

Prehistoric populations of Ukraine: Migration at the later Mesolithic to Neolithic transition

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Abstract

This paper focuses on the identification of population movements during the Mesolithic and Neolithic periods in the Dnieper Basin region of Ukraine. We assess the evidence for migration from the perspective of individual life histories using a combination of palaeoanthropology/pathology, radiocarbon dating, stable isotopic studies of diet, and mtDNA.

Keywords

Mesolithic, Neolithic, Mariupol-type cemeteries, Bioarchaeology, mtDNA, Migration, Cultural transition, Life History

Dedication: The authors would like to dedicate this paper to the memory of Professor Dmitry Telegin who passed away on 1st January 2011 at the age of 91. Professor Telegin was a commensurate archaeologist and the patriarch of Ukrainian archaeology (Potekhina and Mallory 2011). He was the Head of the Department of Stone Age Archaeology at the Institute of Archaeology NAS Ukraine for 20 years, and published around 500 scientific papers and monographs during his career. He influenced a generation of Ukrainian archaeologists, and a number of western researchers, particularly with his generous, patient and open approach to Ukrainian prehistory and changes in method and theory, during this time. An outstanding scholar, his intellect and insightfulness will be sorely missed.

Introduction

The cemeteries of the Dnieper Basin (Fig. 1) have been the subject of a considerable amount of reinvestigation and analysis since they were originally reported in a synthetic volume by Telegin and Potekhina in 1987. An interim stage of these investigations was marked by the completion of Lillie's PhD research in 1998 (Lillie, 1998a), during the production of which a number of preliminary papers were published (e.g. Lillie, 1996, 1997, 1998b, 1998c). We worked closely with Professor Telegin to refine the chronology of the Mariupol-type cemeteries, and the Ukrainian chronology in general (Telegin et al., 2000, 2002, 2003), and whilst disagreements persist in relation to the assumed cultural affinities of the various sites and cemeteries investigated, a greater chronological resolution has been achieved. Elements of the scheme have been questioned due to the use of conventional dates from the Kiev radiocarbon facility, which often appear to produce ages that are too young (Lillie, 1998a), and because the resolution of the culture-chronologies needs to be considered with caution (Anthony, 2007; Dolukhanov and Shilik, 2007; Rassamakin, 1999; Velichko et al., 2009). Significantly, more recently we have identified a reservoir effect impacting upon the precision of these dates (Lillie et al., 2009).

In addition to the on-going studies of chronology, we have been actively investigating the evidence for diet and subsistence strategies at a number of sites in Ukraine (Fig. 1). These studies have demonstrated variability in access to dietary proteins across the Epipalaeolithic to Eneolithic periods (Lillie,

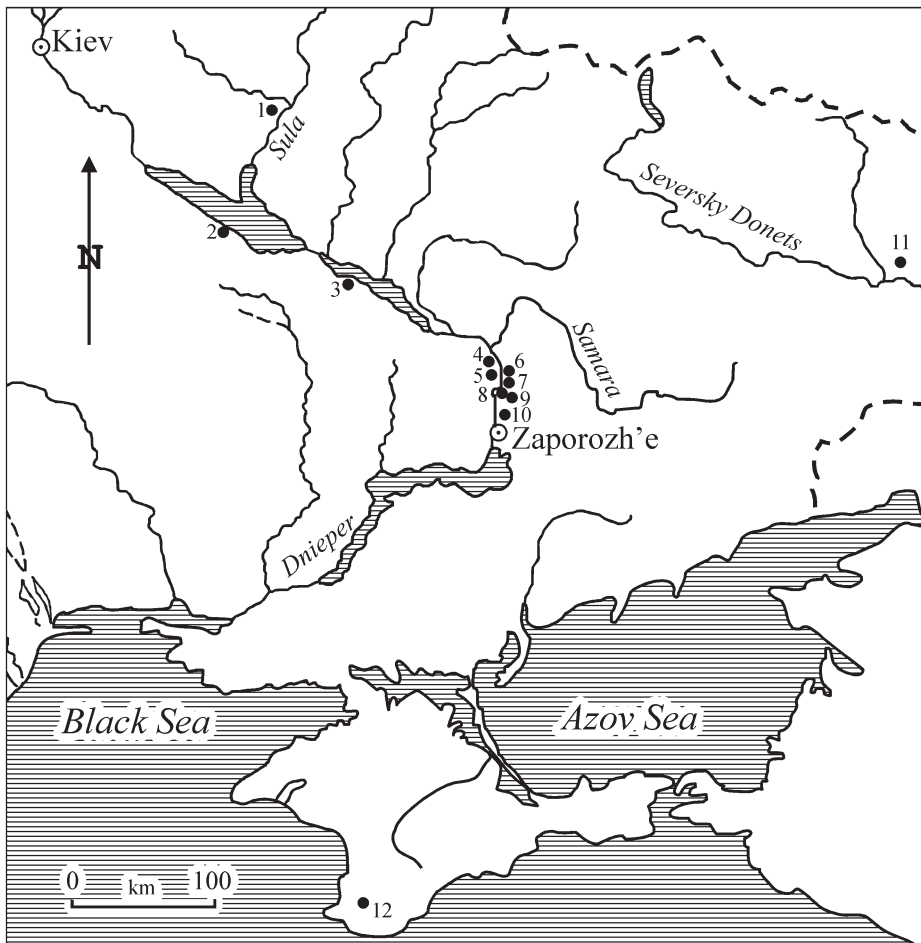


Fig. 1 | Location map showing cemeteries and sites used in the current study. Legend: 1 Vyazivok, 2 Molukhov Bugor, 3 Dereivka, 4 Voloshskoye, 5 Nikolskoye, 6 Vasilyevka II, III, V, 7 Marievka, 8 Vovnigi I, 9 Yasinovatka, 10 Vil'nyanka, 11 Rogalik II, 12 Fat'ma-Koba

