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THE DIET AND HEALTH STATUS OF THE EARLY NEOLITHIC COMMUNITIES OF THE CENTRAL BALKANS (6200-5200 BC)

Doctoral Dissertation

Belgrade, 2017

UNIVERZITET U BEOGRADU

FILOZOFSKI FAKULTET

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ISHRANA I ZDRAVSTVENI STATUS STANOVNIKA CENTRALNOG BALKANA U RANOM NEOLITU (6200.-5200. G. PRE N.E.)

doktorska disertacija

Beograd, 2017

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Acknowledgements

I would like to express sincere gratitude to my PhD supervisor Prof. Sofija Stefanović for her support, guidance and encouragement over the past several years. She introduces me to the one of the most exciting periods in human evolution, the Mesolithic-Neolithic Transition, and provided me with the opportunity to work with the Danube Gorges skeletal collection. I very much appreciate the contribution she made to this project in terms of time, ideas and funding; her help made my PhD-related work much more productive and stimulating than it would have been without it. She welcomed me to the project "Bioarchaeology of Ancient Europe: humans, animals and plants in the prehistory of Serbia" (Ref: III 47001) funded by the Ministry of Education, Science and Technological Development of the Republic of Serbia within which I partially conducted my PhD research.

I am also deeply indebted to Dr Gwenaëlle Goude for crucial advice and a critical eye throughout the research and the dissertation writing processes. Her thorough and insightful comments on the first drafts of thesis broadened my perspective and significantly improved this dissertation. I am also grateful to her for encouraging me to explore dietary pathways through stable isotope analysis and for providing me with excellent training and facilities in the LAMPEA laboratory in Aix en Provence.

My heartfelt thanks to Dr Marko Porčić (Faculty of Philosophy, Department of Archaeology, University of Belgrade), for the help, support and very useful discussions throughout my PhD studies. I would also like to thank Dr Dragana Rančić from the Faculty of Agriculture, University of Belgrade who kindly shared her knowledge and the workspace in which I conducted starch grain analysis under her guidance. I am grateful to Dr Dragana Filipović (Institute for Balkan Studies, Serbian Academy of Sciences and Arts) for valuable advice on the use of plants in prehistory.

This dissertation would not have been possible without the assistance of many people and institutions, each of whom deserve special thanks. I am grateful to Divna Gačić and Đorđe Gačić (City Museum of Novi Sad), Prof. Nenad Tasić (Faculty of Philosophy, Department of Archaeology, University of Belgrade), Lidija Balj (Museum of Vojvodina), Dragan Anđelić (Provincial Institute for the Protection of Cultural Monuments, Vojvodina), Snežana Marinković (National Museum, Zrenjanin) and Dr

Andrej Starović (National Museum in Belgrade) for the help and access to the studied material.

I would also like to thank to my friend and colleague Camille de Becdelièvre. Not only was he there for me to hear my ideas and answer questions regarding my thesis, he has also been a great friend and I will always remember the time we spent together in Serbia, France and through Europe. I am grateful to my friend and colleague Jelena Bulatović for useful advices and all support. I would also like to thank to all my other friends and colleagues of the Laboratory for Bioarcheology at the University of Belgrade: Tamara Blagojević, Mina Amzirkov, Kristina Penezić, Ivana Živaljević, Dr Sonja Vuković, Prof. Vesna Dimitrijević, Jelena Marković; and Dr Stefan Milošević and Dr Dragana Filipović for English corrections of the thesis and very useful comments. I am also grateful to Dr Estelle Herrscher from the LAMPEA laboratory for help and fruitful discussions.

Lastly, I would like to thank my dear friends Tanja, Maja, Jelena S., Jelena K., Miki, and the family who encouraged and inspired me in so many ways through the last several years. I am particularly grateful to my parents, Marina and Dragan, and my fiancé Mladen for their unconditional love, understanding and constant support, and for not letting me give in.

The diet and health status of the Early Neolithic communities of the Central Balkans (6200-5200 BC)

Abstract

With climatic improvement at the beginning of the Holocene, small human groups across the world experienced important changes that over the following several millennia significantly impacted their lifestyles. The process began of the transition from mobile foragers to sedentary agro-pastoralists and, in a few thousand years, the world population increased. This process is known as the Neolithic Demographic Transition and represents one of the major events in human prehistory which significantly influenced human biology, dietary choices and health patterns. The new, Neolithic way of life spread from the Near East through western Anatolia to central Europe. The Balkans represents one of the key areas for studying the process of Neolithisation, as it is located at the crossroad between the Near East and central Europe. However, biological and cultural mechanisms behind the process of Neolithisation in the central Balkans are poorly understood. This thesis gives the first direct insights into how the process of Neolithisation in the Central Balkans influenced human lifestyle, particularly the diet and health. For the first time, the data from the Central Balkans and from Europe are compared, which helps better understand the dynamics of the Neolithisation process across the continent.

This research focuses on examination of the diet and health status of 267 humans whose skeletal remains were recovered from 14 Mesolithic and Neolithic sites across the Central Balkans. The study focuses on two geographic regions: 1) the Danube Gorges (sites Padina, Lepenski Vir, Vlasac, Hajdučka Vodenica and Ajmana), where Mesolithic-Neolithic continuity of occupation has been attested for the period 9500-5500 cal BC; and 2) the regions to the west from the Danube Gorges, the territory of the Central Balkans (Golokut-Vizić, Klisa, Sremski Karlovci, Perlez-Batka, Obrež-Baštine and Starčevo) and the southern part of the Great Pannonian Plain (Vinča-Belo Brdo, Grivac and Rudnik Kosovski) where Early Neolithic period lasted from 6200 to 5200 cal BC.

Over this period, the inhabitants of these areas underwent Neolithic transformations which included major changes in the lifestyle. The changes included the beginning of a fully sedentary way of life, cultivation of domestic plants and breeding of

animals. Many scholars hypothesized that these changes, seen not only in the Central Balkan region but also across whole Europe, had a positive effect on female reproductive system and that, as a result, within few thousand years the world population significantly increased. In fact, one of the key explanations for the causes of Neolithic Demographic Transition emphasises the changes in female nutrition – from protein-based diet to diet dominated by carbohydrates.

Thus the aim of this thesis was to determine whether the Early Neolithic in the Central Balkans saw changes in human diet which could have had impact on fertility rates and the overall population health. Therefore, the first hypothesis underlying the study is that Neolithic people in the study region had less protein and more carbohydrates in their diet. This assumption is tested through the stable isotope and starch grain analysis, as well as through macroscopic examination of dental caries and calculus deposits.

The rise in fertility was also followed by a general decline in health status in the Neolithic which is reflected in the higher occurrence of various skeletal and dental pathological conditions. Thus, the second hypothesis is that the transition to food production resulted in the overall health decline. This is tested through macroscopic analysis of non-specific stress indicators (cribra orbitalia, porotic hyperostosis, dental enamel hypoplasia), as well as through the analysis of ante mortem tooth loss and the presence of caries and dental calculus.

Since this study focuses on two geographic regions that differ in subsistence economy, the third hypothesis is that the Neolithic groups occupying the Gorges and the groups who lived to the west from the Gorges differed in their dietary choices and health patterns.

The stable isotope analysis showed that, at the beginning of 7th millennium, the Danube Gorges hunter-fisher-gatherers, which were strongly reliant on aquatic resources and wild game, experienced a change seen in the increase in consumption of terrestrial resources (which entailed smaller intake of aquatic proteins and possibly more carbohydrates in the diet); this was noted at some sites from the Neolithic period. However, in the Danube Gorges, this was a gradual process since many Neolithic individuals remained reliant on aquatic products. In contrast, the stable isotope values of the Neolithic communities outside the Gorges, as well of the Early Neolithic groups in

Europe, point at a predominantly terrestrial diet with only a little input of aquatic resources. Overall, the results for the study region show that the Mesolithic-Neolithic transition was not a simple linear process, but that it encompassed significant regional differences related to environmental factors, cultural traditions, and/or the dietary habits of the Neolithic newcomers.

The results of starch grain analysis lend weight to the argument that Neolithic people based their diet on terrestrial resources and probably consumed significant amounts of carbohydrates. The appearance of new foods (cereals and milk), combined with novel food preparation techniques (cooking in pots), enabled central Balkans Neolithic mothers to reduce the length of the period during which they breastfed their children since they had a good replacement for their own milk and a possibility to make porridges. This could have positively affected female fertility rates and, together with the increase in the energy-rich food intake and decreased sedentism, may have allowed women to have more children and stay pregnant more often; the consequence of this was the increase in the number of people on Earth.

