Abhandlung

Marta Chmiel-Chrzanowska*, Rafał Fetner

Are you those folks from across the sea? Biochemical analysis of human remains from the Roman Iron Age site in Grzybnica (Poland)

https://doi.org/10.1515/pz-2024-2035

Zusammenfassung: Steinkreise der Wielbark-Kultur, wie die in Grzybnica, faszinieren Forscher seit langem, die über ihre Funktion und Bedeutung debattieren. Ziel der vorliegenden Studie ist es, die Herkunft und Lebensweise der Bevölkerung zu bestimmen, die in der Nähe der Steinkreise in Grzybnica bestattet wurde, was zur Klärung der Rolle dieser Orte innerhalb der Wielbark-Gemeinschaften beitragen kann. Für die Analyse wurden menschliche Überreste vom Friedhof in Grzybnica, Westpommern, Polen, verwendet. Es wurden Radiokarbondatierungen von fünf Proben, stabile Isotopenanalysen von Kohlenstoff und Stickstoff in zwei Proben sowie Strontiumisotopenanalysen an 20 kremierten menschlichen Überresten und 12 Pflanzenproben durchgeführt. Die Radiokarbondatierungen bestätigten die frühere Datierung des Fundorts auf den Zeitraum zwischen etwa 80 und 260 n. Chr. Ernährungsstudien zeigten, dass die hier bestatteten Individuen regelmäßig Hirse (mittlerer $\delta^{13}C$ = –17,8) und tierisches Eiweiß (mittlerer $\delta^{15}N$ = 9,5) konsumierten. Diese Ernährung entspricht der Variabilität, die für den Wielbark-Kultur-Fundort in Rogowo beschrieben wurde. Die Strontiumisotopenanalyse ergab eine signifikante Variation zwischen dem Flusstal (0,7157–0,7264) und dem angrenzenden Hochland (0,7109–0,7138). Die Isotopenwerte bei den Menschen waren homogen und lagen im Bereich von 0,7113 bis 0,7130, was keine Ausreißer erkennen ließ, die auf die Anwesenheit von Migranten hinweisen könnten. Die beobachtete Variabilität bei den Menschen entspricht den Werten, die im Hochland beobachtet wurden. Die Ergebnisse deuten darauf hin, dass die Gruppe der in Grzybnica bestatteten Personen eine kleine Gemeinschaft war, die ihre Nahrung aus dem Hochland bezog. Es ist möglich, dass diese Gemeinschaft an der Pflege der Steinkreise beteiligt war und dass die Kreise selbst Orte für Versammlungen der lokalen Gemeinschaften waren. Es sollte jedoch beachtet werden, dass nur etwa 20 % der an der Fundstelle gefundenen Gräber analysiert wurden. Das Fehlen von Migranten könnte auf die geringe Mobilität dieser Gruppe oder auf methodische Einschränkungen im Zusammenhang mit der postglazialen Natur des geologischen Substrats zurückzuführen sein. Alternativ könnte es auch auf die Einschränkungen bei der Untersuchung von kremierten Überresten zurückzuführen sein, die nur die Rekonstruktion von Ereignissen aus einem Zeitraum von etwa 10 Jahren ermöglichen.

Schlüsselworte: Wielbark-Kultur, Isotope, Ernährung, Herkunft, Römischen Kaiserzeit, Polen

Abstract: Stone circles of the Wielbark culture, such as those found in Grzybnica, have long fascinated researchers, who debate their function and significance. The aim of the presented study is to determine the origins and subsistence strategies of the population buried near the stone circles in Grzybnica, which may help highlight the role of these sites within Wielbark communities. For analysis, human remains from the cemetery in Grzybnica, West Pomeranian Voivodeship, Poland, were utilized. Radiocarbon dating of five samples, stable isotope analysis of carbon and nitrogen in two samples, and strontium isotope analysis in 20 cremated human remains and 12 plant samples were conducted. Radiocarbon dating confirmed the earlier dating of the site to the period between approximately 80 and 260 CE. Dietary studies indicated that the individuals buried here regularly consumed millet (mean $\delta^{13}C$ = –17.8) and animal protein (mean $\delta^{15}N$ = 9.5). This diet corresponds with the variability described for the Wielbark culture site in Rogowo. The strontium isotope analysis revealed significant variation between the river valley (0.7157–0.7264) and the adjacent upland (0.7109–0.7138). The isotopic values in humans were homogeneous, ranging from 0.7113 to 0.7130,

***Corresponding author: Marta Chmiel-Chrzanowska**, Department of Archaeology, Institute of History, University of Szczecin, Krakowska 71-79, 71-017 Szczecin, Poland.
E-Mail: marta.chmiel-chrzanowska@usz.edu.pl.
https://orcid.org/0000-0001-6668-1628
Rafał Fetner, Faculty of Archaeology, University of Warsaw, Krakowskie Przedmieście 26/28, PL00-927, Warsaw, Poland.
E-Mail: rafetner@uw.edu.pl. https://orcid.org/0000-0002-9489-0424

Open Access. © 2024 the author(s), published by De Gruyter. This work is licensed under the Creative Commons Attribution 4.0 International License.

indicating no outliers that might suggest the presence of migrants. The variability observed in humans corresponds with the values observed on the upland. The results suggest that the group of individuals buried in Grzybnica was a small community that sourced their food from the upland. It is possible that this community was involved in the care of the stone circles, and the circles themselves may have been places of gatherings for local communities. However, it should be noted that only about 20 % of the graves found at the site were analyzed. The lack of migrants may be due to the low mobility of this group or methodological limitations related to the post-glacial nature of the geological substrate. Alternatively, it could also be due to the limitations associated with studying cremated remains, which allow for the reconstruction of events from only about 10 years prior.

Keywords: Wielbark Culture, Isotopes, Diet, Origin, Roman Iron Age, Poland

Streszczenie: Kręgi kamienne kultury wielbarskiej, takie jak te znajdujące się w Grzybnicy, od dawna budzą zainteresowanie badaczy, którzy debatują nad ich funkcją i znaczeniem. Celem przedstawionego badania jest określenie pochodzenia i gospodarki ludności pochowanej przy kręgach kamiennych w Grzybnicy, co może pomóc w zrozumieniu roli tych miejsc w społecznościach kultury wielbarskiej. Do analizy wykorzystano szczątki ludzkie pochodzące z cmentarzyska w Grzybnicy, województwo zachodniopomorskie, Polska. Przeprowadzono datowanie radiowęglowe pięciu próbek, badanie proporcji izotopów trwałych węgla i azotu w dwóch próbkach, a także analizę izotopów strontu w 20 próbkach ludzkich szczątków ciałopalnych oraz 12 próbkach roślinnych. Datowanie radiowęglowe potwierdziło wcześniejsze datowanie stanowiska na okres między około 80 a 260 rokiem n.e. Badania diety wskazały, że pochowani tutaj osobnicy regularnie konsumowali proso (średnia $\delta^{13}C = -17.8$) oraz białko zwierzęce (średnia $\delta^{15}N = 9.5$). Dieta ta wpisuje się w zmienność opisaną dla stanowiska kultury wielbarskiej w Rogowie. Analiza proporcji izotopów strontu ujawniła duże zróżnicowanie między doliną rzeczną (0.7157–0.7264) a sąsiadującą z nią wysoczyzną (0.7109–0.7138). Wartości izotopowe u ludzi były homogeniczne, mieszcząc się w przedziale 0.7113–0.7130. Zmienność wartości obserwowanych u ludzi koresponduje z wartościami notowanymi na wysoczyźnie. Wyniki wskazują, że grupa osób pochowanych w Grzybnicy była małą społecznością, która zdobywała pożywienie na wysoczyźnie. Możliwe, że społeczność ta była zaangażowana w opiekę nad kręgami kamiennymi, a same kręgi mogły być miejscem zgromadzeń lokalnych społeczności. Należy jednak zaznaczyć, że przebadano jedynie około 20 % grobów znalezionych na stanowisku. Brak migrantów może wynikać z niskiej mobilności tej grupy lub ograniczeń metodycznych związanych z postglacjalnym charakterem podłoża geologicznego. Alternatywnie, może to być również wynikiem ograniczeń związanych z badaniem szczątków ciałopalnych, które pozwalają na rekonstrukcję zdarzeń z okresu jedynie około 10 lat wstecz.