1996, 1997, 1998a, 2003), alongside a significant input of freshwater resources during each of these periods (Lillie, 1998a; Lillie and Richards, 2000; Lillie et al., 2003; Lillie and Jacobs, 2006; Lillie and Budd, 2011; Lillie et al., 2011). The studies undertaken to date, focussing on palaeopathology and stable isotope analyses of diet, have demonstrated an absence of 'typical' dental pathologies commensurate with carbohydrate consumption (i.e. caries) and the consistent presence of calculus, indicative of protein consumption (Lillie, 1996; Haeussler and Potekhina, 2001, 2002). Similarly, the stable isotope data reflects the exploitation of freshwater resources and herbivores, but the method lacks the resolution necessary to allow an evaluation of the relative contribution of plants, or cereals in particular to the diets of the populations under study. To some degree this reflects the nature of the analyses undertaken to date and the fact that the number of sites investigated is limited in relation to the identification of domesticated plants, and plant use in general (Kotova and Pashkevich, 2002), as many of the earlier Neolithic cemeteries investigated are considered to be those of pastoralists as opposed to agriculturalists. Targeted archaeobotanical investigations are required if we are to enhance our understanding of the contribution of cereals to subsistence economies (e.g. Motuzaite Matuzeviciute et al., 2009; Motuzaite Matuzeviciute, 2010).

In the current report we present the results of anthropological analyses of craniometrics (Potekhina, 1999a), alongside preliminary results from ancient mitochondrial DNA (mtDNA) studies and an overview of the stable isotope data for the individuals studied. The methodological approaches include the craniometric analysis of ca. 300 skulls from the sites of Dereivka I (119 individuals), Nikolskoye (30 individuals), Vovnigi I and II (74 individuals), Vilnyanka (33 individuals), Vasilyevka II (16 individuals) and Kapulovka (16 individuals) (Potekhina, 1987). Six individuals from the cemetery of Yasinovatka have been analysed with respect to their aDNA composition, and 113 of the 300 individuals from the Dnieper Rapids cemeteries have also been analysed for their $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ stable isotope values (Lillie and Richards, 2000; Lillie et al., 2003; Lillie and Jacobs, 2006; Lillie et al., 2011).

The mtDNA analysis of past populations has been enhanced considerably over the past decade, with recent studies indicating that all modern haplogroups coalesce in Africa around 150,000 years ago (e.g. Cann et al., 1987; Forster, 2004), and that most present-day haplogroups found in Europe likely evolved in the Middle East some 40,000 years ago. At this time branches of the N* node diffused into Europe through Anatolia and across the lower Danube Basin. Other branches of the same node, notably members of the J/T cluster, advanced into Europe via the same route with the advent of agriculture (Richards et al., 2000; Roostalu et al., 2007; after Nikitin et al., 2009). As almost all major human mtDNA haplogroups follow a regionally specific pattern of distribution, mtDNA polymorphism allows for the identification of haplotypes in past populations and can provide insights into the origins of human founder lineages in Europe.

The main cemeteries considered in the current study include Vasilyevka II, Dereivka I and Yasinovatka. Vasilyevka II is dated to 7300–6220 calBC (Lillie and Jacobs, 2006; Potekhina and Telegin, 1995). The site is located on the left bank of the Dnieper, in the rapids region near the village of Vasilyevka. It was excavated by A.D. Stolyar (1959), who uncovered twenty-seven graves, with 32 individuals interred in the extended position. Subsequently, eleven male and five female skulls were analysed by Gokhman (1966), and some discussion of this site is also provided by Konduktorova (1974). Lillie (1998a) analysed twelve males and five females, and also recorded the presence of the dentitions of three nonadult individuals in the collections housed in Kiev. Grave goods found in association at this cemetery include fish and deer teeth, turtle, flint tools and bone bracelets (Telegin and Potekhina, 1987; Kotova, 2003).

Dereivka I is located on the right bank of the river Omelnik close to its confluence with the Dnieper. The largest of the Mariupol-type cemeteries, with 165 Neolithic burials, it is located on the boundary between the forest-steppe and steppe zones. Telegin and Zhilyaeva investigated 144 burials in 1960 and 1961, and a further 20 were subsequently studied by Telegin in 1965 and 1967 (Telegin, 1991). Single and grouped burials were recovered from two areas of the site, the central area having been destroyed by earth-moving activities before the excavations (Telegin and Potekhina, 1987). The human remains from these investigations were studied by Zinevich (1967) and Potekhina (1978, 1987, 1999a).

Lillie (1998a) analysed 104 of the individuals interred at Dereivka I, and obtained dates for 5 of the interments. These dates indicated a main period of use at ca. 5270–4950 calBC, but with at least one individual of later Mesolithic date at 6360–5880 calBC. Given the fact that the Mesolithic individual, № 84, is located amongst a number of individual burials to the north/north-east of the cemetery, some distance away from the main clusters of burials, it is conceivable that a small proportion of the cemetery population is in fact dateable to this earlier chronological period.

Grave goods include fragments of pottery with either stroked or comb ornamentation, a decorated plate of Mariupol-type, deer and fish tooth pendants, flint knives, annular beads, spear points and a flint scraper.