Concerning the assessment of the macroscopic dietary indicators, the results are different for the two study regions. Although slight changes in the diet toward greater consumption of carbohydrates left evidence on the teeth of the Danube Gorges people, detected as the higher occurrence of caries in the Neolithic compared to the Mesolithic, this rate of occurrence here is still lower than in other Early Neolithic populations, including the Neolithic communities from outside the Gorges. The diet rich in animal proteins served as a buffered whilst, in contrast, the higher consumption of terrestrial food by the Neolithic groups outside the Gorges led to, in their case, the higher frequency of caries. However, although more common in the Mesolithic due to the protein-based diet, dental calculus was also frequent in the Neolithic groups in both of the studied regions, but had a different aetiology, probably linked to the introduction of dense, sticky, cooked carbohydrate-rich food. Furthermore, the highest record of pre-mortem tooth loss was observed in the Neolithic humans from outside the Danube Gorges, which is in accordance with the prevalence of caries rates, suggesting that the presence of caries was the probable cause of the tooth loss. Although the high occurrence of ante mortem tooth loss was also noticed in the Mesolithic, the causal factors are different and probably connected with severe attrition and high calculus deposits.

Regarding the evidence of non-specific stress indictors, there are also some regional differences. The distribution of cribra orbitalia and enamel hypoplasia is similar in the Mesolithic and the Neolithic sequence of the Danube Gorges, albeit more stress episodes of linear enamel hypoplasia were observed in the Neolithic. In human groups outside the Gorges, these two stress indicators are much more common, similar to the other European Mesolithic-Neolithic transitional populations. Concerning the presence of cribra orbitalia and porotic hyperostosis, the main difference between the periods, and in both study areas, is in the activity of lesions which show that many Neolithic people failed to heal. Overall, the result suggests different origins of these non-specific stress indicators. While the causes for cribra orbitalia and enamel hypoplasia could, *inter alia*, lie in the nutritional imbalance, reduced food diversity and the low food quality, the extremely high percentages of porotic hyperostosis were more likely caused by infectious diseases (e.g. treponemal infections were detected in the Danube Gorges) or cultural habits (e.g. making hairstyles with intensive use of comb or wearing ribbons around head can form lesions).

Various diseases coupled with the shorter breastfeeding period and the consumption of new food that had negative effects left multiple consequences for human health. This is also evident in the decrease in the average stature and body mass in the Danube Gorges Neolithic human groups compared to the Mesolithic. This could also have been influenced by the arrival of non-local people with small body proportions. However, the decrease seen in the Gorges was not as dramatic as that documented in other Early Neolithic populations in Europe. Although humans in the Gorges were more affected by physiological stress and were less mobile than the Mesolithic groups, their diet rich in aquatic resources could have had positive effect and precluded a significant decrease in the stature characteristic of other Early Neolithic populations. Further, in the Danube Gorges there was no sex-specific trend toward greater decrease in the female stature compared to males – contrary to was observed in other Early Neolithic populations in Europe. The females from outside the Danube Gorges were short and small in comparison to females in the Gorges and they resemble Early Neolithic women from Europe. For these females it is impossible to suggest whether their stature and weight decreased over time, since their genetic origin is unknown, but the detected high frequencies of physiological stress could have led to the decrease in their body proportions. It may also be argued that girls during childhood had a different treatment compared to boys, which rendered them more vulnerable to various stress conditions that, eventually, affected their body proportions. Furthermore, higher number of pregnancies could also have had negative effect on their overall health. At the same time, the reduction in female body size could have resulted in changes in pelvic bones, which may have become narrower. Narrower pelvic bones, in combination with abundant carbohydrates in female diet that may have led to the increase in the size of foetus' head, may have impacted the childbirth process which probably became more risky and painful than it was before. More pregnancies, resulting in the growth of world population, also had negative effects to the most sensitive members of the communities, i.e. children. Neolithic children in the Central Balkan region show lower immunity than the Mesolithic children, likely due to the shorter length of breastfeeding in the Neolithic. The consequence of this is the higher frequency of physiological stress in the Neolithic children, and its occurrence earlier in life, compared to the Mesolithic children – as indicated by the results of enamel hypoplasia analysis. Besides children, the process of Neolithisation in the Central Balkans had as well a huge impact on the mothers, who also display high frequency of physiological stress and pathological conditions.

The results obtained within this thesis represent an important step toward better understanding of the process of Neolithisation and its consequences to human health and biology. They provide a unique contribution to our knowledge of the first Balkans agro-pastoralist communities, especially those who occupied areas outside the Danube Gorges. The first Balkan farmers outside the Gorges were of very poor health, similar to most of the contemporary Neolithic communities across Europe. In contrast, the Neolithic communities in the Danube Gorges show no significant decline in health compared to the Mesolithic inhabitants of the same region; moreover, they seem to have been of (much) better health than the Neolithic groups outside the Gorges. This marked difference is a result of multiple factors, most prominently the differences in dietary pathways, environmental conditions, cultural habits and, at least for the Danube Gorges, adherence to the Mesolithic traditions. All of the hypotheses set out at the beginning of the thesis have been confirmed and the obtained results are in accordance with the

theory of the Neolithic Demographic Transition. In conclusion, although the most important aspects of the Neolithic was the increased number of children, Neolithic developments in the Central Balkans also brought about profound health problems to both children and their mothers.
Key words: physical Anthropology, Mesolithic-Neolithic Transition, Danube Gorges, Central Balkans, diet, stable isotope analysis, health status, macroscopic indicators of diet and health

Scientific field: Archaeology

Scientific subfield: Physical Anthropology

UDC number: 572:903(497.11) ”633/634”(043.3)

233-442+371.72] ”633/634”(043.3)

Ishrana i zdravstveni status stanovnika centralnog Balkana u ranom neolitu (6200.-5200. g. pre n.e.)

Sažetak

Sa poboljšanjem klimatskih uslova početkom holocena dolazi do značajnih promena u načinu života ljudi širom sveta. Ljudi tada prelaze sa lovačko-sakupljačkog načina života na novi sedelački način života koji je podrazumevao bavljenje poljoprivredom, što je na kraju dovelo do prvog značajnog uvećanja broja ljudi. Ovaj proces naziva se neolitska demografska tranzicija i predstavlja jedan od najvažnijih događaja u ljudskoj prošlosti, jer je značajno uticao na čovekovu biologiju, ishranu i zdravlje. Novi neolitski način života širio se sa Bliskog istoka i preko zapadne Anadolije odakle je dospeo na tle Balkana. Područje centralnog Balkana važno je za proučavanje procesa neolitizacije jer se tu susreću uticaji sa Bliskog istoka i centralne Evrope. Ipak, biološki i kulturni mehanizmi procesa neolitizacije su veoma malo istraženi na ovom području. Ova teza pružiće prve biološke pokazatelje o tome kako je neolitizacija uticala na ljude, prvenstveno na njihovu ishranu i zdravlje. Istovremeno to će omogućiti da se po prvi put podaci sa centralnog Balkana uporede sa podacima iz drugih delova Evrope kako bi se razumela ukupna dinamika procesa neolitizacije na čitavom kontinentu.

U tezi je istraživana ishrana i zdravstveni status u ovom periodu, analizom 267 ljudskih skeletnih ostataka koji potiču sa 14 mezolitskih i neolitskih lokaliteta širom centralnog Balkana. Studija je fokusirana na dva geografska regiona: 1) Đerdap (lokaliteti Padina, Lepenski Vir, Vlasac, Hajdučka Vodenica i Ajmana), gde je period mezolita i neolita trajao od 9500.-5500. godina pre nove ere; i 2) regione zapadno od Đerdapa, odnosno na teritoriju centralnog Balkana (Golokut-Vizić, Klisa, Sremski Karlovci, Perlez-Batka, Obrež-Baštine, Starčevo) i južnog dela Panonske nizije (Vinča-Belo Brdo, Grivac, Rudnik Kosovski), gde je rani neolit trajao od 6200.-5200. godine pre nove ere.

Tokom ovog perioda, stanovnici u ovom regionu prošli su kroz proces neolitizacije koja je značajno uticala na njihov život i dovela do velikih promena. Te promene dovele su do ustaljivanja sedelačkog načina života, kultivacije biljaka i domestikacije određenih vrsta životinja. Mnogi istraživači smatraju da su ove promene koje se uočavaju širom sveta, a ne samo u regionu centralnog Balkana, imale pozitivan

efekat na fertilitet žena, što je rezultiralo uvećanjem populacije u roku od nekoliko hiljada godina. Zapravo, kao jedno od glavnih bioloških objašnjenja neolitske demografske ekspanzije navode se promene u ishrani žena, koje prelaze sa proteinske ishrane na ishranu bogatu ugljenim hidratima, što dovodi do povećanog energetskog balansa žena.

Upravo zbog toga cilj ove teze je da utvrdi da li je početkom ranog neolita na teritoriji centralnog Balkana došlo do promena u ishrani koje su mogle pozitivno da utiču na stopu fertiliteta i ukupan zdravstveni status. Zbog toga je prva hipoteza da u ranom neolitu centralnog Balkana dolazi do promena u ishrani, odnosno da ljudi koriste manje proteina i više ugljenih hidrata u ishrani. Ona je ispitana putem analize stabilnih izotopa i skrobnih zrna iz zubnog kamenca, kao i putem makroskopskih analiza karijesa i zubnog kamenca.