Słowa kluczowe: kultura wielbarska, izotopy, dieta, pochodzenie, okres wpływów rzymskich, Polska

Introduction

In the first century AD, the cultural landscape of Central Europe changed. The Wielbark culture emerged from the previous Oksywie culture. This change has long been associated with the arrival of Goths, as mentioned by Jordanes. The people known as Goths and Gepids were supposed to leave the Skandza region in three boats under King Berig, and to arrive in the new lands of Gothiscandza[1], and, indeed, the emergence of a new burial ritual model is present in archaeological sources. This substratum, by merging with the local culture, led to the emergence of the Wielbark culture. Furthermore, recent genetic studies support the migration of at least part of the biological population from Scandinavia to the Polish Lowlands, which coincided with those events.[2]

The Wielbark culture introduces many elements not previously observed in Poland, such as biritual burials, a taboo on equipping the deceased with iron objects (including weapons), and new types of cemeteries, both barrow-like and with stone constructions in the form of circles (Odry-Węsiory-Grzybnica type). The role of the latter remains disputed, as some believe they were places for Tings or tribal assemblies[3]. The presence of such sites could also imply the introduction of new forms of social organization. However, despite many decades of research, our knowledge of those communities remains limited to cemeteries, while settlements have been rarely studied, resulting in a bias toward burial rites, with limited knowledge about subsistence and everyday life.

With the development of isotopic analysis in archaeology, new opportunities arise to study the origins and subsistence of past people, including in research on the Roman Iron Age in Poland. However, the studies conducted for Wiel-

1 Zwolski 1984, 25.
2 Stolarek *et al.* 2023.
3 Kokowski 2007, 49–68; Cieśliński 2016, 217–255.

Fig. 1: Location of the cemetery in Grzybnica.

bark culture cemeteries in Malbork-Wielbark[4], Rogowo[5], Karczyn/Witowy[6], and for individual grave in Bagicz[7], still remain more of an exception than common practice.

The main goal of this paper is to answer questions about the origin and diet of people buried on cemetery with the stone circles at Grzybnica, and to further discuss this within their socio-cultural context. To achieve the goal, analysis of strontium, carbon, and nitrogen isotopes from human remains collected at the cemetery during excavations in the 1970s and 1980s was carried out. Additionally, several modern plant samples were collected to create a local background for the strontium analysis.

Stone constructions in Grzybica

Grzybnica site (54 °04'04.72"N; 16 °26'11.55"E, Fig. 1) is one of the most well-known cemeteries of the Wielbark culture. The cemetery is located in the area of the southern Baltic Pomeranian Coast, on the Białogard Plain[8]. The terrain is formed of a flat moraine plateau, and moraine hills and a subglacial trough with peat accumulation are present. The plateau consists of glacial till and river sands of accumulative terraces, while the subglacial trough is filled with peat. Pleistocene sands, sand deposits, moraine clays, glacial sands and gravels, as well as river sands, gravels, and muds dominate the plain. Holocene sands, gravels, river silts, as well as peat and mud, fill the river valleys[9].

4 Łuczkiewicz *et al.* 2021.
5 Reitsema/Kozłowski 2013.
6 Pośpieszny/Bełka 2015.
7 Chmiel-Chrzanowska/Fetner 2020.
8 Kondradzki 2014, 72.
9 Zielony/Kliczkowska 2010, 200.

Fig. 2: Stones circles in Grzybnica.

Grzybnica cemetery was first described in 1925 by the amateur archaeologist G. Magdaliński. Long-term research in Grzybnica was conducted between 1974 and 1986 by Ryszard Wołągiewicz. Over an area of about 3 hectares, 5 stone circles (Fig. 2), 2 barrows, and 95 flat graves have been identified[10]. In 1979, the archaeological heritage site, the Stone Circles in the Grzybnica Forest was established. The chronological scope of the site, based on the artefacts recovered, covers the phase B2a–B2/C1a Roman Iron Age in Poland (I–III century AD). The purpose of the Grzybnica site remains unclear. On the one hand, the flat part of the site undoubtedly served a funerary function, while on the other hand, the form of the stones strongly resembles with a similar chronology and spatial organisation constructions located in southern Scandinavia, which serve as the Tings, places of courts and meetings.

Isotope studies in archeology

Strontium isotope analysis of bone bioapatite is used to determine the origin of diet and, consequently, the geographic origins of individuals[11]. Strontium isotopes in the environment reflect the composition of the underlying bedrock. Released by water, strontium can be absorbed by plants[12], due to its chemical similarity to calcium[13]. Animals then assimilate strontium from their diets into their bone apatite. Because of negligible isotopic fractionation, the isotopic similarity between their diet and their own tissue is preserved[14].

Cremated bones retain strontium isotopic information relevant to an organism's diet and origin[15]. Analysis of cremated remains typically focuses on bioapatite in long bones, which reflects about the last decade of the individ-

10 Wołągiewicz/Hahuła 2001.

11 Britton 2019.
12 Bentley 2006.
13 Åberg *et al.* 1990.
14 Blum *et al.* 2000.
15 Snoeck *et al.* 2015.

ual's life[16], contrasting with enamel analysis that reflects early life[17]. However, the interpretative scope of cremated remains analysis is narrow as specific biological informations about individuals are often unavailable. Therefore, analyses should ideally be performed at the population level, assuming each sample represents a distinct individual.

Several bioarchaeological studies have been carried out on strontium isotope ratios in the Southern Baltic Sea basin, including in Pomerania[18]. The region's geology has been significantly influenced by successive glaciations, which have transported geological materials across vast distances. This has resulted in a diverse landscape with various forms and timings of sediment deposition, complicating the analysis of strontium isotopes. Notably, there is a marked contrast between the uplands—composed of mixed sediments—and the alluvial flood plains formed during the Holocene[19].

The stable isotope analysis of bone collagen allows for the estimation of an organism's trophic position[20], utilization of marine/aquatic or terrestrial resources[21], consumption of C_3 and C_4 plants[22], and, in some cases, manuring[23] or irrigation[24]. The difference between bone collagen of a consumer and the bulk of consumed proteins is step-wise and well documented[25], and the value of the $\delta^{13}C$ and $\delta^{15}N$ increase with higher position in the trophic chain. Specific food-items can affect the $\delta^{13}C$ and $\delta^{15}N$ values. Terrestrial organisms consuming marine resources, which are rich in heavier carbon isotopes, express higher $\delta^{13}C$ values[26]. Opposite, regular consumption of the freshwater organism usually results in low $\delta^{13}C$ values, as they commonly express values below –20‰[27]. In both cases, consumption of aquatic predators increases the $\delta^{15}N$ values.

The window for the reconstruction is limited by the bone turnover of studied tissue: roots provide information about the time of formation[28], while long bones about years before death of a person[29].

Isotopic studies of the diet in the southern Baltic basin for the Roman Iron Age are limited by the burial customs, where cremation is common. However, some studies allow for an insight in the subsistence. In the Southern Baltic Basin and Central Europe three types of subsistence can be observed (Fig. 5): 1) diet rich in the animal proteins in the coastal zone e. g. Bagicz[30] and Slusegård[31]; 2) further inland communities consuming significant amount of millet, e. g. Rogowo[32], and 3) relying chiefly on the C_3 plants with low, if any, consumption of millet, like many sites in Lithuania[33], and in Cracow Upland[34].

