**The Corded Ware culture in the Eastern Baltic: new evidence on chronology, diet, beaker, bone and flint tool function**

**1.0. Introduction**

The peoples of the Corded Ware culture (hereafter CWC) are traditionally regarded as mobile stockbreeders who brought animal husbandry into the Eastern Baltic between *ca*. 2900–2300 cal BC. The presence of domesticated faunal remains within CWC contexts as well as stable isotope data obtained on human bone collagen has demonstrated that terrestrial derived protein was preferentially consumed when compared with the preceding Subneolithic hunter-gatherers who relied heavily on aquatic resources (Lõugas et al., 2007; Piličiauskas et al., 2017b; d). Throughout Europe the CWC suddenly appears and differs to all preceding cultures in all aspects of material culture. Thus, nearly 100 years ago it was postulated that the CWC was brought into Europe by a mass migration of pastoralists from the Pontic steppe (Childe, 1926; Gimbutas, 1979); a hypothesis that has been critiqued numerous times (e.g. Lang, 1998; Furholt, 2014; Beckerman, 2015) until recently proved by genetic analyses (Allentoft et al., 2015; Haak et al., 2015; Saag et al., 2017; Mittnik et al., 2018).

This contribution focuses on several CWC graves in the Eastern Baltic. Whilst CWC human remains are highly sought-after for AMS radiocarbon (14C) dating, stable isotopic and genetic analyses, less than a third are available for scientific analysis. Moreover, human remains are, in general, poorly preserved. This has largely been attributed to the acidic soils in the region, which have affected the organic component of the bones, but also unsolicited excavations and the mishandling of materials in storage (Žukauskaitė, 2004).

In 2017, one of us (GP) was fortunate to discover and excavate a new CWC inhumation at the site of Benaičiai in North West Lithuania. It was during these investigations when we realised Belarusian CWC burials are also poorly understood. A grave found inside the flint mine at Krasnasieĺski is one such example. Although the remains were well preserved it has not been directly AMS radiocarbon (14C) dated. In order to rectify this imbalance, reconstruct the diets of these two individuals and place them into the wider context, here, we present new osteological, radiocarbon and stable isotope data from the two skeletons.

To supplement the aforementioned dietary reconstruction we undertook organic residue analysis of two CWC beakers. Prior to this study it was unknown why beakers were placed within inhumations and what their function was. Unfortunately pottery was absent at Benaičiai as well as other Lithuanian CWC graves, whilst a beaker found at Krasnasieĺski was not available for analysis. To overcome this, beakers were sampled from two Belarusian CWC burial-bearing sites, Dakudava 5 and Drazdy 12 located in the Upper Neman (Lakiza, 2008; Asheichyk and Vaitovich, 2016).

Lastly, we present the use-wear results obtained on a flint ‘knife’ recovered from the Benaičiai burial. Moreover, a flint blade and axe as well as a bone ‘pin’ recovered from another CWC grave in Lithuania, Biržai, were analysed. Since use-wear analyses have not been previously undertaken on CWC grave goods, it is currently unknown whether they were intentionally commissioned for internment with the deceased as has been demonstrated elsewhere in Europe (e.g. Little et al., 2017) or held a utilitarian function prior to deposition.

To summarise, we present and discuss: (1) osteological analyses alongside radiocarbon measurements, and δ13C and δ15N stable isotope data obtained on human bone collagen from two CWC graves located in Lithuania and Belarus; (2) organic residue analyses undertaken on ceramic beakers from two CWC burials located in Western Belarus; and (3) use-wear data obtained on several flint and bone tools from two Lithuanian CWC inhumations. We hope that our findings will provide a more comprehensive and reasoned insight into the lifeway’s of the CWC peoples in the Eastern Baltic.

*1.1. CWC graves in the Eastern Baltic*

In general, the burial customs of the CWC in the Eastern Baltic are relatively well known. Although single graves or small cemeteries of up to ~10 individuals are often found (e.g. Sope in Estonia), larger cemeteries are unknown. From Lithuania, Latvia, Estonia and Western Belarus there is no evidence for burial mounds, which differs to Central and Northern Europe (see Kristiansen et al., 2017). Internment is, however, a common practise of the CWC where the deceased were usually buried in the flexed or supine position. Although grave goods typically consist of battle-axes, flint axes and large bladed knives, bone pins and wild boar (*Sus scrofa*) tusks, pottery is rare. In Lithuania, Latvia and Estonia around 90 CWC graves have been identified (Fig. 1) (Grasis, 2007; Žukauskaitė, 2004; 2007; Lõugas et al., 2007) whilst at least six are known from the Upper Neman basin in Western Belarus (Charniauski, 1997; Lakiza, 2008; Asheichyk and Vaitovich, 2016).

Remarkably, the material culture and burial customs of the CWC in the Eastern Baltic do not have their roots in any preceding local hunters-gatherer cultures, and must therefore be directly linked to Central Europe. The absence of barrows in the Eastern Baltic is, however, somewhat of a conundrum since thousands are known from Central Europe and the Pontic steppe (Kristiansen et al., 2017).