Sa porastom fertiliteta dolazi i do pogoršanja zdravstvenog statusa u ranom neolitu, koje se reflektuje povećanom učestalošću raznih dentalnih i skeletnih patoloških stanja. Zbog toga je druga hipoteza da je promena u ishrani početkom neolita dovela do opšteg pada zdravstvenog statusa. Ona je istražena primenom makroskopskih analiza nespecifičnih markera stresa (kribre orbitalije, porozne hiperostoze, hipoplazije zubne gleđi), kao i analizom zaživotno izgubljenih zuba, karijesa i zubnog kamenca.

Budući da analizirani materijal u ovoj tezi potiče iz dva regiona, koji imaju drugačiju ekonomiju, treća hipoteza koja je ispitana je da se neolitski ljudi koje žive u Đerdapu razlikuju u obrascima ishrane i zdravstvenom statusu, od onih koji žive van njega, u regionima zapadno od Đerdapa.

Analize stabilnih izotopa pokazale su da početkom 7.milenijuma dolazi do promena u ishrani ljudskih zajednica u Đerdapu, čija je prehrana prethodno bila pretežno bazirana na akvatičkim resursima i mesu divljači. Na pojedinim lokalitetima uočava se blagi porast upotrebe kopnenih izvora hrane, sa manje akvatičkih resursa i verovatno više ugljenih hidrata. Ipak, ovaj proces je bio postepen, budući da dosta individua u neolitu i dalje ima ishranu bogatu ribom. Nasuprot tome, rezultati analize stabilnih izotopa ljudi van Đerdapa, sličniji su ostatku neolitske Evrope, jer su pokazali da se njihova ishrana zasnivala uglavnom na kopnenim resursima sa minimalnim udelom ribe. Generalno, rezultati ukazuju da mezolitsko-neolitska tranzicija nije bila uniforman proces, već da postoje brojne regionalne varijacije koje su uslovljene prirodnim okruženjem, kulturnim tradicijama, kao i navikama u ishrani neolitskih migranata.

Rezultati analiza skrobnih zrna takođe upućuju da su ljudi početkom neolita počeli da menjaju ishranu i da centralnu ulogu sada imaju kopneni izvori hrane koji uključuju povećanu konzumaciju ugljenih hidrata. Pojava nove hrane (npr. žitarica i mleka), kao i novog načina pripreme (kuvanje) možda je omogućila majkama na centralnom Balkanu da kraće doje decu jer su sada imale odgovarajuću zamenu za njihovo mleko, kao i mogućnost da prave kašice za bebe. Pojava kašica, praćena većim energetskim balansom žena i smanjenom mobilnošću mogla je pozitivno da utiče na fertilitet žena, jer im je ishrana bogata ugljenim hidratima omogućila veći energetski balans, što je moglo pozitivno da utiče na povećanje broja ljudi u neolitu.

Rezultati makroskopskih indikatora ishrane pokazali su da postoje regionalne varijacije. Male promene u ishrani bogatijoj ugljenim hidratima ostavile su tragove na zubima neolitskih stanovnika Đerdapa, u vidu povećane učestalosti karijesa u odnosu na mezolit. Ipak, učestalost karijesa je niža nego ona zabeležena kod ljudi van Đerdapa u ispitivanom području, kao i kod ostalih ranoneolitskih populacija širom Evrope. Proteinska ishrana đerdapskih zajednica imala je zaštitnu ulogu, dok je većinski kopnena ishrana ljudi van Đerdapa dovela do veće učestalosti karijesa. Sa druge strane, proteinska ishrana dovela je i do veće učestalosti zubnog kamenca u mezolitu, iako je visok procenat zuba bio zahvaćen kamencem i u neolitu, ali je etiologija nastanka drugačija i verovatno više vezana za uvođenje lepljive kuvane hrane bogate ugljenim hidratima. Najveći broj zaživotno izgubljenih zuba konstatovan je kod neolitskih ljudi van Đerdapa, gde je verovatno karijes bio glavni uzrok. Pored toga, veliki broj zaživotno izgubljenih zuba uočen je i u mezolitu, ali je njihov gubitak verovatno izazvan posledicom velikog stepena istrošenosti zuba i visokom stopom kamenca.

Rezultati analiza nespecifičnih indikatora stresa takođe pokazuju regionalne razlike. Distribucija kribre orbitalije i hipoplazije zubne gleđi slična je u mezolitu i u neolitu Đerdapa, iako je više stresnih epizoda uočeno u neolitu. Kod neolitskih populacija van Đerdapa, učestalost oba ova indikatora je veća i slična onima uočenim u ostalim delovima ranoneolitske Evrope. Kada su u pitanju, kribra orbitalija i porozna hiperostoza glavna razlika između mezolita i neolita u Đerdapu i van njega je u aktivnosti lezija, jer rezultati pokazuju da je u neolitu veći procenat ljudi imao aktivne lezije u trenutku smrti što znači da je manji broj njih mogao da se izleči u odnosu na mezolit. Pored toga, uočava se i da je etiologija nespecifičnih indikatora stresa različita. Uzroci nastanka kribra orbitalije i hipoplazije zubne gleđi verovatno su bili posledica nutritivnog poremećaja, smanjene raznovrsnosti i kvaliteta hrane. Sa druge strane, visoka učestalost porozne hiperostoze mogla je biti posledica kulturnih navika (npr. pravljenje frizura koje je podrazumevalo jaču upotrebu češlja ili nošenje traka oko glave moglo je prouzrokovati lezije) ili infektivnih bolesti (npr. treponematozne infekcije uočene su kod stanovnika Đerdapa).

Različite bolesti u kombinaciji sa kraćim dojenjem, kao i prelazak na novu hranu ostavili su brojne posledice po ljudsko zdravlje. To se takođe ogleda i u smanjenju prosečne visine i težine đerdapskih ljudi u neolitu. Međutim, tome je mogao doprineti i dolazak ljudi ne-lokalnog porekla koji su bili nižeg telesnog rasta. Iako su ljudi u Đerdapu imali veću stopu fiziološkog stresa i bili manje mobilni u odnosu na mezolitske ljude, ishrana bogata akvatičkim resursima moglo je imati pozitivan efekat u smislu da se kod ovih ljudi ne uočava smanjenje proporcija tela u velikoj meri, kao što to pokazuju studije na ranoneolitskim skeletima u ostatku Evrope. Takođe, ovo smanjenje nije pogodilo više đerdapske žene nego muškarce, kao što je to slučaj kod ostalih ranoneolitskih populacija u Evropi. Žene u neolitu van Đerdapa bile su sitne građe i niske u poređenju sa ženama u Đerdapu i one više liče na ostale ranoneolitske žene u Evropi, ali budući da podaci o njihovom genetskom poreklu nisu poznati, teško je reći da li i u kojoj meri se one u neolitu razlikuju, mada je visoka stopa fiziološkog stresa kod njih takođe mogla negativno uticati na smanjenje proporcija tela. Moguće je i da su ženska deca imala drugačiji tretman u odnosu na mušku decu, što je dovelo do toga da one tokom odrastanja budu više podložne fiziološkom stresu i na kraju rezultiralo smanjenjem telesnih proporcija. Sa druge strane, veći broj trudnoća je takođe uticao na njihovo celokupno zdravlje. Istovremeno, ovo smanjenje proporcija tela moglo se odraziti i na morfologiju karlica koje bi u tom slučaju postale uže. Takve karlice i ishrana bogata ugljenim hidratima mogli su dovesti do povećanja glave fetusa, što bi umnogome uticalo na porođaj koji tada postaje izuzetno težak i opasan. Više stope trudnoća dovele su do povećanja broja ljudi, ali su istovremeno imale i negativne posledice, posebno po decu na centralnom Balkanu koja pokazuju slabiji imunitet u odnosu na mezolit, koji je verovatno prouzrokovan skraćenjem perioda dojenja u

neolitu. To je rezultiralo većom stopom i ranijom pojavom fiziloškog stresa kod dece u neolitu, na šta upućuju rezultati hipoplazije zubne gleđi. Pored dece, proces neolitizacije najviše je pogodio i njihove majke, koje takođe pokazuju visoke stope fiziološkog stresa.