Material and Methods

The analysis concentrated on 22 burials (20 cremated and 2 uncremated inhumations) unearthed in the flat cemetery in proximity to the stone circles at Grzybnica (Fig. 3). Samples were selected for radiocarbon dating, carbon and nitrogen stable isotope analysis, and strontium isotope analysis. The final analysis was completed with 12 samples of modern plants from the vicinity of the site, collected to establish a local baseline for strontium isotope values.

Originally, it was planned to perform the analysis based on bones obtained from inhumation graves. However, the condition of the bone material did not allow for this approach. Consequently, we were decided to base the considerations on cremation burials, selecting the most representative ones. The main criterion for selecting samples was the preservation condition of the bone material. For analysis, graves where the bone mass exceeded 100 grams were chosen. The chronology of the burials was also considered, where possible. While keeping in mind that the long bones used in the study would allow for determining the potential migration of the cemetery users only within a perspective of about 10 years. On the other hand, this approach allowed for determining the area that was used by the group burying their dead on the cemetery at Grzybnica.

Six samples, from 4 cremated and 2 uncremated inhumations, were subject to radiocarbon dating at the Poznań Radiocarbon Laboratory, Adam Mickiewicz University, Poznań, Poland. Cremated human remains were dated using the protocol described by Lanting and colleagues[35],

16 Fahy *et al.* 2017.
17 Hillson 2005.
18 Chmiel-Chrzanowska/Fetner 2020; Pośpieszny/Bełka 2015; Łuczkiewicz *et al.* 2022; Price *et al.* 2012.
19 Łuczkiewicz *et al.* 2022; Bełka *et al.* 2019.
20 Koch 2008.
21 Schoeninger/DeNiro 1984.
22 Marshal *et al.* 2008; Pyankov *et al.* 2010.
23 Bogaard *et al.* 2007.
24 Wallace *et al.* 2013.
25 cf. Szpak *et al.* 2012.
26 e. g., Orton *et al.* 2011.
27 e. g., Fetner/Iwaszczuk 2021.
28 Hillson 2005.
29 Fahy *et al.* 2017.
30 Chmiel-Chrzanowska/Fetner 2020.
31 Jørkov *et al.* 2010, 2.
32 Reitsema/Kozłowski 2013.
33 Simčenka *et al.* 2023.
34 Wojenka *et al.* 2023.
35 Lanting *et al.* 2001

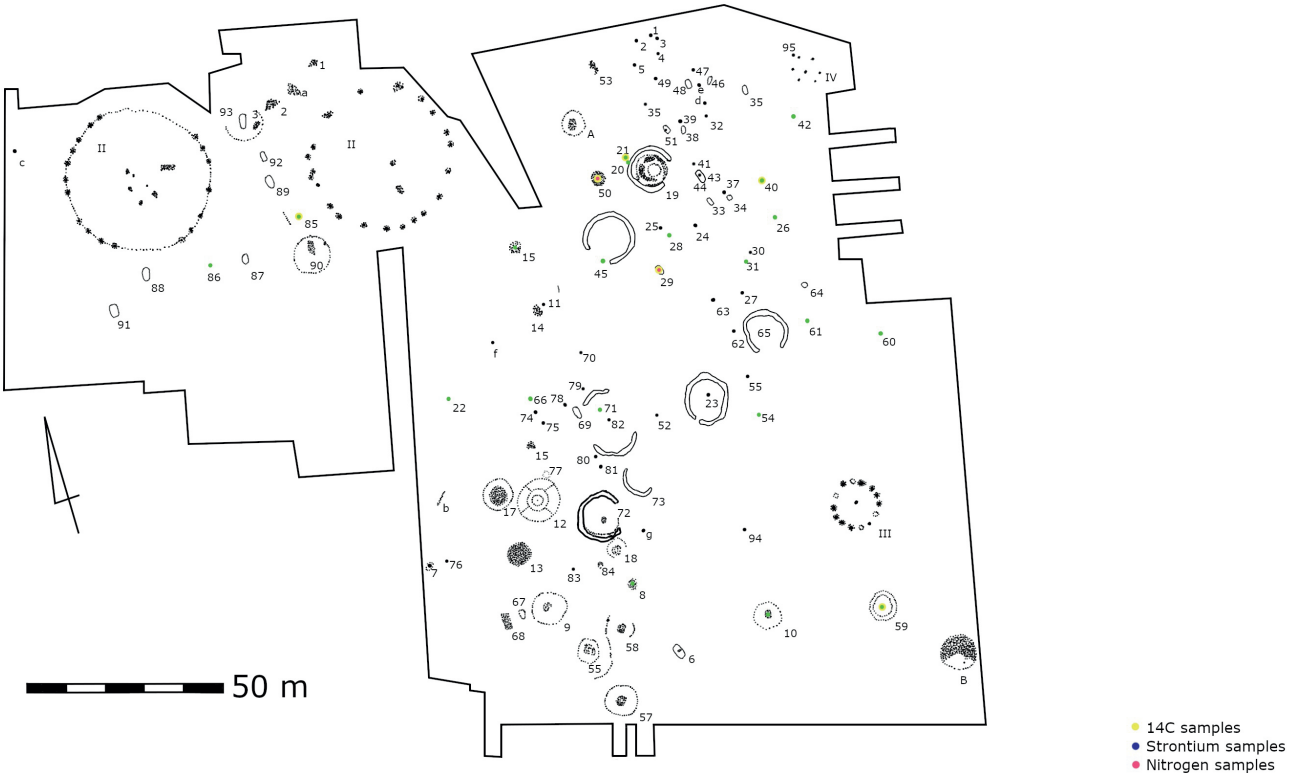

Fig. 3: Plan of Grzybnica with isotopic sampling locations marked.

while the dentine underwent collagen extraction following the method of Longin with modifications[36]. Samples were radiocarbon dated using an Accelerator Mass Spectrometer. The radiocarbon dates obtained were calibrated using OxCal 4.4.2[37] and IntCal20[38].

The extracted collagen was also subjected to carbon and nitrogen stable isotope analysis. Samples were transferred to the Stable Isotope Laboratory, Institute of Geological Sciences Polish Academy of Sciences (Warsaw, Poland), and measured for the $\delta^{13}C$ and $\delta^{15}N$ stable isotopes ratios using Flash 1112 HT EA and ConFloIV peripheral devices (Thermo Scientific) coupled to Delta V Advantage IRMS (Thermo Scientific) against IAEA 600, USGS 40, and USGS 41a standard materials. The measurement precision (1σ) and reproducibility were generally better than ±0.1‰ for $\delta^{13}C$ and ±0.3‰ for $\delta^{15}N$, respectively. To calculate the C/N ratio, the same standards were used, and the C/N ratio was estimated with an accuracy of ±0.1.

A total of 32 samples were subject to strontium isotope analysis: 20 fragments of cremated human remains and 12 modern plants. Human remains were selected from 20 separate burials, and are assumed to represent different individuals. Well-burned (white) samples of thick cortical bone were selected and transferred to the Isotope Laboratory of the Adam Mickiewicz University in Poznań, Poland. Samples were prepared according to the protocol described in Łuczkiewicz and colleagues[39], and analysed using a Finnigan MAT 261 mass spectrometer, against NBS 987 standard material. The $^{87}Sr/^{86}Sr$ values were corrected to $^{86}Sr/^{88}Sr$ = 0.1194, and normalised to NIST-987 = 0.710240.

Results

Radiocarbon dating using the AMS method was applied to six samples from graves, two of which were characterized as skeletal, and the others as cremation burials (graves 21, 29, 40, 50, 59, 85). The results are presented in the Tab. 1 and Fig. 4.