*1.2. Background to the investigated sites*

*1.2.1. Benaičiai, Northwestern Lithuania*

The Benaičiai cemetery is located on the banks of the Šventoji River *ca*. 10 km from the Baltic Sea coast in Northwestern Lithuania (Fig. 1). The site is represented by settlement features, a mixture of material culture from different periods, two cremations (grave Nos. 2 and 4) and two inhumation graves (grave Nos. 1 and 3). Inhumation grave No. 1 was heavily damaged during gravel extraction and contained a > 40 year old female who was most likely buried in a flexed position together with a bone awl and at least three amber pendants (Merkevičius, 2002). The female mandible was recently AMS radiocarbon (14C) dated by Piličiauskas et al. (2017a) to *ca*. 2620-2470 cal BC (Poz-66923, 4025 ± 30 BP). Grave No. 2 consisted of a cremation that had been placed into a small pit. Together with another cremation (grave No. 4) it lacked grave goods (Merkevičius, 2002). Grave No. 3 was that of a 0–1-year old infant that contained a flint blade, a goat (*Capra* sp.) pelvic bone, and a bone awl. Similarly, the infant skull was recently AMS radiocarbon (14C) dated by Piličiauskas et al. (2017a) to *ca*. 2830–2470 cal BC (Poz-61591, 4040 ± 30 BP). Both cremations were assigned to the Late Bronze Age, whilst the inhumation graves were attributed to the CWC based on the typology of the grave goods and radiocarbon results.

In 2017, a new pit from the illegal extraction of gravel was identified at Benaičiai. A lens of darker gravel with protruding human remains demonstrated a potential third CWC inhumation (i.e. grave No. 5) at the site. Urgent rescue excavations were undertaken in order to investigate the remaining part of grave No. 5. In total, an area of 1.5 x 3 m was uncovered. The human remains were found in a single heap within a rectangular pit measuring 0.7 x 1.8 m that had been filled with dark brown gravel (Fig. 2). In the same pit a Silurian flint knife made from a short blade was found. The position of the remains demonstrated that they were not in articulation It appears that the corpse was reduced. We assume that the corpse was inhumed and then decomposition occurred in the pit that had a dark gravel fill. However, at one juncture the whole grave had been reopened and it would appear that portions of the skeleton were removed. Unbeknown to us some remains were left behind, which had been grouped together in a bundle. It remains unclear when reduction of the corpse occurred. Since parts of the Neolithic cemetery were used intensively during the Bronze and Iron Ages for cremations and construction, for instance a dwelling area, pits and stone pavements (Merkevičius, 2002; 2005), it is possible that the grave was reopened during either of these periods. Then, in 2017 the burial was disturbed by illegal gravel workers who subsequently destroyed the northwestern section of the pit. Whilst disinterment and reburial of selected remains is normally associated with the Pitted Ware culture of Southern Scandinavia (Larsson, 2009), it is very uncommon for the CWC.

*1.2.2. Biržai, Northern Lithuania*

In 2014, a single CWC grave was found in the city of Biržai. It had been partially destroyed during construction. The inhumation contained an adult male between 30 and 35 years of age. He had been buried in a crouched position with an array of grave goods, including a wild boar tusk and flint axe, a swine (*Sus* sp). fibula bone ‘pin’ and a flint blade/knife (Duderis, 2015). The individual was directly AMS radiocarbon (14C) dated to *ca*. 2570-2350 cal BC (Poz-64678; 3955 ± 30 BP), whilst stable isotope analyses of bone collagen and teeth dentine demonstrated a terrestrial protein derived diet with a shift to aquatic derived protein during adolescence (Piličiauskas et al., 2017b).

*1.2.3. Krasnasieĺski, Western Belarus*

At the middle flow of the Roś River, one of the Neman River’s tributaries, near the town and village of Krasnasieĺski and Karpaŭcy respectively, there are numerous chalk outcrops that are rich in raw material. Here, a dense network of settlements, flint workshops and extraction sites existed from the Final Palaeolithic through the Bronze Age (Charniauski et al., 1996). Open and shaft flint mining was particularly intensive during the Neolithic and the beginning of the Bronze Age, when the Globular Amphora Culture and CWC communities quarried raw materials for the mass production of flint axes (Gurina, 1976; Charniauski, 1995; Charniauski et al., 1996).

In 1962, a CWC burial was found at chalk block No. 2 near Krasnasieĺski. Here, a prehistoric mine had been destroyed during quarrying by the local cement factory. Mikhal M. Charniauski described the burial according to the excavator operator and other workers (Charniauski, 1963; Charniauski et al., 1996). He stated that a human skeleton was found at the bottom of a mine that had been in-filled with chalk debris. It was situated in a horizontal extension of the vertical shaft, at an estimated depth of 3-5 m from the soil surface. The individual lay in a flexed position on its right side facing the east, and oriented towards the south. A bone needle accompanied the skeleton (Fig. 3). Next to the foot bones on the western side of the individual there was a flat-bottomed and long-necked beaker with a smooth transition from neck to body. The upper part of its neck was decorated with a single row of short oblique lines and a horizontal single row with herringbone pattern (Fig. 3). Although the practice of burying the dead in flint mines took place throughout the prehistory of Northern Europe (e.g. Barber et al., 1999), to our knowledge this is the first example dating to the CWC.

*1.2.4. Dakudava 5, Western Belarus*

The Dakudava 5 settlement is located on a sandy hillock on the floodplain of the Neman River. The site was discovered in 1998. In total, 172 m2 were excavated in 1998, 1999 and 2004. These investigations yielded large pottery and lithic assemblages that were assigned to various cultures from the Early Neolithic to the Iron Age (Lakiza and Sidarovich, 2007; Lakiza, 2008, 66–73).