Rezultati dobijeni u ovoj tezi omogućili su bolje razumevanje procesa neolitizacije i njegovih posledica na biologiju i zdravlje ljudi. Osim toga, ova teza značajno doprinosi našem znanju o prvim neolitskim zajednicama na Balkanu, posebno onima koje su živele van regiona Đerdapa. Ti prvi evropski zemljoradnici van Đerdapa pokazuju značajno pogoršanje zdravstvenog statusa, koje je uočeno i kod ostalih ranoneolitskih populacija širom Evrope. Nasuprot tome, kod neolitskih zajednica u Đerdapu ovo značajno pogoršanje nije uočeno. Ove razlike u zdravstvenom statusu posledica su sinergije različitih obrazaca ishrane, prirodnog okruženja, kulturnih navika i starih tradicija. U ovom radu sve postavljene hipoteze su potvrđene i rezultati su u skladu sa teorijom neolitske demografske tranzicije. Celokupno gledano, iako je najvažnija posledica neolitizacije povećanje broja dece, neolit na centralnom Balkanu doneo je najveći zdravstveni problem upravo njima i njihovim majkama.
Ključne reči: fizička antropologija, mezolitsko-neolitska tranzicija, Đerdap, centralni Balkan, ishrana, analize stabilnih izotopa, zdravstveni status, makroskopski indikatori ishrane i zdravstvenog statusa

Naučna oblast: Arheologija

Uža naučna oblast: Fizička antropologija

UDK broj: 572:903(497.11) ”633/634”(043.3)

233-442+371.72] ”633/634”(043.3)

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1. INTRODUCTION

Human skeletal remains recovered from archaeological sites provide a valuable source of information for the reconstruction of ancient life histories. Since bones and teeth are the hardest parts of human skeleton and are highly resistant to decomposition, they often represent the most lasting record of an individual's existence (White and Folkens 2005). By studying these remains it is possible to estimate the sex and age and thus to reconstruct a palaeodemographic picture. The analysis of bone and teeth can also help infer subsistence strategies, health status, physical activities, mobility patterns and cultural behaviour in the past. Moreover, research on ancient skeletal remains has proved to be very useful for improving the quality of life and well being of present-day populations.

Studying ancient life-histories and individual osteo-biographies is of major importance for understanding the key bio-cultural mechanisms driving population dynamics (Zvelebil and Weber 2013). One of the most important adaptive shifts in human history was the transition from hunter-gatherer lifestyle to agricultural food production in the Holocene. This event is known as the Neolithic Revolution (Childe 1936), during which significant social, cultural and biological changes affected our species. Humans became the agents of environmental changes and gained control over reproduction and evolution of plants and animals (Stock and Pinhasi 2011). Within few thousand years the world population took off and this demographic shift is known as the Neolithic Demographic Transition (Bocquet-Appel 2011). The population growth was followed by a significant increase in the proportion of juvenile skeletons and a rise in female fertility rates. Furthermore, with an increase in population size, the overall health decline has also been documented worldwide (Cohen and Armelagos 1984).

One of the main questions raised by the concept of Neolithic Revolution is "What influenced fertility rates and led to the population growth (Stock and Pinhasi 2011)?" The few explanations referring to biological causes of the rise in fertility rate, which are often quoted in archaeological literature, are: (1) the shift to sedentary lifestyle led to a reduction in physical activity and to an increase in the maternal energetic balance which enabled more pregnancies and higher birth rate; (2) the shift to agriculture resulted in new subsistence strategies whereby Mesolithic protein-dominated diet was replaced by diet rich in carbohydrates (e.g. cereals). This high-calorie food led to an increase in maternal energy balance and consequently impacted fertility rates (Bocquet-Appel 2008). However, all these assumptions are based on indirect forms of evidence; direct analyses of human skeletal remains in order to test female mobility and diet are rarely conducted.

In this context, the direct analyses of human skeletal remains provide an exceptional opportunity to understand the biological causes of population growth in the Neolithic. Critical for understanding the process of Neolithic Demographic Transition in Europe is the Balkan area, where influences from the Near East and continental Europe meet. In the territory of Serbia, more than 300 Mesolithic and Early Neolithic sites have been discovered[1]. Human skeletal remains from these sites offer an excellent opportunity to explore biological aspects of Neolithisation on a regional level.

1.1. The aim of the research

This research focuses on examination of diet and health status of Early Neolithic people who lived in the Central Balkans between the 7th and 6th millennium BC. Over this period, inhabitants of this area underwent Neolithic transformations which included major changes in the lifestyle of these communities. The changes resulted in a sedentary way of life, cultivation of plants and breeding of animals. Noteworthy, many scholars hypothesized that these changes, seen not only in the Central Balkan region but also across whole Europe, had a positive effect worldwide on female reproductive system and that, as a result, within few thousand years the world population significantly increased (Bocquet-Appel 2011). An important population growth was also detected in the Central Balkan region (Porčić et al. 2016). In fact, one of the key explanations for the causes of Neolithic Demographic Transition emphasises the changes in female nutrition – from protein-based diet to diet more rich in carbohydrates.

Once they engaged in cultivation of plants, people started to eat more carbohydrates-containing food such as cereals. Cereals as a high-calorie foodstuff could

[1] Based on the results collated within the project “Bioarchaeology of ancient Europe: humans, animals and plants in prehistory of Serbia” (III 47001) funded by the Ministry of Education, Science and Technological Development of the Republic of Serbia.

have had positive impact on female fertility in terms of better energy balance (Bocquet-Appel 2008). Studies show diet based on carbohydrates can lead to increase in women weight which impacted on earlier age of menarche and subsequently on earlier pregnancies[2]. However, the evidence of plant cultivation in the Early Neolithic of the Central Balkans is poor. Archaeobotanical analysis has been conducted only for few Early Neolithic sites in this region (Filipović and Obradović 2013) and the plant remains were usually hand collected or recognized as impressions in pottery or burnt daub. Therefore, our knowledge of the role of plants in the Early Neolithic in the Central Balkans is severely limited. Thus researchers often use other lines of evidence to discuss the assumed agricultural character of the Early Neolithic communities. Findings of grinding stones, hoes, pickaxes, digging tools, saws (Антоновић 2005) and sickle blades (Šarić 2014) are often interpreted as artefacts confirming agricultural activity. However, these are all indirect lines of evidence and there are no studies carried out directly on human skeletal remains. *Therefore, the first hypothesis underlying this study is that Neolithic people in the study region had less protein and potentialy more carbohydrates in their diet.*

Although population growth has been detected in the Neolithic, studies across Europe carried on human skeletal remains, documented general decline in the health status. This is reflected in the prevalence of various skeletal and dental pathological conditions and also in the global increase in mortality, suggesting that the shift toward agriculture had an adverse effect on human physiological fitness. The main cause of this decline is usually explained by the changes in diet, the limited food range and the low level of food quality (Cohen 2008). Some studies suggest that hunter-gatherer communities probably had more adequate diet, given the wide food repertoire that included vitamins, minerals and above all protein, than agriculturalists (Cohen 1977: 27). Stable isotope analysis carried out on Mesolithic-Neolithic human skeletal remains from across Europe showed a significant drop in the food quality in the Early Neolithic (Tauber 1981; Richards et al. 2003, 2008; Ogrinc and Budja 2005; Le Bras Goude et al. 2010; Lightfoot et al. 2011; Oelze et al. 2011; Schulting 2011; Carvalho and Petchey 2013; Ash et al. 2016). There was an increase in caries rates since carbohydrate-

[2] http://www.ined.fr/fr/tout-savoir-population/memos-demo/fiches-pedagogiques/l-age-aux-premieres-regles/

containing food (e.g. cereals) is rich in sugars which greatly contribute to the development of caries. Beside cereals, consumption of milk could also cause negative effects on individual health. Namely, at the time when people started to consume milk, they were not tolerant to lactose (Gerbault et al. 2013) which could have thus caused gastro-intestinal problems.

The consumption of this new food and its negative effects had multiple consequences with respect to human health, of which some are evident on human bones and teeth (e.g. cribra orbitalia, porotic hyperostosis and enamel hypoplasia). The analysis of Early Neolithic skeletons in Europe showed that around 50% of individuals had some kind of growth disruption as a consequence of the new lifestyle and poor diet, while in the Mesolithic only 20% of individuals had traces of bad health (Papathanasiou 2011; Jarošova and Dočkalova 2008; Wittwer-Backofen and Tomo 2008). *Thus, the second hypothesis is that the transition to food production resulted in the overall health decline.*

The aim of this thesis is to determine whether the Early Neolithic in the Central Balkans saw changes in human diet which could have had impact on fertility rates and the overall population health. This will be tested through a direct examination of human bones and teeth. Although Early Neolithic human skeletal remains are the focus of this study, the analysis of Mesolithic individuals is also included in order to facilitate comparative analysis. The Early Neolithic in the study area began around 6200 cal BC (Whittle et al. 2002). This study focuses on the Early Neolithic in two geographic regions:

1) the Danube Gorges[3], where Mesolithic-Neolithic continuity of occupation has been attested for the period 9500-5500 cal BC, and

2) the regions to the west from the Danube Gorges, the territory of the central Balkans and the southern part of the Great Pannonian Plain[4], where Early Neolithic period lasted from 6200-5200 cal BC (Whittle et al. 2002; Tasić et al. 2016)

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[3] Stratigraphically and chronologically, of the Mesolithic and Neolithic sequence in the Danube Gorges is divided into: the Early Mesolithic (9500-7400 cal BC); the Late Mesolithic (7400-6300 cal BC); the Transformational/Early Neolithic (6200-6000/5950 cal BC) and the Early/Middle Neolithic (5900-5500 cal BC) (Borić and Dimitrijević 2007, 2009; Borić and Price 2013). However, for the purpose of this thesis, the Transformational/Early Neolithic and the Early/Middle Neolithic periods are considered together as the Early Neolithic period.