Radiocarbon dating corresponds with the archaeological dating of the cemetery. There are no traces indicating a reservoir effect. The results for grave 40 suggest that this

36 Piotrowska/Goslar 2002.
37 Bronk Ramsey 2020.
38 Reimer *et al.* 2020.
39 Łuczkiewicz *et al.* 2022.

Tab. 1: Radiocarbon dating of samples from the Grzybnica cemetery, calibrated using OxCal v4.4.2 (Bronk Ramsey 2009) and IntCal20 (Reimer *et al.* 2020), laboratory: Poznań Radiocarbon Laboratory, Poznań, Poland.

Grave number	Type of material	Type of grave	Laboratory number	Date	Calibration
21	bone	Cremation	Poz-164961	1965±30	1 BC – 126 AD cal at 85.7 %
29	bone	Inhumation	Poz-164962	1985±35	46 BC – 121 AD cal at 95.4 %
40	bone	Cremation	Poz-164963	2005±30	53 BC – 84 AD cal at 92.1 %
50	tooth	Inhumation	Poz-163206	2030±35	120 BC – 77 AD cal at 93.1 %
59	bone	Cremation	Poz-163207	1950±30	4 AD – 132 AD cal at 87.4 %
85	bone	Cremation	Poz-164960	1930±30	22 AD – 206 AD cal at 95.4 %

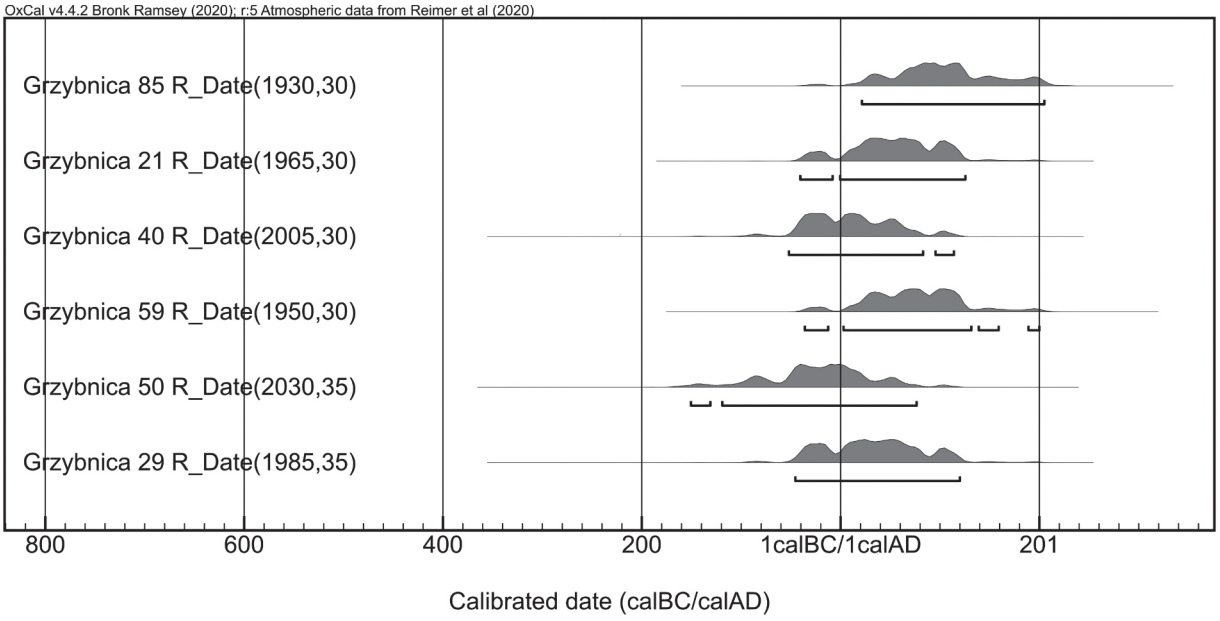

Fig. 4: Grzybnica cemetery, calibrated using OxCal v4.4.2 (Bronk Ramsey 2009) and IntCal20 (Reimer *et al.* 2020), laboratory: Poznań Radiocarbon Laboratory, Poznań, Poland.

must have been one of the first individuals buried in this cemetery.

Carbon and nitrogen stable isotope data were obtained for two individuals, one from grave 29 ($\delta^{13}C$ = –17.95; $\delta^{15}N$ = 9.93, C/N ratio = 3.34; archaeological dating – early Roman Iron Age), and one from grave 50 ($\delta^{13}C$ = –17.68; $\delta^{15}N$ = 9.15; C/N ratio = 3.18; archaeological dating – B2a). Compared to other communities from the Roman Iron Age in Central Europe and Southern Baltic, the two individuals from Grzybnica are consistent with the isotopic variation of individuals from Rogowo (Fig. 5).

The distribution of strontium isotope ratio values ($^{87}Sr/^{86}Sr$) is presented in Fig. 6 and Tab. 2. Plants growing on Holocene formations covering river meadows, peat bogs, and muds, show values between 0.7174 and 0.7216 (3 measurements). Plants collected in the floodplain (including in the vicinity of the burial ground), growing on sands, gravels, and river muds, show values ranging from 0.7157 to 0.7264 (7 measurements). Plants collected in the upland, growing on glacial deposits brought during the Vistulian glaciation, show values of 0.7109 and 0.7138 (two measurements). Based on the results of strontium isotope ratios, two zones can be distinguished: the river channel and floodplain with values between 0.7157 and 0.7264, and the upland with values between 0.7109 and 0.7138. The results for human remains vary between 0.7113 and 0.7130, and can be attributed to values observed for the local uplands.

Discussion

Studied group creates isotopically homogenous group dated to first two centuries of the first millenium CE. An interesting situation can be observed in the case of burial 40, located in the flat part of the cemetery. Radiocarbon dating

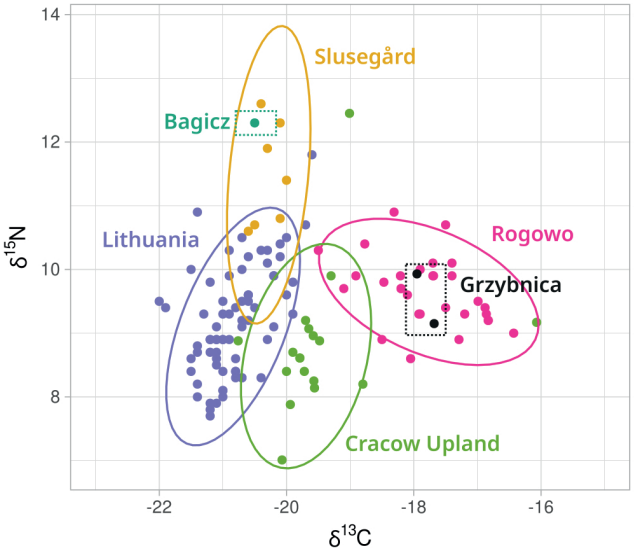

Fig. 5: Distribution of the carbon and nitrogen stable isotope values from sites dated to the Roman Influence Period and Migration Period in Central Europe and Southern Baltic Basin (Data after: Chmiel-Chrzanowska/Fetner 2020; Jørkov *et al.* 2010; Reitsema/Kozłowski 2013; Simčenka *et al.* 2023; Wojenka *et al.* 2023).

ranges from 53 BC to 84 AD (Poz-164963; 92,1 % of probability), and the beginning of the cemetery's use dates back to the period 80–110/120 AD. The long bone was used for dating, so the date is synonymous with the time of the woman's death. Therefore, it can be assumed that the adult woman buried in grave 40 must have been one of the first users of the cemetery in Grzybnica. The isotopic signature of the deceased also shows a relatively high degree of radiogenicity, but it does not deviate significantly from the levels of the surrounding environment.