In 2004, Feature H was investigated. According to the excavator, it formed as a result of two overlapping separate structures, termed H1 and H2 (Fig. 4A). Lakiza (2008) identified feature H1 as a household pit with the remains of a hearth and H2 as a CWC grave (“burial 1”) despite the absence of human remains. Feature H2 was represented by a pit measuring 2.8-3.0 x 1.4-1.6 m with a depth of 0.9 m. Modern pits, however, had heavily damaged the feature. To the north, a clay vessel stood in the central part of the pit, on the upper level of its sandy fill (Fig. 4A, B). The vessel is small in size (height, 11.5 cm; rim diameter, 12.7 cm), and had decoration in the form of oval impressions (Fig. 4B). Interestingly, the vessel combines morphological traditions of the CWC (cf. Wlodarczak, 2006, tabl. X: PVEd5) and the Middle Dnieper Culture of the Upper Dnieper basin as well as ornamentation of the Subneolithic and CWC (cf. Kurzawa, 2001, tabl. XІІІ: 10; Wlodarczak, 2006, tabl. LV: 8; LXXXI: 3), and as such may have been locally produced. In addition, a bifacial flint arrowhead and ground flint axe were found near the pit (Lakiza, 2008, tabl. 45:1, 10). Although Lakiza (2008, 84) states that they may represent grave goods associated with “burial 1”, he does not further strengthen his argument.

*1.2.5. Drazdy 12, Western Belarus*

Drazdy 12 is located in the upper reaches of the Neman River. It is situated on a sandy hillock on the banks of the river. The site was discovered in 2005, and a total of 125.5 m2 were excavated between 2012 and 2014 (Asheichyk and Vaitovich, 2016). The investigations yielded archaeology that indicated episodic occupation from the Early Mesolithic through the Early Middle Ages, including the remains of an inhumation grave (Fig. 5). The upper part of the burial had been damaged by natural or anthropogenic post-depositional processes but the burial horizon itself remained undisturbed.

The burial was within a rectangular pit measuring 2.1 x 1.1 m with a depth of 0.7 m. It was oriented NE–SW. Approximately 15 unburnt fragments of molar crowns were recovered to the north of the pit (Fig. 5:12). Other human remains were not preserved. Judging by the condition of the occlusal surfaces of the crowns, the individual was over the age of 35[[1]](#footnote-1). The burial contained numerous grave goods. There was a beaker in the south, which may have been positioned at the feet of the individual. The neck and shoulder of the beaker were ornamented with five horizontal rows of bird feather impressions and a grooved line (Fig. 5:1). To the east, lithics were recovered (Fig. 5:2-11), including a battle axe and nine artefacts made of Cretaceous flint: a ground axe, four arrowheads, two knives and two unretouched shaping flakes.

The peculiarities of the funeral rite and grave goods assuredly assign the Drazdy 12 burial to the CWC. Based on the typology of the lithics and pottery it dates to the second half of the 3rd millennium BC.

**2.0. Methods**

*2.1. Osteological assessment*

Due to the inconsistent preservation of the Krasnasieĺski and Benaičiai individuals, different age-at-death methodological techniques were applied. The age of the Krasnasieĺski individual was estimated using a combination of dental development, molar attrition, cranial suture closure, and the presence of degenerative joint disease (Acsádi and Nemeskéri, 1970; Brothwell, 1981; Ubelaker, 1989; White and Folkens, 2005). The sex of the individual was determined by cranial morphology, and the maximum length of the long bones (Garmus and Jankauskas, 1993; White and Folkiens, 2005). In comparison, the age of the Benaičiai individual was estimated by assessment of epiphyseal development, and fusion of the postcranial elements (Buikstra and Ubelaker, 1994; Scheuer and Black, 2000). It was, however, impossible to determine the sex of the individual due to the fragmented nature of the remains and its age, i.e. juvenile.

*2.2. AMS radiocarbon (14C) dating*

AMS radiocarbon (14C) dating of the human remains were undertaken at the Poznań Radiocarbon Laboratory and Mass Spectrometry Laboratory (Poland), and the Centre for Physical Sciences and Technology, Vilnius (Lithuania). In Poznań, collagen extraction was performed using the procedures originally described by Longin (1971), with further modifications (Piotrowska and Goslar, 2002). The extracted collagen was ultrafiltered using pre-cleaned Vivaspin™ 15 kDa MWCO filters (Brown et al., 1988; Bronk Ramsey et al., 2004). In Vilnius, prior to graphitisation, bone samples were pre-treated using an acid-base-acid (ABA) followed by gelatinisation (Szidat et al., 2017). In this study all radiocarbon ages were calibrated using the OxCal 4.2 software and IntCal13 atmospheric curve (Bronk Ramsey, 2009; Reimer et al., 2013). Calibrated dates are presented at 95.4% probability.

*2.3. Bone collagen stable isotope analysis*

δ13C and δ15N values were determined at the Institute of Geological Sciences, PAS, Warsaw (Poland), and the Centre for Physical Sciences and Technology, Vilnius (Lithuania).

In Warsaw the δ13C and δ15N values were obtained from the same sample that had been directly AMS radiocarbon (14C) dated. A Thermo Flash EA 1112HT Elemental Analyser connected to a Thermo Delta V Advantage Isotope Ratio Mass Spectrometer in continuous flow mode was used. Delta values were normalised to a calibration curve based on the following international standards, USGS 40, USGS 41 and IAEA 600. Standard deviations were ± 0.33 and ± 0.43‰ for δ13C and δ15N respectively.