[4] Since one of the aims of this thesis is to investigate regional variability of the human groups in the Danube Gorges and the communities that lived in the regions located west from the Danube Gorges

For the Danube Gorges many studies (e.g. Radovanović 1996; Borić and Dimitrijević 2007; Borić 2008) have indicated a relatively constant subsistence economy, with no significant changes with the advent of the Neolithic. *Thus, the third hypothesis is that the Neolithic groups occupying the Gorges and the groups who lived outside the Gorges differed in their dietary choices and health patterns.*

Multiple approaches will be applied in order to investigate potential dietary and health changes including the analysis of stable isotope ratios, starch analysis; frequency of dental caries, calculus, antemortem loss of teeth; frequency of non-specific stress markers such as cribra orbitalia, porotic hyperostosis and enamel hypoplasia. The interpretation of the produced data will provide further insights into the effect of Neolithisation on human biology in the Central Balkans.

The thesis is divided into six chapters. Chapter 1 discusses the Neolithic Demographic Transition and its consequences, particularly those relevant to human biology and health. Special attention is paid to the process of Neolithisation in the Central Balkans and the earliest Neolithic culture in this area, the Starčevo culture. A review of previously completed bioarchaeological research is also available within this chapter. Chapter 2 provides description of the archaeological sites from which the skeletons analyzed within this doctoral project derived as well as the size of the sample for every site. Chapter 3 presents the materials and methods used in this study. The sex and age determinations as well as the chronological and spatial distribution of the analyzed samples are also given here, and the detailed description of the methodological framework. In Chapter 4 all of the results are presented on the population levels and according to the sex, age and spatial distribution. Detailed interpretation of the obtained results, the comparison with other Early Neolithic communities and conclusion of the thesis is given in Chapter 5.

1.2. The Neolithic Demographic Transition

The name Neolithic derives from the Greek word *Neolithikos*, which literally means New Stone Age. It was first introduced by Sir John Lubbock in the 19th century to refer to the later part of the Stone Age (Lubbock 1865). This period represents a

(Vojvodina, Šumadija and Kosovo), the common name which will, in this thesis, be used to denote the latter is 'communities outside the Danube Gorges'.

major breakthrough in the history of humanity since many biological, social and cultural changes took place at the time. The term “Neolithic Revolution” was coined by Gordon Child. It refers to the transition from hunting and gathering to agricultural practices (Childe 1936). It is marked by the beginning of human control of the reproduction and evolution of plants and animals. This transitional period represents the shift from mobile foraging to sedentary farming in the Holocene and it is also known as the Neolithic Demographic Transition (Bocquet-Appel 2008). It is the time when humans adopted farming and the world population took off over a period of few thousand years (2011). This process took place more-or-less simultaneously in several regions of the world, from the Near East to Europe. The significant population growth is evidenced by the increased number of children remains discovered at Early Neolithic sites. In this context, the demographic transition should be understood as a significant increase in female fertility, followed by an important rise in death rate (Bocquet-Appel 2008).

The transition to agriculture triggered a series of changes in social organization (Stock and Pinhasi 2011). These changes are based on the rise of food production and storage of food supplies which led to the emergence of property ownership, social hierarchy, task specialization and marked technological development (Stock and Pinhasi 2011). Therefore, the introduction of agriculture was conducive to colonization of new territories. This new environment, with secured steady food supply, enabled mothers to have shorter period of breastfeeding, more pregnancies and, consequently, higher birth rate, which led to the population growth (Bocquet-Appel 2008; Stock and Pinhasi 2011). However, not all scholars agree that this was the order of events. Some of them (Boserup 1965; Cohen 1977) argue that population growth caused the development of agriculture. Regardless of whether demography was a causal factor or not, it is apparent that transitional changes strongly impacted the lifestyle and health of Early Neolithic communities.

1.2. Impact of the Neolithic Demographic Transition on human biology

The question of how the adoption of agriculture and a new way of life influenced human health has been a much debated topic in archaeological science for many years (Cohen and Armelagos 1984; Cohen 1989; Larsen 1995; Cohen 2008;

Wittwer-Backofen and Tomo 2008). Namely, this important process had a strong effect on human biology and led to an increase in various pathological conditions related to the changes in subsistence strategies and nutrition. Besides changes in diet, increasing sedentism and life in villages close to domestic animals resulted in poor hygienic conditions and higher rates of zoonotic disease (Stock and Pinhasi 2011: 3). Also, infectious diseases, particularly those that cause diarrhoea, could have had a negative effect on the absorption of essential nutrients (Danforth 1999).

Most scholars argue that the shift from hunter-gatherer economy and great variety of foods toward a monotonous diet based on carbohydrates can have negative consequences for the health of a population. The likely nutritional deficiencies are reflected in the prevalence in the Neolithic of various dental and skeletal pathological conditions and growth disturbances. Numerous studies have shown that, with the advent of the Neolithic, frequency of caries increased due to the diet rich in carbohydrates (Turner 1979; Powell 1985; Larsen et al. 1991; Larsen 1995). A great number of studies (Rose et al. 1978; Smith et al. 1984; Teegen and Schultz 1997; Al-Abassi and Sarie 1998; Krenz-Niedbała 2001; Wittwer-Backofen and Tomo 2008) also demonstrate that, with the emergence of agriculture, enamel hypoplasia, which reflects childhood physiological stress (Goodman and Armelagos 1989), became more frequent because human diet switched to being mostly based on domesticated plants. Although crop-based diet may have ensured longer periods of feeling full, malnutrition was common since the farmers' diet was deficient in many of the essential nutrients. In this context, two other non-specific stress markers, cribra orbitalia and porotic hyperostosis, also have also higher occurrence in the Neolithic (Angel 1984; Smith et al. 1984; Papathanasiou 2005). They are often interpreted as indicators of childhood nutritional stress, more specifically – iron deficiency anaemia (Stuart-Macadam 1989; Ortner 2003). Since the new, agricultural diet may have caused lack of essential nutrients and, moreover, inhibited absorption of iron, these two conditions could have resulted from it.

Whilst most of the studies focused on the impact of agricultural way of life on human health and demography, there is also research on the impact of the Neolithic Transition on other aspects of human biology. To this end, numerous studies focused on the changes in behavioural characteristics, work load and activity patterns of people at the advent of the Neolithic (Larsen 1995; Larsen and Ruff 2011; Lieverse et al. 2011;

Marchi et al. 2011; Stock et al. 2011; de Becdelièvre et al. 2013a, 2015a, 2016). They suggest that changes in the diet affected activity levels, which led to the decline in mobility and resulted in a general decrease in skeletal robusticity. However, this process had regional variations (Ruff 2008; de Becdelièvre et al. 2016). Some studies examine the process of 'human domestication' (Stock and Pinhasi 2011) based on the idea that, during the transition, human populations underwent morphological (Leach 2003) and behavioural changes (Wilson 1991), same as domesticated plants and animals.

Another field of study that also provides evidence on how the shift to agriculture impacted human biology is human genetics. The selective pressure on the genome, resulting from stresses connected to the agricultural shift, has been detected. A great deal of evidence indicates selection in the number of genes related to lactase persistence (Burger et al. 2007) and amylase gene copy variation (Perry et al. 2007, cited in Stock and Pinhasi 2011), as a direct result of dietary change. Early Neolithic humans in the Central Europe did not possess lactase-persistence (LP) allele which means that they could not digest milk (Gerbault et al. 2013). The earliest evidence for the presence of this allele in Europe comes from Scandinavian hunter-gatherers (5400-3400 BP) (Malmström et al. 2010) and Neolithic farmers (between 5000 and 4500 BP) in Spain (Platinga et al. 2012). Lactase is the enzyme required to break down milk sugar lactose. Children almost universally can digest lactose in their mother's milk, meaning they are lactase persistent. However, as they are growing up, most of them switch off the lactase gene. The lactase persistence was not possible without fresh milk, which led to a gene-culture co-evolutionary model where lactase persistence is only favoured in cultures practicing dairying and dairying is more favoured in lactase persistent populations (Itan et al. 2009).

Milk residues have been detected in potsherds at southeast European Neolithic sites: in the Danube Gorges (Schela Cladovei, Romania) (Evershed et al. 2008) and in Ecsegfalva (Hungary) (Craig et al. 2005). This could suggest that Neolithic people from the region studied in this thesis also exploited milk products, due their close proximity to the sites of Schela Cladovei and Ecsegfalva. Genetic studies showed that LP-associated allele probably started to be positively selected in Central Europe between the 7th and the 5th millennium BC (Itan et al. 2009). Although consumption of dairy products has a lot of benefits, the fact that Early Neolithic people were intolerant to lactose could mean that they suffered from a number of gastro-intestinal problems which could cause anaemia. On the other hand, the consumption of milk and dairy products has its advantages since it represents a rich new source of nutrients, calcium and vitamins D, A and B12. Lactose helps absorb a number of minerals, such as Mg and Zn. Also, dairy products are available almost year-round, they can be stored for longer periods and can sustain communities when harvests fail.