The skeletal grave 29 is dated, based on its artefacts, to the B2a phase (80–110/120 AD) of the Roman Iron Age, which aligns well with the ^{14}C results. The situation becomes more complex for burial 50. It is also dated to the B2a phase, but radiocarbon dating indicates an older chronology, even when considering dates with a lower probability (Tab.1 and Fig. 4). It should be noted that a tooth was used as material for the ^{14}C study. This means that the result provides the date of tooth formation. Permanent teeth do not undergo remodeling during life[40]. Anthropological analysis conducted by F. Rożnowski indicated a woman of old age, that is, older than 50 years[41]. Therefore, the date is consistent with the dating obtained using artefacts.

Other burials included in the ^{14}C analysis were generally dated to the Roman Period, and radiocarbon dating provided specific dates. The radiocarbon dating results correspond to the archaeological dating of the cemetery and align with its operational phases. No deviations were observed that could indicate the influence of a potential reservoir effect, as was seen, for example, in case of the Bagicz Woman[42].

At this point, any interpretation of human diet is challenging. The lack of animal remains that can serve as a reference for diet reconstruction makes any interpretation tentative. The only way is to ascribe these two individuals to known groups operating in the region, whose diet is isotopically recognised.

Two individuals from Grzybnica (graves 29 and 50) present evidence for the diet observed among individuals from the Kuyavia region[43], but not with a female from Bagicz (ca. 50 km. away), whose diet resembles the dietary practices of the Baltic coast populations[44], here represented by the group from Slusegård, Bornholm[45]. In both Grzybnica and Bagicz, samples come from dental roots and represent early stages of life[46], hence age-based differences in diet have to be ruled out. This result raises a question about the variation in subsistence practices in Pomerania, and among Wielbark communities in general. This is a very challenging question, as the recognition of Wielbark culture settlements is limited, allowing only for general observations. Studies on plant macro remains from known Roman Iron Age sites, including in Pomerania, show a domination of barley and millet in the assemblages[47], supporting the biochemical observation.

The other isotopically recognized groups from Central Europe present lower carbon isotope ratio values. As for sites in Lithuania, this can be explained by the decreasing importance of millet in Baltic communities in the Roman Iron Age, as, further north, the thermal conditions for cultivating millet are more difficult to meet. In the Cracow Upland, millet is abundant[48], but despite that, humans found in the caves of the Cracow Upland do not show values typical for millet consumption[49].

The provenience of diet, studied by the strontium isotopes, advocates for its local origin. The human isotopic ratios observed at Grzybnica fall within the variation observed for local uplands, advocating for their local diet in the last decade of their lives. Hence, no traces of migration were observed. However, considering the nature of the

40 Hillson 2005.
41 Rożnowski 2001, 74.
42 Chmiel-Chrzanowska/Fetner 2020.
43 Reitsema/Kozłowski 2013.
44 Chmiel-Chrzanowska/Fetner 2020.
45 Jørkov *et al.* 2010.
46 Chmiel-Chrzanowska/Fetner 2020.
47 Lityńska-Zając 1997
48 Lityńska-Zając 1997.
49 Wojenka *et al.* 2023.

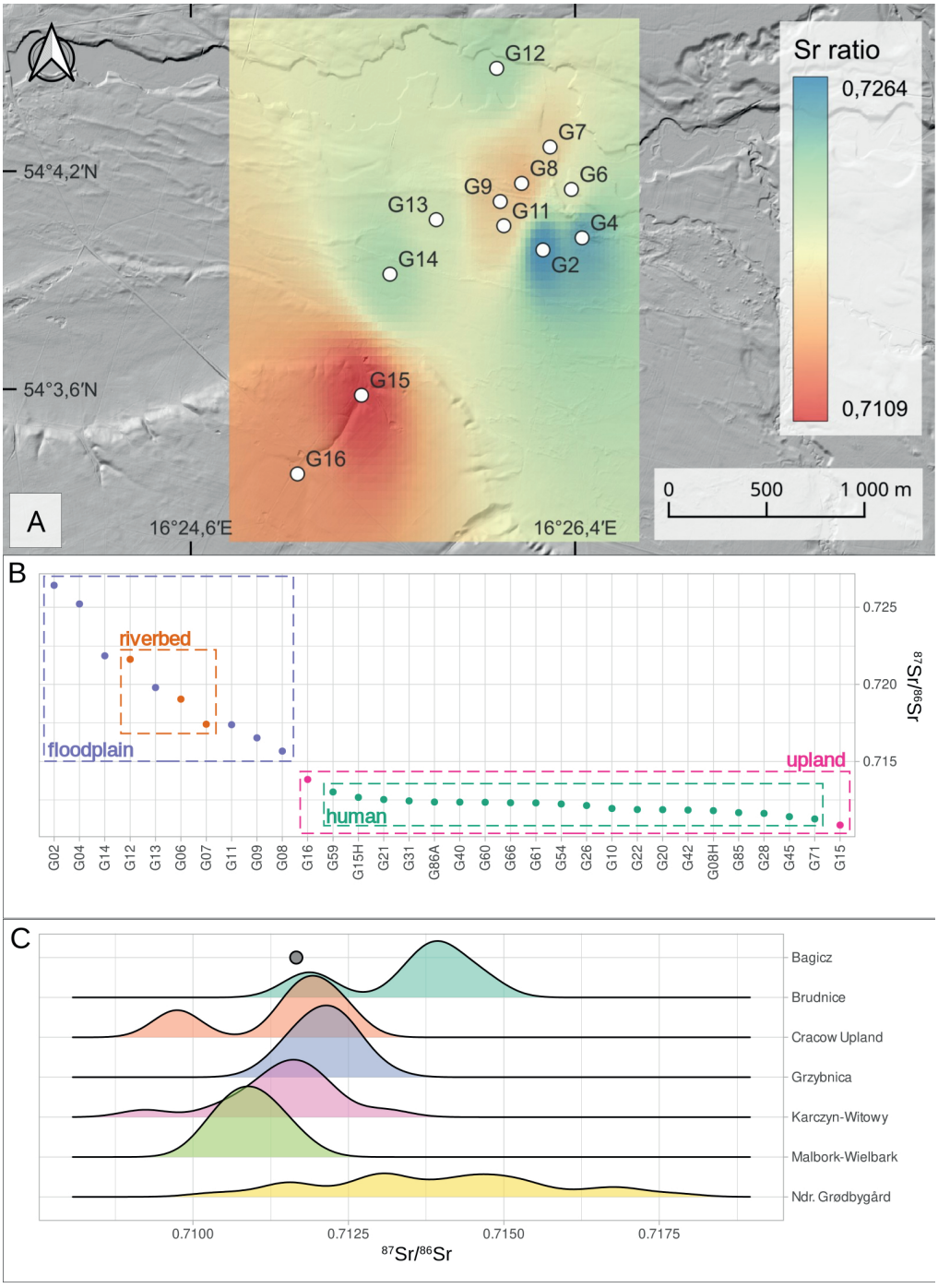

Fig. 6: Distribution of strontium isotope values: A) modern plants in the proximity of the Grzybnica site; B) results of the samples (plants and humans) measured in the study; C) variation of human remains values in the Roman Iron Age sites in Central Europe (Data after: Chmiel-Chrzanowska/Fetner 2020; Szela 2021; Wojenka *et al.* 2023; Pośpieszny/Bełka 2015; Łuczkiweicz *et al.* 2022; Price *et al.* 2012).

studied samples, bone bioapatite, the possibility of migration studies is limited to the last decade of an individual's life. These results do not definitively rule out the possibility of non-local origins for at least some of the individuals.