At Yasinovatka, 68 individuals were excavated, with the burials in this cemetery falling into three groups. The A-type burials (dated to ca. 5550–4930 calBC), were interred in oval grave pits (Telegin and Potekhina, 1987). The second and third groups are found in the B group graves, with the B–1 graves dating to 5550–4750 calBC and the B–2 graves dating to 4980–4460 calBC (Lillie, 1998a) (all at 2σ). Some of the individuals interred in the A-type burials at Yasinovatka were severely contracted at the sides, especially at the shoulders, with the legs straightened and in a closed position. It is likely that this is a result of the practice of binding or ‘swaddling’ of the dead (Telegin and Potekhina, 1987).

During excavation, the B stage burials (B–1 and B–2) were found to be in a greater state of disarticulation when compared to the A-stage burials. In addition to a considerable degree of recutting of the graves and disarticulation of the interred individuals, many single bones of destroyed skeletons were also present in the pits. This led Telegin to conclude that the evidence reflected the repeated use of the B stage burial area, and disarticulation prior to the full decomposition of the bodies. Many of the burials at Yasinovatka (e.g. A-type burials in the oval grave pits, group graves and the B group graves) contained a range of grave goods, including pottery, small flint implements, knife-like blades, boar-tusk plates, Unio shells, fish- and deer tooth pendants.

These cemeteries are in effect a small component of the available skeletal inventory for the Dnieper Rapids region. Their cultural affiliations, as designated by various researchers, and the resource base available during the Mesolithic and earlier Neolithic are subjects of widespread discussion. Of interest is the recent suggestion that Mesolithic economies developed in an environment of growing scarcity of hunting resources (Dolukhanov, 2008) and that the dietary focus of the populations interred in the Dnieper cemeteries cannot be taken to reflect a long-term trend in dietary preferences in Ukraine. However, this assertion is somewhat erroneous and reflects a misinterpretation of the evidence presented by Jacobs (1994), Lillie (1996), Lillie and Richards (2000) and others. The latter authors have constantly emphasised the fact that the cemeteries they study belong to the cultures that occupied the middle and lower Dnieper Basin to the south of Kiev and that the general subsistence evidence does not suggest an impoverished resource base during the Mesolithic period. In addition, the cemeteries studied do reflect long-term dietary preferences in central, and probably eastern/south-eastern Ukraine.

The subsistence strategies followed from the Epipalaeolithic through to earlier Neolithic periods reflect similar strategies adopted by human groups throughout the European landmass at the transition to the earlier Holocene, and are fundamentally a reflection of the ease with which these populations adapted to changes in the available resource base. Hunting, fishing and gathering are all attested in the archaeoenvironmental record for Ukraine; the degree to which an individual or group placed an emphasis on a particular resource, or range of resources reflects both individual preference and socio-economic, political and even ritual influences. It should also be remembered that, as will be discussed below, the human groups occupying the Dnieper basin were not necessarily all indigenous to the region, even during the Mesolithic period. To suggest otherwise would be to ignore the evidence, and as suggested by Lillie (1998a), it is methodologically unsound to assume that close geographic proximity equates to close socio-economic and cultural proximity in the absence of evidence to support such an assertion.

Methodology

In the course of the current study it became apparent that in some cases the original age/sex identifications differed from those reached in the more recent analyses (e.g. Gokhman, 1966; Potekhina, 1978, 1981; Lillie, 1998a). We attribute these differences to a number of causes; including the fact that *in situ* analyses will have allowed for the assessment of the post-cranial skeletal material, much of which was too poorly preserved to warrant curation. This has resulted in a reliance on cranial material for ageing and sexing of the skeletal remains in the more recent studies. The use of cranial suture closure in ageing in earlier studies has been critiqued by Lillie (1998a), as in many instances complete closure accompanies a low functional wear stage of the dentitions. We have sought a balance in many cases by offering a combination of the earlier and later classification as reached by different researchers. Lillie (1998a) was able to seek the opinion of Professor Gokhman whilst he was researching in St. Petersburg in relation to the Vasilyevka III and II ageing and sexing, but for the later cemeteries some discrepancies still exist. We will be working on these in future collaborations.

The age groupings used by earlier researchers in Eastern Europe follow the standard set by V.P. Alekseev and G.F. Debets (1964), these being:

Infantilis I	=	<6–7 yrs.
Infantilis II	=	<13–14 yrs (or until appearance of M2).
Juvenis	=	13–20 yrs.
Adultus	=	up to 30–35 yrs.
Maturus	=	up to 50–55 yrs.
Senilis	=	+55 yrs.

These categories are included where the analyses undertaken by colleagues such as Potekhina (1978, 1981, 1999a) differ from those undertaken by Lillie (1998a).

Craniometrics

In the current study craniometric data is used to determine whether the individuals being studied represent a local or nonlocal physical type in the populations being studied (Potekhina, 1987). Assignment of an individual on the basis of the metric data (after Martin and Saller, 1957; Alekseev and Debets, 1964; Buikstra and Ubelaker, 1994; Bass, 1995) relates to the determination of whether the individual studied exhibited a combination of traits characteristic of either (a) the indigenous Proto-European Mesolithic population (classified as Craniological Type I); or (b) the nonlocal ancient hypermorphic north-European populations (classified as Craniological Type II).

This latter group is believed to represent one of the Late Palaeolithic anthropological types (Potekhina, 1987). Studies by Gokhman (1958) at Vasilyevka; Zinevich (1967) and Zinevich and Kruts (1968) at Nikolskoye and Kapulovka, Zinevich (1967) and Potekhina (1978) at Dereivka have distinguished two craniological variants: dolichocranic and mesobrachy- or mesochranic. The suggestion is that some degree of heterogeneity exists in the populations of the Dnieper Basin.

