Neolithic in northern Serbia and south-east Hungary. *Antaeus* 25, 1–51.

Zaliznyak, L. 1997. *Mesolithic forest hunters of the Ukrainian Polessye*. Oxford: BAR.

Zvelebil, M. 1986. Mesolithic prelude and Neolithic revolution. In M. Zvelebil (ed.), *Hunters in transition: Mesolithic societies of temperate Eurasia and their transition to farming*, 5–15. Cambridge: Cambridge University Press.

Zvelebil, M. 2006. Mobility, contact and exchange in the Baltic Sea basin 6000–2000 **BC**. *Journal of Anthropological Archaeology* 25, 178–192.

Zvelebil, M. and Dolukhanov, P. 1991. The transition to farming in eastern and northern Europe. *Journal of World Prehistory* 5, 233–278.

Zvelebil, M. and Lillie, M. 2000. Transition to agriculture in eastern Europe. In T.D. Price (ed.), *Europe's first farmers*, 57–92. Cambridge: Cambridge University Press.

Notes:

(*) Received June 2009, updated December 2011.

(1.) Dates after around 3900 BC in Switzerland are generally based on dendrochronology.

László Bartosiewicz

László Bartosiewicz obtained his degrees in animal science from the University of Gödöllő, Hungary. He has worked for over thirty-five years as an archaeozoologist mostly studying large mammals and fish, including research in Switzerland, Belgium, and the UK. His interests encompass animal–human relations in all post-Palaeolithic periods in Europe, the Near East, and South America. His work was published in four books and over three hundred scholarly articles. He has taught zooarchaeology at the Universities of Budapest and Edinburgh and served two consecutive terms (2006–2014) as president of the International Council for Archaeozoology.

Malcolm Lillie

Malcolm Lillie, University of Hull.