Firstly, individuals originating from regions with similar strontium values would be indistinguishable. Moreover, when compared with other Roman Iron Age sites in Poland, all sites share at least some similarity with Grzybnica (Fig 6.C), making migrations from these communities difficult to detect. Certain values observed among individuals buried at Grzybnica have been attributed to migrants from Scandinavia, as seen in the case of a medieval burial

Tab. 2: Results of $^{87}Sr/^{86}Sr$ isotope analysis (laboratory: AMU Isotope Laboratory, Poznań, Poland). Data on age-at-death and sex after Rożnowski (Rożnowski 2001).

Sample/grave number	Age/sex	Chronology	Sample type	Location	Substrate	87Sr/86Sr value
G02	-	-	plant	54.066389N; 16.437500E	sand and silt	0.72642
G04	-	-	plant	54.066944N; 16.440556E	sand and silt	0.72521
G06	-	-	plant	54.069167N; 16.439722E	peat and sand	0.71904
G07	-	-	plant	54.071111N; 16.438056E	peat and sand	0.71741
G08	maturus/female	RP	bone	cemetery		0.71181
G08	-	-	plant	54.069444N; 16.435833E	sand and silt	0.71567
G09	-	-	plant	54.068611N; 16.434167E	sand and silt	0.71653
G10	juvenis/female	B2c	bone	cemetery		0.71195
G11	-	-	plant	54.067500N; 16.434444E	sand and silt	0.7138
G12	-	-	plant	54.074722N; 16.433889E	peat and sand	0.72162
G13	-	-	plant	54.047778N; 16.429167E	sand and silt	0.71979
G14	-	-	plant	54.065278N; 16.425556E	sand and silt	0.72185
G15	-	-	plant	54.059722N; 16.423333E	till and sand	0.71087
G15	adultus (20–30)/male	?	bone	cemetery		0.71267
G16	-	-	plant	54.056111N; 16.418333E	till and sand	0.71383
G20	adult	80–110/120	bone	cemetery		0.71187
G21	maturus (35–40)/male	1 BC–126 AD	bone	cemetery		0.71253
G22	adult	?	bone	cemetery		0.71188
G26	maturus (30–40)/male	RP	bone	cemetery		0.71214
G28	adult	?	bone	cemetery		0.71163
G31	adult	RP	bone	cemetery		0.71244
G40	adultus (20–30)/female	53 BC–84 AD	bone	cemetery		0.71236
G42	adultus (20–30)/female	?	bone	cemetery		0.71185
G45	adult	RP	bone	cemetery		0.71142
G54	adultus (20–30) female	RP	bone	cemetery		0.71224
G59	juvenis/female	4 AD–132 AD	bone	cemetery		0.71302
G60	matures (30–40)/male	80–110/120 AD	bone	cemetery		0.71235
G61	matures (30–40)/male	80–160 AD	bone	cemetery		0.71231
G66	adultus (20–30) male	?	bone	cemetery		0.71232
G71	maturus (30–40)/male	?	bone	cemetery		0.71127
G85	maturus (40–50)/female	22–206 AD	bone	cemetery		0.71168
G86A	maturus (40–50)/male	170–220 AD	bone	cemetery		0.71237

from Ciepłe[50]. While this claim cannot be conclusively rejected, the local variation in bioavailable strontium reduces its likelihood.

Secondly, the group appears homogeneous in terms of strontium values, indicating a common dietary source of calcium/strontium, likely sourced from the upland area. It is plausible that they cultivated fields and exploited woods in these areas. Such distribution of strontium isotopic values supports the hypothesis of local residency among these individuals. Therefore, while the birthplaces of the studied individuals remain undetermined, leaving open the possibility of migration at various points earlier during their lives, those results suggest the presence of a stable community utilising this cemetery.

When considering diet as an indicator of affiliation, it is noteworthy that two members of this community exhibit a diet commonly observed among members of the Wielbark community at Rogowo[51], and distinct from Northern communities (e. g., Slusegård[52]). It remains uncertains whether these results can be extrapolated to cremated members of the group. Nonetheless, this study suggests that, biochemically, both cremated and non-cremated groups can be associated with the Roman Iron Age communities of Poland.

Among the findings, grave 59, situated under a stone wreath, contains the remains of an adult woman aged between 20 and 30 years, as indicated by F. Rożnowski[53]. Radiocarbon dating places the burial between 4–132 AD.

50 Bełka *et al.* 2019.

51 Reitsema/Kozłowski 2013.

52 Jørkov *et al.* 2010.

53 Rożnowski 2001, 74.

The strontium ratio for the deceased is 0.713023, closely resembling that of burial 45 ($^{87}Sr/^{86}Sr$ = 0.7130) from an Early Medieval cemetery in Ciepłe. Scholars suggest a potential Scandinavian origin for the individual in grave 45 in Ciepłe, due to a similar environmental radiogenicity observed in central and eastern Scandinavia and the Czech Massif[54]. Although grave 59 in Grzybnica initially suggests a Scandinavian origin based on radiocarbon dating, isotopic signature, and burial context, the environmental signature of Grzybnica indicates a high level of radiogenicity, consistent with the strontium signature of the deceased from grave 59.

Wielbark communities are known for their migrations, earlier from Scandinavia to Central Europe and later to the Black Sea shores[55]. Despite that, the migration pattern is difficult to trace. The strontium measurements from the Malbork-Wielbark cemetery indicate a local population[56]. Grzybnica exhibits significantly higher radiogenicity than Malbork-Wielbark, and, without strontium measurements from plants surrounding the cemetery, some individuals in Grzybnica might have been mistaken for Scandinavian migrants. Currently, the results of strontium isotope analysis do not clearly identify migrants among Wielbark communities.

Studies of Grzybnica do not preclude the possibility of migration. It is conceivable that new cultural influences reached the population through direct interactions[57]. The region's glacial history implies that its high radiogenicity could result from glacial transport, potentially masking evidence of migration from Scandinavia in strontium analysis. Consequently, distinguishing potential migrants from the local population may be challenging.

The analysis only included remains from 20 out of 101 graves, representing ca. 20 % of the total burials. While this sample is likely representative, it is possible that including strontium isotope ratios from the remaining graves could affect the findings, given the small size of the population in Grzybnica. Considering potential migrations and cultural disruptions, the cemetery likely served no more than 30 individuals, indicating migration from Scandinavia might have involved small groups[58]. Moreover, only 8 burials are dated to the B2a period, the earliest phase of cemetery use, and approximately 70 % of graves remain undated archaeologically[59]. This raises concerns about whether isotopic studies could accurately target an appropriate sample.

The Grzybnica cemetery interred a total of 101 individuals over approximately 150 years, suggesting a small and insular local population, with no apparent traces of immigrants in the strontium results. This observation is particularly intriguing given the assumed function of the stone circles in Grzybnica as assembly places (Ting). The significant labour required to construct these circles raises questions about whether other groups also used the cemetery, given its potential extra-funerary purpose. Research indicates that graves beneath the circle constructions are secondary and relatively poorly equipped, interpreted as sacrifices during gatherings[60]. Alternatively, it is proposed that the cemetery served as a meeting place maintained by individuals from a broader community[61]. Regular ritual practices may have been conducted at sites with stone circles, suggesting a stable settlement nearby, visited by various groups who, along with the local "Grzybnicka group", formed a broader community.

Conclusions

Stone circles represent a novel concept absent in the Oksywie culture. Their purpose remains a subject of academic debate. The isotopic analysis of human remains from Grzybnica revealed that members of the local sedentary community were interred in proximity to the stone circles. However, the findings of strontium isotopic analysis leave some room for the non-local origin of these individuals, as the window for residency reconstruction is limited to the last decade of their lives. An examination of diet is constrained by the limited number of subjects studied, but compared to other sites from this period, it suggests the existence of variation in the subsistence practices of Wielbark communities, warranting further investigation.