Stable isotopes

The stable isotope analysis of the recently studied Ukrainian material (Lillie et al., 2011) was carried out at the Research Laboratory for Archaeology and the History of Art (RLAHA), University of Oxford, by one of the authors (CB). The earlier analyses of Vasilyevka II and a limited number of samples from Mariievka, Vasilyevka V, Dereivka I and Yasinovatka (Lillie and Richards, 2000; Lillie et al., 2003, Lillie and Jacobs, 2006), were undertaken by Mike Richards while he was at the RLAHA. In the current study 35 isotope analyses are included for the cemeteries studied (Table 1). A number of additional, as yet only partially published isotope ratios (Potekhina, 1999b, 2005), are also included in the current study, bringing the total number of samples available for consideration in the entire Dnieper cemetery series to 113 (Lillie et al., 2011).

As outlined by Lillie and colleagues (2011), in the earlier work on the Dnieper basin skeletal material the collagen was extracted from human bone samples following the protocol outlined in Richards (1998). This method is similar to other published methods of collagen extraction (e.g. Brown et al., 1988; Ambrose, 1990), with occasional variation, and is summarised as follows. For each sample a solution of 0.5 M HCl was added to approximately 100–300 mg of cleaned whole bone (with a preference for cortical bone), and the bone was left to demineralise at approximately 5°C for 3–5 days. The remaining solid was rinsed in H₂O and then gelatinised in a sealed sample holder (in a pH3 HCl solution and heated at approximately 70°C for 24 hr). This solution was then filtered through an 8 µm polyethylene filter, and then centrifuged at 65°C for 15 hr under a vacuum in order to evaporate water and acid. The resultant residue was then rehydrated in 2–3 ml of distilled H₂O, and then lyophilised for 48 hr (Lillie and Richards, 2000).

In the more recent stable isotope work, the samples were prepared using a modified version of the pre-treatment protocol which is set out in Ramsey et al. 2004. Approximately 0.6g of bone were shot-blasted using aluminium oxide and crushed into powder. The samples then underwent demineralization in 0.5HCl at 4degrees C. The acid is changed 3 times during this process and samples are left for 3-5 days or until the CO₂ ceases to evolve. The samples are then rinsed 3 times in deionised MilliQ water and placed in sealed tubes in HCl pH3 and gelatinised at 75degreesC for 48h. The supernatant produced from this process is then filtered using a 5-8mm Eze filter. The soluble gelatine fraction is then placed in liquid nitrogen and freeze-dried for 48h. All of the samples were measured in triplicate; 3 samples were taken from each skeletal sample and the average isotope value was calculated. The samples were analysed using an automated carbon and nitrogen analyzer and a continuous-flow isotope-ratio-monitoring mass-spectrometer (Carlo Erba carbon and nitrogen elemental analyser coupled to a Europa Geo 20/20 mass spectrometer). Typical replicate measurement errors were of the order of ±0.2‰ for δ¹³C and δ¹⁵N. Only samples which produced collagen yields with a C:N ratio between 2.9–3.6 (DeNiro, 1985) were used in the analysis of palaeodiet.

DNA analysis

In the current study six Neolithic osteological samples from the Yasinovatka cemetery were subjected to mtDNA analysis with the goal of retrieving mtDNA sequences to investigate maternal genetic origins of the individuals studied. This stage of the research was undertaken by one of the authors (AN at Grand Valley State University, Michigan, USA).

All manipulations related to sample preparation and DNA analysis were performed in facilities specially dedicated to aDNA research, spatially separating cleanup, DNA extraction, and amplification processes, in accordance with the standards for working with ancient DNA (Cooper and Poinar, 2000). MtDNA was typed by amplifying key segments of the coding region and the first hypervariable segment (HV1) of the control region. The HV1 region was amplified in four overlapping segments and amplicons were subsequently cloned and sequenced, or subjected to direct DNA sequencing after amplification. The coding region amplicons were analyzed by the RFLP method.

Results

Craniometrics

The morphology of all of the individuals interred at the cemetery of Vasilyevka II (8020–7620 calBC), indicates that these individuals are related to the ancient hypermorphic north-European population i.e. they are nonlocal in origin, having ancestral links to more northerly regions of Europe (Fig. 2 and Table 1).

Whilst 27 graves were investigated by Stolyar in 1953, Konduktorova (1974) reported that only 11 male and 5 female skulls proved suitable for analysis. The finds associated with the interments included the characteristic fish and deer tooth pendants, fragments of tortoise shell and a unique artefact for the Dnieper (Mariupol-type) cemeteries, decorated bone bracelets/arm rings.

At this cemetery, analysis by Lillie (1998a) has indicated that there are 12 adult males (3 of which could not be assigned an age estimate), and 5 adult females. The males are aged between 20–60 years (identified in 10 year age brackets e.g. 20–30, 30–40, etc.), with all age categories represented. The females are aged 18–60, but there are no females in the 25–40 year age bracket. Three of the females are aged 18–25 years – Individuals 11 (18–25 years), 15 (18–25 years) and 18 (18–22 years) – one is aged 40–50 (Individual 17) and the remaining female (Individual 2) is aged 50–60. This is a small, nonlocal, cemetery population. The lack of evidence for females in the 25–40 year age categories is difficult to explain, but it could relate to the nature of the group dynamic for a mobile/immigrant population, optimum carrying capacity, optimum breeding structure, differential burial practices, exogamy, or even intergroup theft of marriage partners.