In Vilnius, the δ13C and δ15N values were obtained from a second sample (of the same bone) since there was insufficient collagen after AMS radiocarbon (14C) dating. The samples were combusted on an Elemental Analyser (FlashEA1112) connected to an Isotope Ratio Mass Spectrometer (Thermo Finnigan Delta Plus Advantage). Accuracy was assessed by the repeated measurements of an international (IAEA-600 Caffeine, n = 6) and internal laboratory standard (flour powder, n = 9). Standard deviations of IAEA-600 were ± 0.03 and ± 0.07‰ for δ13C and δ15N respectively whilst ± 0.07 and ± 0.10‰ were obtained for the flour powder.

The stable isotope data are expressed as delta values according to the formula δX = [(*R*sample/*R*standard– 1)] x 1,000, where *R*sample is the isotope ratio of the sample (13C/12C or 15N/14N) and *R*standard is the isotope ratio of the standard (13C/12C or 15N/14N). All isotope ratios are reported as delta (δ) values and expressed per mille (‰) relative to Vienna Pee Dee Belemnite (V-PDB) for δ13C values and air N2 (AIR) for δ15N values.

*2.4. Organic residue analysis*

To reduce potential contamination from the burial environment, the surfaces of the two potsherds were removed to a depth of between 1 and 2 mm using a Dremmel Drill fitted with a tungsten abrasive bit. This powder was then disposed of. Approximately 2 g of the ceramic powder was removed by drilling to a depth of between 2 and 4 mm from the interior surfaces of the potsherds. These samples were homogenised using a mortar and pestle and split into two for acidified methanol extraction (Correa-Ascencio and Evershed, 2014; Craig et al., 2013; Papakosta et al., 2015) followed by Gas Chromatography-Mass Spectrometry (GC-MS) and Gas Chromatography-Combustion-Isotope Ratio Mass Spectrometry (GC-C-IRMS) (Craig et al., 2007; Craig et al., 2012; Hansel et al., 2004), as well as solvent extraction (Craig et al., 2007; Dudd and Evershed, 1998; Hansel and Evershed, 2009) followed by GC-MS.

*2.5. Use-wear analysis of flint and bone tools*

The traceological analyses were performed using two microscopes. The technological traces of the bone ‘pin’ and the initial use-wear analysis of the flint artefacts were determined under a microscope (Nikon SMZ-2T) fitted with a camera (Nikon D7100) between 12.6-120 x magnifications. The photomicrographs presented in Fig. 12: D-F were made using this setup. Polish observations were obtained using a Zeiss-Axiotech microscope, between 50-500 x magnifications, fitted with an Axiocam 105 camera. The photomicrographs presented in Fig. 12: A-C, G-I were captured using this equipment. Prior to analysis, the material was cleaned with detergent diluted in water and pure ethanol (C2H5OH).

The employed methodology and terminology used was based on the following works: Vaughan (1985), van Gijn (1989), Juel Jensen (1994), Korobkowa (1999) and Osipowicz (2010).

**3.0. Results and discussion**

*3.1. Osteological assessment of the human remains from Benaičiai and Krasnasieĺski*

Only a portion of the skeleton from grave No. 5 at Benaičiai was available for anthropological analysis. The remains included fragments of the pelvis, femora, the left tibia, ribs, the 4th lumbar vertebra as well as the left calcaneus and talus (Fig. 6). The osteological assessment demonstrated that the remains belonged to one individual. Incomplete epiphyseal fusion of the long bones, including the left ilium and ischium, were consistent with an age of 10 to 15 years at the time of death. Additionally, the left tibia diaphysis displayed signs of healed periostitis indicating a non-specific infection that affected the individual during life.

In comparison, the Krasnasieĺski skeleton was more complete. The skull with 11 teeth, left scapula and clavicle, humeri, left radius and ulna, left 5th metacarpal, femora, tibiae, left fibula as well as the majority of the vertebral column and ribs were present (Fig. 6). The lack of evidence for degenerative joint disease, closed endocranial sutures, presence of the erupted 3rd molars and slight molar attrition indicated that the individual was between 20-40 years at the age of death. The absence of the pelvis impeded the determination of the sex. Yet, the length of the long bones combined with the overall cranial morphology indicated that the individual was probably male.

A few cases of pathology were present. A small osteophyte was present on the anterior aspect of the distal articular surface of the left radius. The vertebral column had evidence of slight Schmorl’s nodes on the superior side of the 12th thoracic vertebra and the 1st lumbar vertebra, including osteophyte formation on the articular surfaces of the lumbar vertebrae. Additionally, the individual had poor dental hygiene, resulting in dental caries in three right lower molars, and an abscess on the left first molar of the maxilla.