To comprehensively understand the transmission of the innovative concept embodied by stone circles, and the communities associated with these structures, similar analyses to those conducted at the Grzybnica cemetery should be undertaken for each known complex. Presently, six extensively excavated sites featuring such constructions are known in Poland: Odry[62], Węsiory[63], Grzybnica[64], Babi Dół-Borcz[65] and Leśno[66], although it is probable that more

54 Bełka *et al.* 2019, 443.
55 Cieśliński 2016.
56 Łuczkiewicz *et al.* 2022.
57 Ibid. 12.
58 Kokowski 2007, 56.
59 Wołągiewicz/Hahuła 2001, 58.
60 Kokowski 2007, 60.
61 Wołągiewicz 1977, 57–61.
62 Kmieciński 1968; Grabarczyk 1997.
63 Kmieciński *et al.* 1966.
64 Wołągiewicz/Hahuła 2001.
65 Mączyńska/Urbaniak 2007.
66 Walenta 2009.

originally existed. These sites, sometimes separated by distances exceeding 100 km, exhibit comparable chronological parameters. The recent discovery of a site in Pławno holds promise for fresh insights[67]. Hence, it is hoped that new research will soon emerge.

Acknowledgement: The paper is funded by National Science Centre in Poland under the project "Miniatura 5", no UMO-2021/05/X/HS3/00770.

References

Åberg *et al.* 1990: G. Åberg/G. Jacks/T. Wickman/P. J. Hamilton. Strontium Isotopes in Trees as an Indicator for Calcium Availability. CATENA 17, 1990, 1–11. https://doi.org/10.1016/0341-8162(90)90011-2.

Bełka *et al.* 2019: Z. Bełka/J. Dopieralska/S. Królikowska-Ciągło/Z. Ratajczyk/S. Wadyl, Pochodzenie w świetle badan składu izotopowego strontu biogenicznych fosforanów. In: S. Wadyl (ed.), Ciepłe. Elitarna nekropola wczesnośredniowieczna na Pomorzu Wschodnim (Gdańsk 2019) 439–447.

Bentley 2006: R. A. Bentley, Strontium Isotopes from the Earth to the Archaeological Skeleton: A Review. Journal of Archaeological Method and Theory 13, 2006, 135–187.

Blum *et al.* 2000: J. D. Blum/E. H. Taliaferro/M. T. Weisse/R. T. Holmes, Changes in Sr/Ca, Ba/Ca and 87Sr/86Sr Ratios between Trophic Levels in Two Forest Ecosystems in the Northeastern U. S. A. Biogeochemistry 49, 2000, 87–101. https://doi.org/10.1023/A:1006390707989.

Bogaard *et al.* 2007: A. Bogaard/T. H. E. Heaton/P. Poulton/I. Merbach. The Impact of Manuring on Nitrogen Isotope Ratios in Cereals: Archaeological Implications for Reconstruction of Diet and Crop Management Practices. Journal of Archaeological Science 34, 2007, 335–343. https://doi.org/10.1016/j.jas.2006.04.009.

Britton 2019: K. Britton, Isotope Analysis for Mobility and Climate Studies. In: M. Richards/K. Britton (ed.), Archaeological Science (Cambridge 2019) 99–124. https://doi.org/10.1017/9781139013826.005.

Bronk Ramsey 2009: C. Bronk Ramsey, Bayesian analysis of radiocarbon dates, Radiocarbon 51(1), 2009, 337–360.

Chmiel-Chrzanowska/Fetner 2020: M. Chmiel-Chrzanowska/R. Fetner: The Story of one Woman – New Bioarchaeological Data on the Interpretation of a Roman Iron Age Grave in a Log Coffin from Bagicz (woj. zachodniopomorskie/PL). Archäologisches Korrespondenzblatt 50(3), 2020, 371–386.

Cieśliński 2016: A. Cieśliński, The society of Wielbark culture, AD 1–300. In: A. Rzeszotarska-Nowakiewicz (ed.), The Past Societies. Polish lands from the first evidence of human presence to the Early Middle Ages. 500 BC–500 AD, 4 (Warszawa 2016) 217–255.

Fahy *et al.* 2007: G. E. Fahy, Bone deep: Variation in stable isotope ratios and histomorphometric measurements of bone remodelling within adult humans. Journal of Archaeological Science 87, 2007, 10–16. https://doi.org/10.1016/j.jas.2017.09.009.

Fetner 2021: R. Fetner/U. Iwaszczuk, Isotopic evidence of possible long-distance freshwater fish trade in the 13th to 14th century Chełm, modern Poland. International Journal of Osteoarchaeology 31, 2021, 135–145. https://doi.org/10.1002/oa.2931.

Grabarczyk 1997: T. Grabarczyk, Kultura wielbarska na Pojezierzach Krajeńskim i Kaszubskim, (Łódź 1997).

Hillson 2005: S. Hillson, Teeth (Cambridge 2005).

Jørkov *et al.* 2010: M. L. Jorkov/S. L. Jørgensen/N. Lynnerup, Uniform Diet in a Diverse Society. Revealing New Dietary Evidence of the Danish Roman Iron Age Based on Stable Isotope Analysis. American Journal of Physical Anthropology 143(4), 2010, 523–533. https://doi.org/10.1002/ajpa.21346.

Kasprzak 2017: A. Kasprzak, Cmentarzysko kurhanowe z kręgami kamiennymi w Pławnie, pow. drawski – wstępne wyniki badań. In: J. Andrzejowski/C. von Carnap-Bornheim/A. Cieśliński/B. Kontny (eds), Orbis barbarorum. Studia ad archaeologiam Germanorum et Baltorum temporibus Imperii Ro mani pertinentia Adalberto Nowakowski dedicata (Warszawa, Schleswig 2017) 383–392.

Kmieciński 1968: J. Kmieciński, Odry cmentarzysko kurhanowe z okresu rzymskiego w powiecie chojnickim. Acta Archaeologica Lodziensia 15, 1968.

– *et al.* 1966: –/M. Blombergowa/K. Walenta, Cmentarzysko kurhanowe ze starszego okresu rzymskiego w Węsiorach w pow. Kartuskim. Prace i Materiały Muzeum Archeologicznego i Etnograficznego w Łodzi. Seria Archeologiczna 12, 1966.

Koch 2008: P. L. Koch, Isotopic Study of the Biology of Modern and Fossil Vertebrates. In: R. Michener/K. Lajtha (eds), Stable Isotopes in Ecology and Environmental Science (Malden, Oxford 2008) 99–154, https://doi.org/10.1002/9780470691854.ch5.

Kokowski 2007: A. Kokowski, Goci. Od Skandzy do Campi Gothorum (Warszawa 2005).

Kondradzki 2014: J. Kondradzki, Geografia Polski. Mezoregiony fizyczno-geograficzne (Warszawa 2014).

Lanting *et al.* 2001: J. N. Lanting/A. T. Aerts-Bijma/J. van der Plicht, Dating of Cremated Bones, Radiocarbon 43, 2001, 249–254. https://doi.org/10.1017/S0033822200038078.

Lityńska-Zając 1997: M. Lityńska-Zając, Roślinność i Gospodarka Rolna w Okresie Rzymskim. Studia Archeobotaniczne (Kraków 1997).

Longin 1971: R. Longin, New Method of Collagen Extraction for Radiocarbon Dating. Nature 230, 1971, 241–242. https://doi.org/10.1038/230241a0.