At Dereivka (Fig. 2 and Table 1), 173 individuals were interred in both single and grouped burials. Konduktorova reported that only ca. 50 % of the cemetery population were sufficiently well preserved for craniological analysis. Potekhina (1978, 1981) studied the age-sex distribution at Dereivka (113 skeletons), identifying 53 males, 31 females and 29 children. Lillie (1998a) studied 104 adults from this cemetery population, identifying 66 male and 18 female individuals, with 20 adults of indeterminate sex. In the latter study the reliance on the crania appears to have weighted the results in favour of a male biological sex determination in a number of cases, although associated post-cranial remains, when available, were considered in the study (Lillie, 1998a).

At this cemetery the local Proto-European Mesolithic population is attested by Individual 42 (female 18–20). The nonlocal ancient hypermorphic north-European population is attested by Individuals 5 (male-senilis), 29 (male-maturus), 31 (male 18–25), 33 (male 18–25 [female Potekhina 1981]), 35 (male-maturus), 38 (male 18–22 [female Potekhina, 1981]), 46 (male 18–22), 49 (male 20–30 [maturus Potekhina, 1981]), 84 (female 35–55), 109 (male-maturus) and 130 (ND). The richest burial in terms of grave goods is No. 49 (nonlocal [male 20–30] [maturus Potekhina, 1981]), which is dated to

Table 1 | Correlation of numbers in Figure 2 with burials in the Dnieper cemeteries

Vovnigi II		Dereivka		Vovnigi I	
Figure 2 N°	Burial N°	Figure 2 N°	Burial N°	Figure 2 N°	Burial N°
1	26	29	39	52	15
2	39	30	41	Nikolskoye I	
3	40	31	68	Figure 2 No.	Burial No.
4	47	32	129	53	3
5	52	33	134	54	41
6	54	34	150	55	42
7	62	35	162	56	106
8	75	36	9	57	58
9	76	37	52	Yasinovatka	
10	77	38	141	Figure 2 No.	Burial No.
11	36	39	142	58	27
12	84	Vil'nyanka		36	
			59		
13	85	Figure 2 No.	Burial No.	60	44
14	91	40	8	61	55
15	92	41	20	Vasilyevka II	
16	102	42	31	62	11
17	58	43	32	63	12
18	78	44	34	64	16
19	81	45	38	65	17
20	28	46	39	66	19
21	17	47	40	67	20
22	119	48	17	Kapulovka	
23	53	49	18	Figure 2 No.	Burial No.
24	51	50	28	68	7
25	50	Osipovka			
26	71	Figure 2 No.	Burial No.		
27	72	51	18		
28	116				

5245–4940 calBC. This individual had deer tooth pendants, a Mariupol-type plate and 35 fish teeth in association.

Interestingly, Lillie (1998) dated Individual 84 (nonlocal female 35–55) to the Mesolithic period at 6360–5880 calBC, whilst Individuals 42 (local female 18–20 [maturus Potekhina, 1981]), 33 (nonlocal male 18–25), 49 (nonlocal male 20–30) and 109 (nonlocal female-maturus) were all dated to the earlier Neolithic period ca. 5260–4750 calBC.

At Yasinovatka (Fig. 2 and Table 1), ca. 68 individuals were identified during the excavations. Potekhina (1988) identified 36 males, 15 females, 13 children and 4 individuals of indeterminate sex. Forty-eight of the original 68 individuals at Yasinovatka were available for analysis by Lillie (1998a), who recorded 23 male and 9 female individuals, with 9 adults of indeterminate biological sex. The cemetery

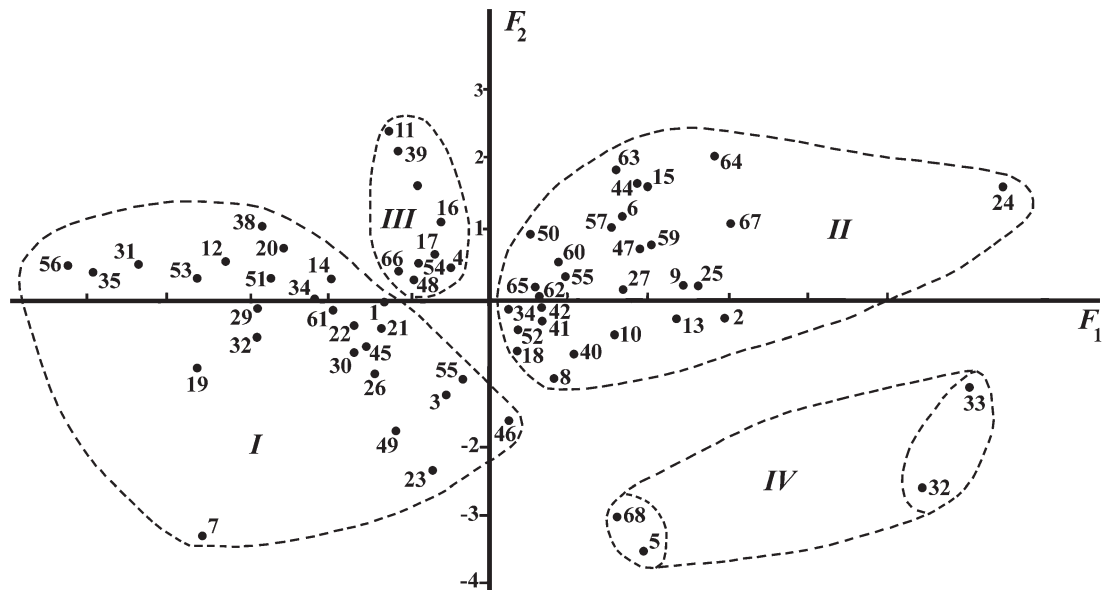


Fig. 2 | Analysis of craniometric data for the Dnieper populations: Variant I = proto-European Mesolithic population; Variant II = ancient hypermorphic north-European populations; Variant III = hybridisation between these two physical types; Variant IV = Dereivka (129 and 136), Vovnigi II and Kapulovka – these four individuals are characterised by a sharp horizontal facial profile and distinct differentiation from the other groups, however, this group is poorly represented in the skeletal series and requires further study