The addition of milk and cereals to the diet certainly contributed to the shorter period of breastfeeding, since mothers had a good replacement for their own milk and a possibility to make gruels. Indeed, the process of weaning is known to disturb mothers' ability to stay pregnant while breastfeeding, which thus affects female fertility (Vitzthum 1994; Wood 1994; Ellison 1995; Stuart-Macadam and Dettwyler 1995). A shorter period of breastfeeding, along with the shorter lactation amenorrhea, may have resulted in a reduction of the interval between births and may have enabled women to have more children. Relevant studies suggest differences in terms of infant feeding practices between foragers and agriculturalists (Schurr and Powell 2005; Waters-Rist et al. 2011; Howcroft et al. 2014; de Becdelièvre et al. 2014; 2015b; Јовановић et al. 2015; Tsutaya et al. 2015). Although the duration of breastfeeding was often longer in hunter-gatherer populations, some scholars suggest that there is no evidence that such populations lacked foods appropriate for weaning (Swellen and Smay 2001). However, it is difficult to imagine how hunter-gatherers' diet (mostly fish and meat) could have been more appropriate food for children than Neolithic milk and cereals.

In spite of disputes between scientists on the impact and consequences of the Neolithic Transition, today most of them agree that agriculture was a consequence of the increasing population pressure, competition for resources and globally favourable climatic conditions which resulted in general health decline among agriculturalist populations (Belfer-Cohen and Goring-Morris 2009; Cohen 2009; Denham 2009; Zeder and Smith 2009; Stock and Pinhasi 2011). However, these are general trends which cannot explain regional and temporal variations that are highly important if we want to understand a complex process such as Neolithisation. Recent research on human populations, human genetic diversity, animal domestication and plant cultivation demonstrated that cultural and biological changes associated with the transition are more complex than previously thought.

Although the process of Neolithisation led to population growth, at the same time, it had an adverse effect on people's health and well-being. A considerable emphasis in the research has been placed on understanding the reasons for health decline simultaneously with the increase in population size. Did higher fertility rates and larger reproductive capacity result in a number of negative health outcomes (Stock and Pinhasi 2011: 3)? The answers are not simple and straightforward since the process was not uniform. Certain variability exists in the overall impact of agriculture depending on the region, time, local environment and cultural factors.

Through the study of diet and health within this thesis, it will be inferred how the new way of life impacted Neolithic communities in the Central Balkans. This will expand our knowledge of the bioarcheological aspect of the Neolithic Transition and will offer further insights into the effect on a regional scale of the process that was critical for the development of human species.

1.4. Neolithisation of the Central Balkans

The questions of how the Neolithic package and the Neolithic way of life advanced in Europe have been, for many years, discussed by many scholars (Anderson 1992; Zvelebil et al. 1998; Price 2000; Tringham 2000; Bocquet-Appel and Bar-Yosef 2008). The so-called Neolithic package, which includes domesticated plants and animals, pottery and sedentary lifestyle, arrived to Europe from the Near East. The staple crops (wheat, barley and pulses) and herded animals (cattle, pig, sheep and goat) of the European Neolithic were originally domesticated in the Near East around 10 000 BC (Price 2000). Their expansion across Europe took place relatively quickly, within the period of approximately 3000 years (Price 2000). From Anatolia, the Neolithic spread across the Aegean and into Greece, and then split into two main routes. The first, which went by land, brought the Neolithic package into southeastern Europe and the Central Balkans. The second route went across the sea, bringing the Neolithic to the northern Mediterranean. The next step was characterized by an explosive expansion of farmers across central Europe. The Neolithic package spread to Europe through several possible mechanisms of diffusion: migration, colonization in small groups, infiltration, gradual winning of border territories and contacts for exchange (Zvelebil and Lillie

2000). However, this process did not take place all over Europe uniformly and it was characterized by a number of regional variations.

The Balkan area, where influences from the Middle/Near East and continental Europe intersect, is critical for understanding the process of Neolithic transition. Nowadays most scholars agree that cultural origins of the southeast European Neolithic lie in the Neolithic communities of Anatolia (Bar-Yosef 2004; Pinhasi et al. 2005; Bocquet-Appel et al. 2009; Krauβ 2011; Özdogan 2011). The oldest Neolithic culture in this region is Starčevo culture (6200-5200 BC) (Garašanin 1979; 1982; Tasić 1997; Whittle et al. 2002; Biagi and Spataro 2005; Borić 2009) which was named after the type-site Starčevo in Serbia and represents the westernmost unit of the large early Neolithic cultural complex called Starčevo-Körös-Criş. The complex extended across southern Hungary, northern Croatia, Serbia, eastern Bosnia and northern Macedonia (Tringham 1971; Gimbutas 1991; Russell 1993; Tasić 1997; Bailey 2000; Minichreiter 2006). It unites several Early Neolithic cultures in southeast Europe which are similar in terms of material culture, but are different in the cultural and territorial sense. Besides Starčevo culture, this complex also includes the Körös culture in eastern Hungary and the Criş culture in Romania. In a broader sense, it encompasses the Čavdar-Kremikovci-Karanovo culture in Bulgaria and the Anzabegovo-Vršnik culture in FYR Macedonia (Minichreiter 2007).

It could be hypothesized that the appearance of regional groups derived from the population heterogeneity of the Starčevo complex. It is possible that, at the beginning of Neolithisation in the Balkans, the local populations were mixing with the newcomers. They adopted the Neolithic package and material culture but, under the local influence, this could have resulted in regional variations. On the other hand, the central position of the Starčevo culture in relation to the other regional variants of the Early Neolithic, and the communication between them, could have led to the occurrence of Starčevo elements in all of these areas (Tasić 2007).

The central role for understanding the Mesolithic-Neolithic transition in the Balkans is played by a series of sites in the Danube Gorges region, along the Serbian-Romanian border. These sites demonstrate a continuity of life along the Danube from the Early Mesolithic to the Early Neolithic (10000-5500 cal BC) (Borić 1999, 2002a, 2002b; Radovanović 1996; Roksandić 1999, 2000; Borić and Miracle 2004; Borić and

Stefanović 2004). Different forms of evidence from these settlements suggest that Mesolithic hunter/fisher/gatherers of southeast Europe adopted the sedentary way of life prior to and independent from the adoption of animal and plant husbandry (Bonsall et al. 1997; Price 2000; Radovanović 2006; Dimitrijević et al. in press). Around 6300 BC, half of the Neolithic package arrived in the area (Borić and Dimitrijević 2007). This was the time when last hunter-gatherers and first farmers started to develop intensive contacts (Borić and Dimitrijević 2009; Borić and Price 2013) which are best seen in the appearance of early Neolithic pottery, polished stone axes, Balkan flint and spondylus beads at these sites. This was followed by a change in the burial practice; the main position of the skeleton changed to the flexed position, typical of the Early Neolithic. However, at the same time, Mesolithic traditions remained highly visible and, as Borić (2011) noted, "it presents a fascinating example of cultural hybridity of forager-farmer interactions in the Danube Gorges that lasted probably not longer than two centuries. This cultural hybridization was expressed in all aspects of life, from body decoration, to the appearance of artistic depictions and elaboration of architectural symbolism" (Borić 2011: 157).

In the following sections, regional specifics, economy, mortuary practice and bioanthropological research of the Starčevo culture are discussed.

1.4.1. Economy of the Neolithic communities

1.4.1.1. The Danube Gorges

The inhabitants of the Mesolithic-Neolithic sites in the Danube Gorges were semi-sedentary and sedentary hunter/fisher/gatherers. A recent study by Dimitrijević and colleagues (in press) showed that a significant degree of sedentism existed in the Danube Gorges already in the Late Mesolithic, prior to and independent from the adoption of animal and plant husbandry.

The economy of the Mesolithic-Neolithic communities in the Danube Gorges remained almost unchanged during the entire occupation sequence, probably due to the specific micro-climate. Favourable climate and the abundance of water, trees and other plants and animals provided secure food sources and contributed to the continuity of life in this region. Mixed oaks forests grew on the river banks from the Mesolithic onwards

(Filipović et al. 2010). The Danube Gorges sites occupied excellent riverside positions and were located near many whirlpools which would have enabled specialized fishing, especially of big species (Bartosiewicz et al. 2008; Dinu 2010; Živaljević 2012).