Łuczkiewicz *et al.* 2022: P. Łuczkiewicz/Z. Bełka/S. Łukasik/M. Krenz-Niedbała/A. Kuzioła/J. Kleemann, Elusive Goths in northern Poland: Initial isotopic insights of the pre-Roman and Roman period populations from the Wielbark Culture cemetery in Malbork-Wielbark. Praehistorische Zeitschrift 97(2), 2022, 2–15. https://doi.org/10.1515/pz-2022-2030.

Magdalinski 1925: G. Magdalinski, Steinkreise. Unsere Heimat. Beilage zur Kösliner Zeitung (Köslin), 3, März.

Marshall *et al.* 2008: J. D. Marshall/J. R. Brooks/K. Lajtha. Sources of Variation in the Stable Isotopic Composition of Plants. In: R. Michener/K. Lajtha (eds), Stable Isotopes in Ecology and Environmental Science (Malden, Oxford 2008) 22–60. https://doi.org/10.1002/9780470691854.ch2.

Mączyńska/Urbaniak 2007: M. Mączyńska/A. Urbaniak, Babi Dół – Borcz, pow. Kartuzy, stan. 2. Badania z okresu rzymskiego w latach 1993–2003. Acta Universitatis Lodziensis, Folia Archaeologica 25, 2007, 25–49.

Orton *et al.* 2011: D. C. Orton/D. Makowiecki/T. de Roo/C. Johnstone/J. Harland/L. Jonsson/D. Heinrich, *et al.*, Stable Isotope Evidence for Late Medieval (14th–15th C) Origins of the Eastern Baltic Cod (Gadus

67 Kasprzak 2017.

Morhua) Fishery. PLOS ONE 6, 2011, e27568. https://doi.org/10.1371/journal.pone.0027568.

Piotrowska/Goslar 2002: N. Piotrowska/T. Goslar, Preparation of bone samples in the Gliwice Radiocarbon Laboratory for AMS radiocarbon dating. Isotopes in environmental and health studies 38, 2002, 267–275. https://doi.org/10.1080/10256010208033272.

Pośpieszny/Bełka 2015: Ł. Pośpieszny/Z. Bełka, Dieta i mobilność u schyłku starożytności. Szczątki ludzkie z cmentarzyska w Karczynie/Witowach stan. 21/22 w świetle badań izotopowych. In: J. Bednarczyk/A. Romańska (eds), Karczyn/Witowy stan. 21/22. Birytualne cmentarzysko kultury przeworskiej z Kujaw. Studia i Materiały do Dziejów Kujaw 12 (Poznań, Inowrocław 2015) 179–195.

Price *et al.* 2012: T. D. Price/M. Naum/P. Bennike/N. Lynnerup/K. M. Frei/H. Wagnkilde/T. Pind/F. O. Nielsen, Isotopic investigation of human provenience at the eleventh century cemetery of Ndr. Grødbygård, Bornholm, Denmark. Danish Journal of Archaeology 1, 2012, 93–112. https://doi.org/10.1080/21662282.2013.798903.

Pyankov *et al.* 2010: V. I. Pyankov/H. Ziegler/H. Akhani/C. Deigele/U. Lüttge, European Plants with C4 Photosynthesis: Geographical and Taxonomic Distribution and Relations to Climate Parameters. Botanical Journal of the Linnean Society 163, 2010, 283–304. https://doi.org/10.1111/j.1095-8339.2010.01062.x.

Reimer *et al.* 2020: P. J. Reimer *et al.* The IntCal20 Northern Hemisphere radiocarbon age calibration curve (0–55 cal kBP). Radiocarbon 62.4, 2020, 725–757.

Reitsema/Kozłowski 2013: L. J Reitsema/T. Kozłowski, Diet and society in Poland before the state: stable isotope evidence from a Wielbark population (2nd c. AD). Anthropological Review 76(1), 2013, 1–22.

Richards 2020: M. P. Richards, Isotope Analysis for Diet Studies. In: K. Britton/M. P. Richards (eds), Archaeological Science: An Introduction, (Cambridge 2020) 125–144. https://doi.org/10.1017/9781139013826.006.

Rożnowski 2001: F. Rożnowski, Ergebnisse der anthropologischen Untersuchungen. In: R. Wołągiewicz/K. Hahuła (eds), Grzybnica. Ein Gräberfeld der Wielbark-Kultur mit Steinkreisen in Pommern. Monumenta Archaeologica Barbarica VIII (Warszawa, Koszalin 2001) 73–75.

Schoeninger/DeNiro 1984: M. J. Schoeninger/M. J. DeNiro, Nitrogen and Carbon Isotopic Composition of Bone Collagen from Marine and Terrestrial Animals. Geochimica et Cosmochimica Acta 48, 1984, 625–639. https://doi.org/10.1016/0016-7037(84)90091-7.

Simčenka *et al.* 2023: E. Simčenka/L. Kurila/J. Kozakaite/G. Piličiauskiene, Human diet in Lithuania during Late Roman and Migration periods (ca. 200–700 AD) based on stable carbon and nitrogen isotope data. Archaeologia Baltica 30, 2023, 80–115.

Snoeck *et al.* 2015: C. Snoeck/J. Lee-Thorp/R. Schulting/J. de Jong/W. Debouge/N. Mattielli, Calcined bone provides a reliable substrate for strontium isotope ratios as shown by an enrichment experiment. Rapid Communications in Mass Spectrometry 29, 2015, 107–114. https://doi.org/10.1002/rcm.7078.

Stolarek *et al.* 2023: I. Stolarek/M. Zenczak/L. Handschuch/A. Juras/M. Marcinkowska-Swojak/A. Spinek/A. Dębski/M. Matla/H. Kóčka-Krenz/J. Piontek/M. Figlerowicz, Genetic history of East-Central Europe in the first millennium CE. Genome Biology 24, 2023, 173. https://doi.org/10.1186/s13059-023-03013-9.

Szela 2021: A. Szela, Brudnice stanowisko V. Nekropola kultury przeworskiej ze środka pustki osadniczej (Warszawa 2021).

Szpak *et al.* 2012: P. Szpak/T. J. Orchard/I. McKechnie/D. R. Gröcke. Historical Ecology of Late Holocene Sea Otters (Enhydra Lutris) from Northern British Columbia: Isotopic and Zooarchaeological Perspectives. Journal of Archaeological Science 39, 2012, 1553–1571. https://doi.org/10.1016/j.jas.2011.12.006.

Walenta 2009: K. Walenta, Leśno i mikroregion w okresie rzymskim (Chojnice 2009).

Wallace *et al.* 2013: M. Wallace/G. Jones/M. Charles/R. Fraser/P. Halstead/T. H. E. Heaton/A. Bogaard. Stable Carbon Isotope Analysis as a Direct Means of Inferring Crop Water Status and Water Management Practices. World Archaeology 45, 2013, 388–409. https://doi.org/10.1080/00438243.2013.821671.

Wojenka *et al.* 2023: M. Wojenka/B. Kontny/M. Przybyła/A. Szczepanek /E. Jaskulska/Z. Bełka/R. Fetner, Cave Funeral Practices During the Roman and Migration Periods in the Cracow Upland, Southern Poland. Journal of Archaeological Science: Reports 52 (December): 104250. https://doi.org/10.1016/j.jasrep.2023.104250.

Wołągiewicz 1997: R. Wołągiewicz, Kręgi kamienne w Grzybnicy (Koszalin 1997).

–/Hahuła 2001: –/K. Hahuła, Grzybnica. Ein Gräberfeld mit Steinkreisen der Wielbark-Kultur in Pommern. Monumenta Archaeologica Barbarica VIII (Koszalin, Warszawa 2001).

Zielony/Kliczkowska 2010: R. Zielony/A. Kliczkowska, Regionalizacja przyrodniczo-leśna Polski 2010 (Warszawa 2010).

Zwolski 1984: J. Zwolski, Historia gocka, czyli scytyjska Europa (Lublin 1984).