comprised two discrete forms of interment, A-type burials in grave pits of oval form, and B-type burials in a large sub-rectangular pit that was highlighted by a red staining from the use of ochre in the burial ritual. The local portion of this cemetery includes Individuals 18 (male-maturus), 19 (female 20–25), 45 (male 20–25), 55 (male 25–30), 57 (male-indeterminate age), 60 (male-indeterminate age) and 63 (male-indeterminate age), whilst the nonlocal individuals are 35 (male 30–40) and 36 (male 25–30).

Individual 19 (local female 20–25) is an A-stage burial, which was dated by Lillie (1998) to 5435–5220 calBC, the earlier Neolithic, whilst Individual 45 (local male 20–25), the only stage B–1 type burial with grave goods in association, is dated to 5430–5150 calBC. The other local individual that was dated by Lillie (1998a) is Individual 18 (male-maturus), who was interred in the stage B–2 type burials and is dated to 5310–5050 calBC. The nonlocal Individual 36 (male 25–30) was dated by Lillie (1998a) to 5565–4780 calBC. This individual was associated with the stage B–1 type burials.

In many of the earlier Neolithic cemeteries in the Dnieper Basin, the first stage of interment appears to be primarily associated with a local population base, whilst the second stage exhibits a more mixed character with both local (Variant I) and nonlocal (Variant II – proto-European) types, with hybridization between these two types (Variant III) in evidence (Fig. 2). A significant number of the individuals identified as being nonlocal at Dereivka I and Yasinovatka are either young adult males or maturus (based on Potekhina's analyses). Whilst a much more detailed study is needed for each of these cemetery populations, e.g. through the application of Sr analysis of tooth enamel, it is interesting to note that during the earlier Neolithic period in the Dnieper Basin, young adult males (but also males generally) appear to predominate in the nonlocal portion of the population. This contrasts somewhat with the situation in evidence in earlier LBK farming populations further west, where females appear to

dominate in the nonlocal part of the cemetery population (e.g. Price et al., 2001). This may be a reflection of the fact that populations of the Dnieper region exploit what are effectively hunter-fisher-gatherer subsistence strategies during the earlier Neolithic period, with only limited integration of domesticated animals in evidence (depending on location), indicating that, in subsistence terms, these populations are effectively continuing to follow Mesolithic food procurement strategies.

Clearly, the local versus nonlocal identifications based on the craniometric data are intriguing, and they may offer an opportunity for further investigations using strontium (and probably $\delta^{18}\text{O}$) studies in order to reinforce the inferred local/nonlocal components in these prehistoric populations.

Stable isotopes

The stable isotope data (Fig. 3) does not indicate any distinct separation between the local and nonlocal individuals as identified from the craniometric data. The main exception to this general rule appears to be the cemetery of Vasilyevka II, which plots to the right of the main cluster, for ^{13}C , although the ^{15}N is consistent with the other groups studied. This cemetery has been shown to exhibit one of the highest ranges of $\delta^{15}\text{N}$ for the entire cemetery series analysed (Lillie et al., 2011), and is second only to Yasinovatka (and one nonlocal from Dereivka I) in terms of the elevated nitrogen levels in evidence. The $\delta^{13}\text{C}$ ratios for Vasilyevka II are also more positive than those obtained for any of the other cemeteries analysed to date, suggesting that the source of carbon in the diet may potentially differ from the main sources throughout the Dnieper Basin, as attested at sites such as Vasilyevka III, Marievka, Yasinovatka, Nikolskoye, Dereivka I and Vasilyevka V.

The data from Vasilyevka II might support the suggestion, based on the craniometric data, that this population is intrusive to the Dnieper Basin. Elsewhere, the data for Dereivka I highlights a very depleted $\delta^{13}\text{C}$ source, perhaps indicating that the exploitation of a different range of freshwater fish species occurs at this site, or that a small number of the nonlocal individuals (e.g. the 3 outliers from Dereivka I) retain some of the $\delta^{13}\text{C}$ source data from their place of origin (e.g. it is possible that the nonlocal individuals may have moved to the new area shortly before death and as a consequence have not had time to incorporate the local dietary signal).

Despite these inferences, in general the data presented in Figure 2 fails to highlight any discrete separation between the two Neolithic populations studied from the region in terms of the $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values of the dietary sources being consumed. That being the case, with the exception of the individuals interred at Vasilyevka II, we might anticipate that the majority of the individuals interred in the earlier Neolithic cemeteries moved into the region and were resident for some time (>10 years) prior to their deaths. The variation in individuals which is evident at Dereivka, e.g. Individuals 49 (−23.4‰ and 9.9‰), 33 (−21.7‰ and 10.5‰) and 31 (−22.32‰ and 15.48‰), might reflect either specific dietary choice or the recent arrival of these nonlocal individuals into the region, thereby allowing us to ‘see’ them as distinct from the main subsistence patterns in evidence.