Archaeozoological analysis. The sites of Lepenski Vir, Vlasac and Padina yielded a significant amount of animal bones, originating from house floors, pits and various waste deposition areas (Bökönyi 1969, 1972, 1978; Clason 1980; Dimitrijević 2000, 2008). In terms of wild game, the most numerous at these sites are the remains of red deer, which was most commonly hunted animal; they are followed by the remains of wild boar, roe and aurochs (Bökönyi 1969, 1970, 1972, 1978; Clason 1980; Dimitrijević 2008). Big game (especially red deer and aurochs) constituted an important part of the diet due to the large amount of meat that they provided (Dimitrijević 2000). Further, they were hunted for their fur, as were rodents (beaver and rabbit) for their fur and meat. Mesolithic-Neolithic inhabitants of the Gorges also hunted various waterfowl species for their meat and feathers, while other birds were targeted mainly for their feathers (except for raven). Regarding changes in the strategy of hunting through time, the only new wild species that were added to the hunted repertoire in the Neolithic were onager and utva (Radovanović 1992). At Hajdučka Vodenica, the identified species include wild and domestic cattle, wild and domestic pig, domestic dog, red and roe deer, brown bear, chamois, rodents and fish (Greenfield 2008). The relative percentages of Early Neolithic domesticates are higher at Hajdučka Vodenica than at the contemporary sites in the Danube Gorges (Padina and Lepenski Vir), but lower than in most Early Neolithic assemblages outside the Gorges (Greenfield 2008). The wild taxa at Hajdučka Vodenica lack diversity when compared to faunal datasets from the other sites in the Gorges. For instance, mollusc shells have not been found in the Hajdučka Vodenica faunal assemblage, whilst many of them were found at other sites in the Gorges. Greenfield (2008) suggests that the absence of shells is a result of the sampling bias. Thus one could assume that the Hajdučka Vodenica inhabitants probably exploited molluscs as well.

Generally, all of the sites in the Danube Gorges (Lepenski Vir, Vlasac, Padina, Hajdučka Vodenica) for which archaeozoological data are available show prevalence of wild animal remains. The only site in the Gorges with more domesticates is Mihajlovac-Knjepište where caprines are the dominant taxon (Bökönyi 1992).

Concerning fish, the remains of various cyprinids (Cyprinidae), Wels catfish (*Silurus glanis* Linnaeus 1758), migratory sturgeons (Acipenseridae) and huchen (*Hucho hucho* Linnaeus 1758) have been discovered at Lepenski Vir, Padina and Vlasac (Bökönyi 1969, 1978; Clason 1980; Dinu 2010; Živaljević submitted). The proportions of remains of different fish vary between the sites. For instance, there is an absolute dominance of catfish at Padina (Živaljević submitted). On the other hand, Lepenski Vir assemblage contains a significant number of cyprinid, catfish and huchen remains, but also a much greater quantity of sturgeon remains in comparison to Padina and Vlasac (*ibidem*). At Hajdučka Vodenica, only a few fragments of fish bones were discovered (Greenfield 2008). The data on faunal remains from the site of Ajmana are lacking.

Archaeozoological analysis (Živaljević submitted) suggests that, given their abundance in the assemblages, fish played important role in the diet of the Danube Gorges communities. Noteworthy, the large size of certain species (beluga sturgeon and catfish in particular) and the fact that approximately two-thirds of their overall weight represent edible protein (*ibidem*) strongly indicate that fish was an important component of the diet. In addition, large females produce over ten kilograms of roe (nutritious caviar), which could also have been consumed by the Danube Gorges inhabitants (*ibidem*). Smaller species of fish, such as those from carp and herring family, which were probably hunted with nets and in large quantities, could have also had a substantial role in the diet (*ibidem*). However, given the poor preservation of fish bones in comparison to those of mammals, it is difficult to assess whether hunting or fishing occupied a more important role in the Danube Gorges diet (*ibidem*). It is most likely that wild game and freshwater fish, which were available throughout the year, represented staple food, whereas fishing large sturgeons took place in the early spring and in autumn, coinciding with the annual migrations of sturgeons from the Black Sea (*ibidem*). Fish and wild game meat could have been smoked on large stone hearths and stored for winter (Dimitrijević et al. in press).

Concerning domesticated animals, remains of dog, pig, cattle and sheep/goat were also found in the Danube Gorges. The analysis revealed that dog was locally domesticated in the Mesolithic (Bökönyi 1975, 1978; Dimitrijević and Vuković 2015). Cutmarks and traces of burning recognised on dog bones suggest their slaughter and /or defleshing by humans (Clason 1980; Dimitrijević 2008). All other domesticated animals start to appear after 6000/5900 BC and were introduced in the Gorges from the south Balkans (cattle) and Near East (sheep/goat) (Борић and Димитријевић 2009).

Archaeobotanical analysis. Although archaeozoological analysis show meat and fish seems to be staple human food over the whole Mesolithic-Neolithic sequence, inhabitants of the Gorges likely consumed various plants which would have provided nutrients essential to their health. Plant remains have been recovered from only few sites in the Danube Gorges. These are, primarily, pollen grains from Lepenski Vir, Vlasac, Icoana and Cuina Turcului (Carciumaru 1973, 1978; Gigov 1969; Pop et al. 1970) which are useful as a basis for the reconstruction of past vegetation and landscape. The analysis of pollen grains retrieved from human coprolites from Lepenski Vir and Icoana shows presence of deciduous and coniferous trees. However, it is difficult to link pollen with human food unless we assume that people consumed flowers (and pine cones), which they may have used as spice, tea or for medical purposes (Filipović et al. 2015). Pollen analysis did not supply evidence for cereal cultivation in the Gorges (Gigov 1969). Archaeobotanical samples were collected at the site of Vlasac and they yielded fruit stones of Cornelian cherry and dogwood, as well as fragments of hazelnut shell, seeds of dwarf elder, possible fragments of roots/tubers and nut kernels and a seed of grass-like wetland plant (sedge) (Filipović et al. 2010; Borić et al. 2014). If intended for human food, the recorded nuts and berries could have been stored for longer periods. In the ongoing analysis of some soil samples from Lepenski Vir (collected in the 1960's) no seed/fruit remains have been encountered (but significant quantities of charcoal are present – Allué et al. 2015). Given the very few sites analysed, and the low visibility/poor preservation of plant material at these sites, it is difficult to assess the role of plants in the diet based on the remains of seeds and fruit. However, plant remains in the form of starch grains may offer more information.

On the surface of a grinding stone found in the Mesolithic layers at Vlasac granules of starch were detected (Filipović et al. 2015). As starch is the main component of tubers and nuts, this may be another indicator that these plant parts represented food. Further research on plant micro-remains preserved in human dental calculus, conducted in the course of the ERC BIRTH project, revealed the presence of starch grains (probably coming from wheat – *Triticum* sp.) (Filipović et al. 2016). Thus, the possibility of cereal cultivation in the Gorges has to be further explored.

Stable isotope analysis on human bones. At the beginning of the 7th millennium, the Danube Gorges communities, which strongly relied on fishing, went through a period of change. This was a gradual process since a number of Neolithic retained this reliance on aquatic resources. One of the possible explanations for a high input of aquatic food, unusual for Neolithic communities elsewhere in Europe, lies in the high likelihood that Mesolithic traditions were still embedded in everyday life. Although the stable isotope analysis shows a high dependence on aquatic products throughout the Danube Gorges Mesolithic/Neolithic sequence, an increase in the consumption of terrestrial resources (less aquatic proteins, possibly more carbohydrates) has been noted at some sites (Lepenski Vir, Ajmana) from the Neolithic period (Grupe et al. 2003; Borić et al. 2004; Nehlich et al. 2010; de Becdelièvre in prep.; Jovanović et al. submitted).

Pottery. Typical Starčevo pottery appears in the Danube Gorges around 6200 BC. The pottery assemblage is marked by fine monochrome (usually red) pottery and less fine but also light-coloured white painted pottery, with characteristic triangle-motif (Garašanin and Radovanović 2001). The coarse-made pottery is also present and often decorated in the barbotine technique. Some of the pottery finds could have been produced locally, such as receptacles with large opening, on low foot, interpreted as used for preparing or serving dishes made from large fish (Garašanin and Radovanović 2001). Besides the Danube Gorges, these characteristic recipients were also found at the Donja Branjevina site (Garašanin and Radovanović 2001).

Chipped stone tools. In terms of chipped stone industry, the local Mesolithic tradition seems to have been very important throughout the Neolithic sequence (Radovanović 1995). One important difference is the increase in retouched blades and decrease in geometric microliths in Lepenski Vir, whilst in Velesnica the local influence is reflected by the presence of trapeze of characteristic shape, with a concave retouched narrower side (Šarić 2014). The appearance of long blades in the Starčevo culture is connected to changes in economy towards agricultural production. Since geographical conditions at Lepenski Vir prevented agriculture to become fundamental economic activity, this site represents an exception to the overall remarkable number of long blades found at the Danube Gorges sites. On the other hand, the persistence of former

Mesolithic traditions can be seen in the appearance of tranchets the Starčevo layers, but found exclusively at Lepenski Vir (Šarić 2014).