*3.2. Chronology of the Benaičiai and Krasnasieĺski graves*

The human remains from Benaičiai and Krasnasieĺski were selected for AMS radiocarbon (14C) dating. However, it became clear that bone collagen preservation differed between the two graves. A C:N atomic ratio of 3.3 was obtained for the individual from Krasnasieĺski, whilst the individual from Benaičiai (i.e. grave No. 5) yielded an atomic ratio of 3.8 that was outside of the acceptable range of 2.9-3.6 as set out by DeNiro (1985) (Table 1). In addition, a low collagen yield was obtained (0.6%), which raises doubts about the reliability of the radiocarbon measurement (van Klinken, 1999). However, the radiocarbon age itself (4166 ± 50 BP) is similar to the other two-inhumation graves at Benaičiai, No. 1 (4025 ± 30 BP) and No. 3 (4040 ± 30 BP) (Table 1), which belong to the CWC. We do not claim that the radiocarbon age is reliable, however, it seems likely that grave No. 5 represents a third CWC individual at the site. Moreover, the Krasnasieĺski radiocarbon measurement (4005 ± 35 BP) and bone collagen quality indicators do not seem suspicious or unreliable (Table 1). The calibrated age of *ca*. 2620-2465 cal BC points to the latter stages of the CWC in the Eastern Baltic (Fig. 7).

Funerary pottery with similar herringbone ornamentation occurs in the Middle Dnieper culture, and at CWC settlements in Prypiat Polesia (cf. Аrtemenko, 1967, fig. 16:4, 39:3, 32:2, 56:1; Kryvaltsevich, 1999, fig. 17:2; Kryvaltsevich, 2011a, fig. 2:5; Kryvaltsevich, 2011b, fig. 4:5). In the Middle Dnieper culture, graves containing pottery with this pattern date to period A, *ca*. 2600/2500-1900/1800 ВС, according to Kryvaltsevich’s (2006; 2011b) periodisation. In general, these observations are in agreement with the calibrated age of the skeleton from Krasnasieĺski where a beaker with similar ornamentation was found.

*3.3. Bone collagen stable isotope data*

Bone collagen δ13C and δ15N data was obtained for two individuals, Benaičiai grave No. 5 and Krasnasieĺski (Table 1). As previously mentioned, the C:N atomic ratio of the individual from Benaičiai grave No. 5 (Table 1) fell outside of the acceptable range (DeNiro, 1985). Despite the low collagen yield and poor collagen quality, the stable isotope values appear somewhat comparable with Benaičiai and other CWC individuals from the Eastern Baltic (Fig. 8). The individual from grave No. 5 yielded δ13C and δ15N values of -21.7 and 8.6‰ respectively that were similar to those obtained for the individuals in grave Nos. 1 and 3 (-21.2 and 9.9‰, -21.4 and 10.6‰) (Table 1). It is, however, worth noting that the δ15N value of the infant (grave No. 3) at Benaičiai is elevated due to breastfeeding (see Fogel et al., 1989; Fuller et al., 2006). In comparison, the δ13C value (-21.7‰) of the individual in grave No. 5 at Benaičiai falls within the range of values (-21.6 ± 0.3‰; n = 14) obtained for other CWC graves throughout the region. Although its δ15N value (8.6‰) is somewhat lower when compared to the mean (10.1 ± 0.5‰; n = 14) of CWC individuals throughout the Eastern and Southern Baltic, it is very similar to that obtained (8.8‰) from the individual in grave No. 241 at Plinkaigalis. In the following we use the stable isotope data of the individual with caution. However, the C:N atomic ratio of the Krasnasieĺski was within the accepted range of 2.9-3.6 (DeNiro, 1985) and as such is considered reliable.

When combined with previously published data, the individuals plot alongside other Lithuanian CWC peoples and fall within the range established for terrestrial herbivores and wild boar (Fig. 8). These data are noticeably different when compared to earlier (Mesolithic and Subneolithic) and later (Bronze Age) individuals throughout the Eastern Baltic. On the whole, CWC peoples, including the individual from Krasnasieĺski, consumed terrestrial derived protein from domestic and wild animals. The δ15N value of 10.9‰ of the Krasnasieĺski individual is presently one of the highest dating to the CWC (Fig. 8). The value either suggests some input of aquatic derived protein (Piličiauskas et al., 2017d) or the consumption of dairy products (Sjögren et al., 2016). Unfortunately, there are no comparative fish data available from these sites. A contribution of freshwater derived protein is difficult to assess given the wide range of δ13C and δ15N values available (Katzenberg, 2008). Moreover, a broad range of δ13C and δ15N values has been identified for freshwater fish taxa, and within the same species (Reitsema et al., 2013). In addition, the δ13C and δ15N values of some freshwater organisms can be very similar to those of terrestrial mammals. That being said, freshwater resources higher up in the trophic level were probably an important dietary component.

Overall, the δ13C values of all individuals had a small range (0.5‰) and are very homogenous demonstrating the long-term consumption of C3 terrestrial foods, and essentially little to no contribution of marine or C4 resources (Lõugas et al., 2007; Piličiauskas et al., 2017b; d; Richards and Hedges, 1999). Moreover, the δ13C values of the CWC individuals are ~3‰ lower when compared to the Late Bronze Age farmers from Lithuania who consumed millet (Fig. 8). This terrestrial based diet is consistent with their reliance on protein derived from domesticated animal resources as well as an input of plant foods. The data show a clear departure from earlier populations that had diets consisting of the partial consumption of aquatic resources, and support the notion of a population replacement of indigenous hunter-gatherer-fishers with stock-herders, as demonstrated recently by DNA analyses (Allentoft et al., 2015; Haak et al., 2015; Saag et al., 2017; Mittnik et al., 2018).