The main point is that the analysis of $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ ratios is not intended to be used to distinguish local from nonlocal individuals in a region. Despite this, Vasilyevka II remains atypical in relation to the core distribution of $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ ratios, perhaps suggesting that this later Mesolithic population had recently moved into the region and had not resided for a length of time sufficient to allow their stable isotope ratios to reach equilibrium with the local environmental ranges.

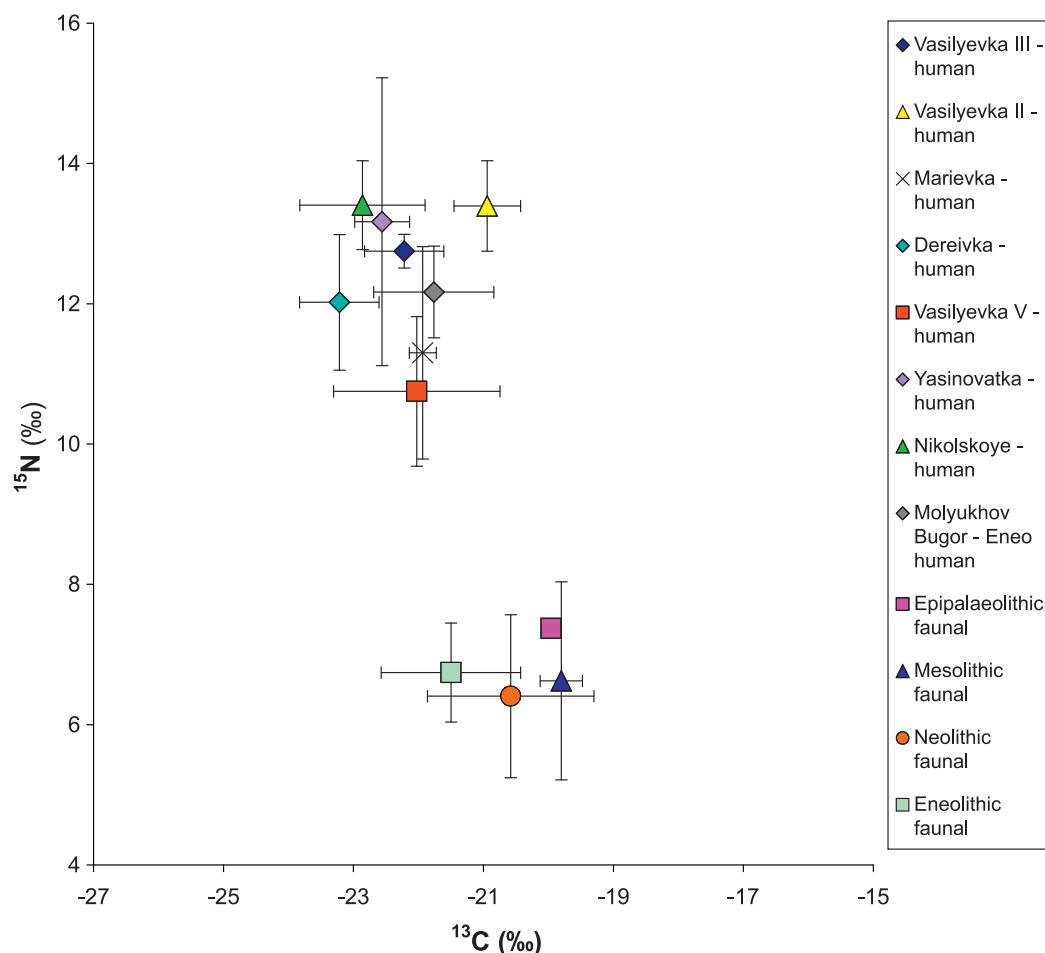


Fig. 3 | Average human and animal $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ data for the Ukrainian cemetery series. All means expressed as $\pm 1\sigma$

Ancient mtDNA

Preliminary results of the mtDNA analysis (Table 2) revealed a heterogenic composition of mtDNA lineages of the Yasinovatka occupants. Of the samples analyzed to date, lineages of west Eurasian and east Eurasian origin have been obtained. The west Eurasian lineages were represented by members of the U clade, identified in sample Ya19, and possibly Ya17, and the T clade. Lineages of the U clade are common in Neolithic remains from other locations in Europe (Sampietro et al., 2007; Bramanti et al., 2009; Malmström et al., 2009). In modern populations, the frequency of U1 is rather low in Europe except for the Mediterranean region, with higher frequencies observed in the Middle East. U3 (Ya19) is related to the founder haplotypes that probably entered Europe from the Near East or Caucasus during the Neolithic (Richards et al., 2002; Roostalu et al., 2007). It is typical of populations from West Asia and the Caucasus region (Derenko et al., 2007, and references therein; Roostalu et al., 2007). It may also have been part of the LUP population expansion in the Near East and Caucasus. Clade T is considered to have originated in the Near East, from where it spread into Europe at the end of the Pleistocene. Within Europe, T is common in the east and the north, particularly around the eastern Baltic Sea.