The terrestrial diet of the Krasnasieĺski individual is further corroborated by the zooarchaeological and macrobotanical data obtained from CWC graves, and settlement sites throughout the region. At the settlement of Alksnynė 3 in Western Lithuania the zooarchaeological assemblage demonstrated a mixed economy that was focussed on terrestrial, including pig (*Sus domesticus*), cattle (*Bos taurus*), sheep/goat (Ovicaprid), roe deer (*Capreolus capreolus*), and aquatic organisms, including seal (Phocidae), northern pike (*Esox lucius*), zander (*Sander lucioperca*), and common bream (*Abramis brama*) (unpublished data). Although only eight bone fragments were identified (swine, *Bos* sp., and red deer (*Cervus elaphus*)) from the site of Alksnynė 4, they similarly demonstrate a terrestrial based economy (unpublished data). Moreover, identified faunal remains from Estonian CWC graves further support our findings. For instance, in the study by Lõugas et al. (2007) terrestrial fauna predominate (represented by cattle, pig, sheep/goat, boar, and beaver (*Castor fiber*)). Elsewhere, the presence of goat hair in a CWC burial at the site of Perttulanmäki in Finland (Ahola et al., 2018) further reinforces our findings. Unfortunately, there are, however, no available macrobotanical data for the CWC in Belarus, Estonia, Finland or Latvia, which may be partly explained by the unsystematic use of flotation. Moreover, despite the flotation of approximately 1620 L of sediment during the excavations at Kvietiniai, Nida, Alksnynė 3 and Šventoji 40 between 2015-2016, not a single domestic plant macroremain was recovered (unpublished data). Thus, it would appear that the CWC peoples in the Eastern Baltic did not practice agriculture despite contradictory evidence, for example cereal pollen (e.g. Poska 2001; Stančikaitė et al., 2002; Vasks et al., 1999), which may be unreliable (see Piličiauskas et al., 2017c).

*3.4. Use of CWC beakers*

The two CWC beakers from the graves at Dakudava 5 and Drazdy 12 (Fig. 9) were selected for organic residue analysis. Although contamination in the form of plasticisers was present in the Drazdy 12 sample during the initial analysis of the mass spectra, it has not effected interpretation. The beakers yielded lipid concentrations of 50.7μg g-1 (Dakudava 5) and 9.4μg g-1 (Drazdy 12) that were above the minimum amount required for interpretation (i.e. >5μg g-1 for ceramic powder) (Evershed, 2008; Craig *et al*., 2013).

In the acidified methanol extracts, a range of saturated fatty acids were identified by GC-MS. The beaker from Dakudava 5 and Drazdy 12 were dominated by equal amounts of C16:0 and C18:0 indicating that animal products had been processed (Regert, 2011). In addition, C15:0 and C17:0 branched fatty acids were identified in both samples that are typical of ruminant products.

In order to identify aquatic derived lipids (Cramp and Evershed, 2014), the samples were analysed using a more polar GC column (DB-23 60 m) with the Mass Spectrometer operating in SIM mode. 4,8,12-trimethyltridecanoic acid, an isoprenoid fatty acid typically associated with aquatic organisms (Hansel et al., 2004), was identified in the beaker from Dakudava 5. It was absent in the beaker from Drazdy 12. Other isoprenoid fatty acids (pristanic and phytanic) were, however, present in both beakers. On the other hand, aquatic derived biomarkers, such as *ω*-(*o*-alkylphenyl) alkanoic acids were absent. Although present in the tissues of aquatic organisms, they are also found in terrestrial animals. Recently, it has been proposed that the ratio of the two natural phytanic acid diastereomers, 3S,7R,11R,15-phytanic acid (SRR) and 3R,7R,11R,15-phytanic acid (RRR), permits further discrimination between aquatic and ruminant organisms (Lucquin et al., 2016a). The *SRR*% values of 33.4% (Dakudava 5) and 33.0% (Drazdy 12) however confirm that ruminant products had been processed in the beakers since they were below the threshold of 64.0% (Lucquin et al., 2016a).

Mono- and diacylglycerides consisting of palmitate (C16:0) and stearate (C18:0) acids were present in the solvent extract from the Dakudava 5 beaker confirming that animal fats had been processed. Though, owing to a lack of triacylglycerides it was not possible to distinguish the origins of the diacylglycerides.

To distinguish the origins of the different foodstuffs further, both samples were analysed by GC-C-IRMS. Carbon stable isotope values were obtained from the two fatty acid methyl esters, methyl palmitate (C16:0) and methyl stearate (C18:0). These data are plotted alongside contemporaneous data (Cramp et al., 2014) in Fig. 10. The beaker from Dakudava 5 plotted within the range established for modern ruminant milk, which was corroborated by a Δ13C value of -5.1 (see Craig et al., 2012). In comparison, the vessel from Drazdy 12 plotted within the range established for modern ruminant adipose, although a mixture of dairy and non-ruminant products would also produce a similar value.

Overall, the data differ when compared with the preceding Late Mesolithic Narva culture as well as the Subneolithic period from the region, which had been preferentially used for processing aquatic resources (Heron et al., 2015; Oras et al., 2017). On the other hand, the data are in agreement with six CWC vessels from three Finnish settlement sites (Cramp et al., 2014) and two CWC beakers from the coastal Lithuanian site at Nida (Heron et al., 2015) in which a range of ruminant products had been processed.

Moreover, it is quite apt that pottery, used for processing a range of ruminant products, was placed in the graves of these individuals. Most likely the CWC beakers are concurrent with the arrival of migrant stock herders who had the genetic ability to digest milk as adults (Vuorisalo et al., 2012) although further DNA analyses of human remains from the Baltic region is required to confirm this. Drinking milk from beakers may have been a novel practice that was both culturally abhorrent and physiologically impossible to indigenous populations. As with other aspects of funerary practice, placing such beakers in graves might therefore have had a deeper significance by marking these incoming populations as different.

*3.5. Use-wear analysis of the flint and bone grave goods*

There was no use-wear or handling traces on the flint axe analysed from Biržai (Fig. 11:1). It is grinded across the majority of its surface: roughly on the butt whilst more precisely along the cutting edge. The cutting edge itself is also polished (Fig. 12:A). Presently, it remains unclear whether the lack of use-wear is intentional or accidental. That being said, at the Polish site of Kowal 14, dating to the Globular Amphora culture, an unused or renewed flint axe had been interred with the deceased (Osipowicz et al., 2014a; b), and so it is possible that we are dealing with a deliberate act for inclusion as a part of the funerary rite.

The use retouch observed on the side edges of the retouched flint blade from Biržai is close/irregular with a step and feather terminations of the scars (Fig. 11:2). Here, a generic weak polish, visible on both sides of the edges as thin (discontinuous) lines along the edge, with a marginal degree of intrusion were present. It has indefinite (probably slightly cratered) topography, and a smooth texture. The cutting edges are slightly rounded in some places (Fig. 12:B). The tool should be considered as probably used,possibly for cutting meat. The artefact was re-sharpened (retouched) directly before deposition in the ground, including “toothing” of the intentional retouch along the edges. There are no signs of destruction of the secondary retouch. This behaviour should be seen as analogous to the one described above in the case of the axe, which confirms the hypothesis of its intentionality and relationship with potential votive activities. Handling traces observed along one of the ridges, on the distal end of the blade (Fig. 11:2; 12:C) are probably connected with a primary function of the artefact.

The only bone tool analysed from Biržai is broken at the bore hole (Fig. 11:3), which is conical and bored mostly from the dorsal side of the bone (Fig. 12:D). The surface of the tool is slightly ground along its axis. In some places there are also some visible traces of flint tools, probably scrapers. In the lower part of the tool, around a half of the specimen’s surface is covered by a brighter polish. This is possibly the result of handling the tool during use. The tip of the artefact is very roughed and crushed (Fig. 12:E, F). The side edges are rounded here and the use polish is almost not visible (being present in only a few places – Fig. 12:G). The tool was probably used as a type of grinder/pounder for processing a relatively hard and abrasive substance. Although it cannot be ruled out that the abrasive character of the traces observed is the result of working in a rough container, while the worked material itself was soft, e.g. of vegetable origin. Based on the shape of the probable working edge of the bone needle from Krasnasieĺski, it may have been used in a similar way.

Both side edges of the flint artefact from Benaičiai (Fig. 2) bore traces from the cutting of soft hide or meat (Fig. 12:H, I). One of the edges (marked as B), on its butt could also have been used to whittle wood, what is indicated by the character of use retouch observed.

**4.0. Conclusions**

Overall, the specific material culture and burial practices of the CWC in the Eastern Baltic do not have their roots in any local hunters-gatherers’ cultures. Flexed burials including an array of grave goods, for example stone and flint axes, ceramic vessels, flint knives, bone pins and other tools, link the Eastern Baltic CWC with Central Europe despite the absence of burial mounds.

The new radiocarbon measurements and stable isotope data reported for Krasnasieĺski and Benaičiai grave No. 5 (the latter used with caution) fit the existing chronology of the CWC in the Eastern Baltic, and demonstrate that the individuals consumed terrestrial derived protein, perhaps from domesticated animals.

The organic residue analysis demonstrated that a range of ruminant products, including milk, had been preferentially processed in the two CWC beakers. Whilst these data are congruent with several vessels from the wider region (see Cramp et al., 2014; Heron et al., 2015; Robson et al., in prep) further analyses of funerary vessels is warranted. It is possible, though, that the beakers held a personal association with the deceased given their generally smaller capacity.

The use-wear analysis demonstrates that bone pins or needles from CWC graves may not have been used us their typological names suggests, and may have been carefully selected for inclusion with the deceased. In this study, the specimen from Biržai had been used as a grinder for processing an unspecified material. In comparison, the flint blades had probably been used for processing meat whilst the axe had either been carefully renewed or not used at all; the latter practice has been observed on similar materials in the wider region (e.g. Osipowicz et al., 2014a; b). We believe that the use-wear analysis of additional grave goods holds great potential to further understand the economy, and the association with the deceased during the CWC.