Table 2 | Individual life history data for selected individuals from Yasinovatka as based on the mtDNA analysis

Cemetery	Individual	Sex/Age	Chronological Age (calBC)	Clade/haplogroup	Likely origin of the haplogroup
Yasinovatka	Yas54	♂ 30–40	5616–5482	T	Near East/West Eurasia
"	Yas19	♀ 20–25	5434–5221	U3	Near East/Caucasus
"	Yas17	adultus	5437–5090	Likely U1	West Eurasia
"	Yas45	♂ 20–25	5432–5148	C	East Eurasia
"	Yas34	infantis	ND (not-dated)	C	East Eurasia
"	Yas32	♂ 30–40	ND (not-dated)	T	Near East/West Eurasia

East Eurasian lineages were represented by the C clade (Ya34 and Ya45), which is uncommon in ancient or present-day European populations, but is found in Neolithic populations, as well as contemporary populations from South Siberia, where this lineage is most likely originated (Starikovskaya et al., 2005; Mooder et al., 2006).

Of interest in this context is the fact that the analysis of Neolithic cemeteries of the Baikal region has suggested that a depopulation event occurred in that region during the 6th millennium BP (Mooder et al., 2006). As such, the dating of Yasinovatka (at ca. 6440–6080 [Hedges et al., 1995]) suggests that there is a possible link between the Baikal depopulation event and the appearance of the C lineage of mtDNA in the North Pontic region.

Whilst the analysis is limited in terms of the numbers of individuals analysed to date, it is of some interest that individual Yas19 (female 20–25) has been identified by Potekhina as being of local origin, and the U3 clade is linked to the founder haplotypes that probably entered Europe from the Near East or Caucasus, possibly linked to the LUP population expansion. A detailed report of the results of the genetic analysis of these specimens is in preparation at the time of writing.

Discussion and Conclusions

The current study has sought to assess the validity of using craniometrics alongside mtDNA to assess local versus nonlocal origins for a number of individuals interred in the cemeteries of the Dnieper river system to the south of Kiev. In addition to these techniques, AMS dating and anthropological and stable isotope analysis has been used to enhance the resolution of the study. In essence, the suggested origins of certain individuals in the cemeteries of Dereivka I and Yasinovatka has been linked to their individual life histories using a combination of standard palaeoanthropological, palaeopathological, craniometric, isotopic and DNA studies. In a number of cases the identification of a nonlocal origin has been shown to exhibit a strong link to biological sex, which appears to be weighted towards males in the earlier Neolithic period at the cemetery of Derievka I.

The stable isotope data, whilst not intended to function as a means for identifying local versus non-local origins for the populations studied, has consistently marked the Vasilyevka II subsistence data as being divergent from the general trend for the Dnieper region (e.g. Lillie and Jacobs, 2006; Lillie et al., 2011). Potekhina (1987, 1999a) has outlined in some detail the craniometric studies undertaken to date on the Dnieper cemeteries, and in general there is good evidence to support the suggestion that there

are two distinct physical types in the cemetery populations, and that the Vasilyevka II population may well be one of the earliest intrusive groups in this region.

A number of individuals at Dereivka I also exhibit $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ ratios that plot apart from the main cluster of the data. Interestingly, whilst these three nonlocal adults diverge from the general trend, the divergence itself is not systematic. Individual 31 (male 18–25 [female, Potekhina, 1981]) exhibits a very high $\delta^{15}\text{N}$ of 15.48‰, very similar to those identified in the Iron Gates region by Bonsall and coworkers (Bonsall et al., 1997, 2000, 2004). Individual 33 (male 18–25) has a more positive $\delta^{13}\text{C}$ value of –21.7‰ (with a low $\delta^{15}\text{N}$ value of 10.5‰), which is very close to the more negative Vasilyevka II $\delta^{13}\text{C}$ values, and finally, Individual 49 (male 20–30 [matures, Potekhina, 1981]) exhibits the lowest $\delta^{15}\text{N}$ values for the individuals considered here, at 9.9‰. This lattermost individual also represents the richest burial at Dereivka, with fish and deer tooth pendants and a Mariupol-type plate in association.

Whilst the consumption of freshwater resources has consistently been highlighted for the Dnieper cemeteries, it is intriguing to note that a number of the Vasilyevka II and Dereivka I individuals that are identified as being of nonlocal origin through the craniometric studies, also differ to some degree in relation to their subsistence preferences as attested by the stable isotope data.

Finally, the mtDNA analysis has resulted in the successful recovery of ancient DNA from the populations of the Dnieper region, and revealed heterogeneity in the mtDNA lineages that have been obtained. These preliminary results indicate that there is considerable potential for the application of mtDNA analysis to the Ukrainian cemetery populations, and whilst limited, the results are informative. The data presented above highlights evidence for both western and eastern Eurasian mtDNA lineages in the Dnieper cemeteries and suggests that we have indications of shared maternal lineages for the populations in the Dnieper region. The direct assessment of local versus nonlocal derivation for individuals from the cemeteries considered here offers an intriguing avenue for research as the craniometric data can be assessed using both mtDNA and Sr analysis in future studies.

It is apparent that the integration of a wide range of analytic techniques has facilitated a detailed consideration of a number of individuals from the Dnieper cemeteries of Dereivka I and Yasinovatka. Whilst the strands of evidence that have been linked in the current study were not initially intended to act as a synergetic study, they have been shown to offer some important informative potential when considering the nature of population migrations in the region. Our future research directions will focus on filling in the gaps, whereby those individuals that have been dated, aged, sexed and subjected to craniometric studies and stable isotope analysis will form the basis for an enhanced resolution study incorporating mtDNA and Sr analysis. This dataset will form the foundation for a refined research agenda aimed at the detailed analysis of entire cemetery populations in order to provide an holistic overview of Mesolithic to Neolithic populations dynamics in the Dnieper region of Ukraine and beyond.

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