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**Tables**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Site** | **Sample** | **Lab. code** | **Radiocarbon age (BP) ± error** | **Calibrated age (BC)**  | **δ13C (‰)** | **δ15N (‰)** | **C:N** | **% col.** | **%C** | **%N** |
| *Benaičiai* |
| Grave No. 1 | Female >40, mandible | Poz-66923 | 4025 ± 30 | 2620-2470 | -21.2 | 9.9 | 3.2 | 5.1 | 37.5 | 13.5 |
| Grave No. 3 | Infant 0-1, skull | Poz-61591 | 4040 ± 30 | 2830-2470 | -21.4 | 10.6 | 3.3 | 12.9 | 39.7 | 14.2 |
| Grave No. 5 | Juvenile 10-15, tibia | FTMC-17-10 | 4166 ± 50\* | 2890-2600 | -21.7\* | 8.6\* | 3.8\* | 0.6\* | 9.0\* | 2.8\* |
| *Krasnasieĺski* |
| Grave | Male (?) 20-40, femur | Poz-89314 | 4005 ± 35 | 2620-2465 | -21.2 | 10.9 | 3.3 | 12.5 | 14.2 | 5.1 |

*Table 1: Radiocarbon measurements and stable isotope data obtained on human bone collagen from the burials at Benaičiai and Krasnasieĺski. The data from grave Nos. 1 and 3 at Benaičiai are taken from Piličiauskas et al. (2017b). The calibrated ages are reported at 95% probability. Key: \* indicates that the data are unreliable (see text).*

**Figures**

*Fig. 1. Map showing the sites investigated in this study as well as known CWC graves in the Eastern Baltic (data from Lõugas et al., 2007, Grasis, 2007, Žukauskaitė, 2004 and Asheichyk and Vaitovich, 2016 with some additions and modifications).*

*Fig. 2. Grave No. 5 at Benaičiai in Northwestern Lithuania. Key: 1, brownish gravel; 2, brown gravel; 3, dark brown gravel. Drawing and photograph by G. Piličiauskas.*

*Fig. 3. A beaker and bone needle from the burial at the site of Krasnasieĺski. Photograph by V. Asheichyk.*

*Fig. 4. (A) Dakudava 5 plan and section of feature H; (B) the vessel from feature H2. Key: 1, grey and ash-grey sand; 2, blackish charcoal sand; 3, modern pits. The black dot marks the location of the vessel. Drawings by V. Lakiza and V. Asheichyk (A) and M. Kryvaltsevich (B).*

*Fig. 5. Drazdy 12 grave plan and artefacts. Key: 1, beaker; 2–5, arrowheads; 6, 7, knives; 8, 9, unretouched flakes; 10, ground flint axe; 11, battle axe; 12, human teeth; a, light-grey sandy loam; b, dark-grey sandy loam; c, black charcoal sand; d, contour of the grave pit at the depth of 0.65–0.70 m. Drawings by V. Asheichyk and A. Vaitovich.*

*Fig. 6. Skeletal element profile outlines for grave No. 5 at Benaičiai and Krasnasieĺski. Note that at least six right and 10 left ribs were identified during the osteological assessment of the human remains from Krasnasieĺski. However, since they were highly fragmented it was not possible to securely identify their position. Skeleton drawing by M. Coutureau and P. Courteau, after Meiklejohn and Constandse-Westermann (1978).*

*Fig. 7. Calibrated radiocarbon measurements of CWC burials in the Eastern Baltic. The new radiocarbon measurements are in bold. Previous radiocarbon measurements are taken from Zagorska (1997), Eriksson et al. (2003), Lõugas et al. (2007), Antanaitis-Jacobs et al. (2009) and Piličiauskas et al. (2017b; d). Note that the radiocarbon age of grave No. 5 at Benaičiai should be used with caution since it was made on collagen of poor quality (see text).*

*Fig. 8. δ13C and δ15N data obtained on bone collagen for CWC graves in Lithuania, Latvia, Poland and Western Belarus. These data are plotted against Mesolithic, Subneolithic and Late Bronze Age individuals from Lithuania (data from Eriksson et al., 2003; Piličiauskas et al., 2017b; Pospieszny et al., 2015; Reitsema, 2012). The data obtained from the individual in grave No. 5 at Benaičiai did not meet the quality criteria as set out by Deniro (1985) and van Klinken (1999) and as should be treated with caution. The expected consumers' areas are marked by dotted squares with a trophic level shift of approximately 1‰ for δ13C and 4.1‰ for δ15N. They were calculated from Lithuanian Subneolithic-Early Bronze Age fauna (Piličiauskas et al., 2017b; d) and Latvian Subneolithic freshwater fish (Schmölcke et al., 2015). LT – Lithuanian, LV – Latvian, PL – northern Polish, BLR – western Belarusian.*

*Fig. 9. The two CWC beakers from the Belarusian sites of Drazdy 12 (A) and Dakudava 5 (B) that were investigated in this study. Photograph by V. Asheichyk.*

*Fig. 10. δ13C values of C16:0 and C18:0 n-alkanoic acids extracted from the Dakudava 5 and Drazdy 12 beakers. These data are plotted against contemporaneous data from Finland (Cramp et al., 2014). The ellipses are derived from authentic reference fats that are plotted at 67% confidence (Colonese et al., 2015; Craig et al., 2012; 2013; Cramp et al., 2014; Dudd, 1999; Lucquin et al., 2016a; b; Spangenberg et al., 2006; Taché and Craig, 2015).*

*Fig. 11. The flint and bone tools from the Biržai grave in Northern Lithuania that were analysed for use-wear. Photograph by G. Piličiauskas.*

*Fig. 12. Examples of use-wear and technological traces observed on the bone and flint artefacts from Biržai (A-G) and Benaičiai (H, I). Photographs by G. Osipowicz.*

1. Osteological analysis conducted by Dr Łukasz Maurycy Stanaszek, an anthropologist at the State Archaeological Museum in Warsaw (Asheichyk and Vaitovich, 2016) [↑](#footnote-ref-1)