The essential raw materials for chipped stone industries during the Mesolithic were of local origin. A small percentage of non-local obsidian tools (from the Tokay Presov region) suggest the existence of exchange networks. A more significant role of exchange can be observed from the beginning of the Neolithic based on the appearance of yellow spotted Balkan flint. This type of flint is the most prominent raw material in the Early and Middle Neolithic of Oltenia, Banat and Transylvania, as well as at the Körös sites in Hungary (Šarić 2014; Radovanović 1996).

Ground stone tools. The ground stone industry was built upon the Mesolithic foundations and developed independently, mostly in line with the basic needs of the Danube Gorges inhabitants (Antonović 2003: 143). Various types of tools were made exclusively from pebbles, which makes this region different to the rest of Serbia. Tools such as mallet-sceptres, grindstones, hammer stones, pebble-axes and mallets with grooves were probably used for hunting of wild animals or for fishing of large fishes. They appeared mostly in the Mesolithic (Vlasac, Lepenski Vir, Padina, Hajdučka Vodenica), whilst some types continued to be in use in the Early Neolithic. The tools typical of the Starčevo culture (ground-edge tools, axes and adzes characterized by semi-circular cross-section, made of specific hard and fine-grained rocks of grey-green colour) appear at the start of the Neolithic.

Osseous tools. Concerning the Mesolithic bone industry in the Danube Gorges, the most common raw materials were antlers and bones of deer and aurochs. Furthermore, teeth of wild boar, deer, bear and beaver were also utilized (Radovanović 1992: 311). Different kinds of tools were found: awls, points, projectile points, needles, harpoons, chisels, wedges, burnisher wedges, burnishers, punches, hafts, spatulas, spatula-spoons, scrapers, amulets (Srejović and Letica 1978; Bačkalov 1979; Radovanović 1992). There are significant differences between the sites in the quantity of tools. Most bone tools were found at Vlasac, whilst at the other sites bone tools are not as numerous. This could be due to the excavation/recovery bias (Bačkalov 1979). Burnished tools and axes-hammers were not found at Lepenski Vir (Radovanović 1992). Picks have not been discovered at Padina. Harpoons were discovered at Vlasac and Kula (Vitezović 2011b).

Various hunting tools, projectiles and harpoons made from bones and antlers, chisels made from long bones of ungulates, as well as rich antler industry and massive tools for woodworking are also characteristic for other Mesolithic cultures in Europe (Vitezović 2010). Antler was the dominant raw material through the entire Mesolithic (Radovanović 1996) and continued to be important in the Neolithic (Vitezović 2010). Persistence of the Mesolithic tradition is also seen in the techniques of antler working but also in the particular form of boar tusk points, antler chisels and projectile points (Vitezović 2011b).

1.4.1.2. Early Neolithic outside the Danube Gorges

Although many Early Neolithic sites have been documented in the regions to the west of the Danube Gorges, in the territory of the Central Balkans and the southern edge of the Pannonian Plain, they were not studied to the same detail as the sites in the Danube Gorges. Furthermore, human skeletal remains are rarely found at sites outside the Gorges and thus the information on the lifestyle of these Early Neolithic communities is limited.

The two regions are characterised by contrasting environments – lowlands of the southern Pannonian Plain and valleys and hills of the Central Balkans. Different environments may have dictated different economic strategies of the Early Neolithic communities.

Archaeozoological analysis. The subsistence economy of Neolithic communities outside the Danube Gorges is known mostly through archaeozoological analysis in Vojvodina, of the sites Nosa (Bökönyi 1984), Ludoš-Budžak (Bökönyi 1974), Sajan-Domboš (Vörös 1980), Golokut (Blažić 1985), Starčevo (Clason 1980), Donja Branjevina (Blažić 1992, 2005), Zlatara (Blažić 1995), Šašinci (Blažić 1995), Malo Kuvalo-Krnješevci (Blažić 1995), Prosine-Pećinci (Blažić 1995), and in Central Serbia – the sites of Bataševo (Марковић et al. in preparation), Divostin (Bökönyi 1988), Bukovačka Česma (Greenfield 1993), Bunar and Blagotin (Arnold and Greenfield 2006). The main domestic animals were cattle, sheep, goat and pig. However, there are some differences in terms of domesticates between the sites. At Sajan-Domboš, Golokut, Zlatara, Starčevo, Divostin and Bukovačka Česma cattle seems to have been the most important economic species, while at Nosa, Ludoš-Bužak, Donja Branjevina, Bataševo and Blagotin caprines are best represented. Among the wild fauna, the most common are red deer, wild boar, aurochs and roe deer. At Nosa, most ubiquitous are the remains of *Equus hydruntinus* – a relict Pleistocene species of small horse (Bökönyi 1984). Other wild resources, such as fish and waterfowl, have also been documented in small amounts at sites located near water bodies. At some sites the evidence is represented by the material retrieved through sieving, and at others by artefacts (e.g. net weights and fishing spear points).

In contrast to the sites in the Danube Gorges, almost all of the Early Neolithic sites in Central Serbia and Vojvodina yielded much higher percentages of domestic than wild fauna. However, at Nosa, Golokut and Bukovačka Česma remains of wild animals are more frequent then the remains of domesticates. High percentages of wild animals at these sites may be explained by the properties of the local environment; it is possible that some of the sites were chosen specifically because of the location favourable for hunting, or that hunting was simply a common supplementary activity in regions with abundant game and more modest agricultural potential (Orton 2008). In the Danube Gorges, except the local environment, Mesolithic traditions of hunting and fishing could also have influenced the high wild:domestic ratios.

Archaeobotanical analysis. Similar to the sites in the Danube Gorges, archaeobotanical data for Early Neolithic sites outside the Gorges are scarce but they still provide some grounds for discussion. The paper by Filipović and Obradović (2013) provides a good overview of archaeobotanical research in the Neolithic of Serbia. The analysis of plant remains have so far been conducted only for six Early Neolithic sites (Blagotin, Drenovac, Međureč, Starčevo, Belotić, Divostin and Nosa). Filipović and Obradović (2013) also mention two other sites where cereal remains were mentioned in the excavation reports, but were not examined. Throughout the Neolithic, hulled wheats (einkorn and emmer) are the most frequently recorded crops, followed by barley (Filipović and Obradović 2013). Free-threshing wheat (*Triticum aestivum/durum*) was found only in Belotić in the hand-picked material (and is ambiguous in terms of age). The sporadic finds of common millet (*Panicum miliaceum*) at Early Neolithic sites (Starčevo, Nosa) cannot be connected to their cultivation and probably represent weeds of cultivated crops. Oat (*Avena* sp.) was found only at Drenovac and it is unlikely that it was cultivated in the Neolithic (Filipović and Obradović 2013). Concerning pulses, only pea and lentil are documented at the Starčevo culture sites. Among traces of collected wild fruits, Cornelian cherry is most common, followed by apple, pear and blackberry. There are also remains of various flowering plants and grasses that could have been used for medical purposes (Filipović and Obradović 2013). The tree species recorded in the charcoal assemblages signal the presence of mixed oak (and beech) forest around the Early Neolithic sites.

Stable isotope analysis on human bone collagen. Stable isotope analyses were conducted for only few sites located outside the Danube Gorges.The two relevant studies (Whittle et al. 2002; Nehlich et al. 2010) document mostly terrestrial diet with only minor input from aquatic resources.

Pottery. Early Neolithic Starčevo pottery can be divided into three main groups: coarse ware, fine monochrome ware and painted pottery. Coarse pottery is usually decorated in barbotine technique or by nail indentations. Fine monochrome ceramics is usually red coloured; most common ornaments are channels. The fine ware is painted white over red base, light colour on dark background, or is polychrome; ornaments generally include geometric designs (zigzag lines, checkerboard or garland). The decoration also consists of net patterns, spirals, garlands and floral motifs. The pottery assemblages consist mainly of globular and semi-globular vessels, sometimes on foot, bowls and altars. The majority of potsherds contain organic inclusions (in the form of cereal chaff); this kind of tempering is the main and widespread characteristic of pottery technology at almost every Early Neolithic site in the Central Balkans (Garašanin and Radovanović 2001).

Chipped stone tools. Starčevo chipped stone industry shows a decrease in the range of types and the disappearance of many specialized tools (Šarić 2014). The most common types were retouched and unretouched blades, geometric microliths, endscrapers, double sidescrapers, perforators, truncations with abrupt retouch, “splintered” tools, composite tools, chisel-like tools, projectiles, hammer stones, anvils, anvils-hammer stones. The tools were mostly used for cutting, scraping or drilling, engraving, processing of soft materials such as leather, for working horn/antler or bone, for making needles. Various types of chert, chalcedony, yellow spotted Balkan flint, quartz, quartzite, and obsidian were used as raw materials.

The appearance of long blades is the main characteristic of the Starčevo culture and it is most likely related to certain improvements in agricultural techniques. Blades had the widest use as parts of composite tools, whilst they could also have been used as multifunctional tools. This tendency resulted from changes in the economy prompted by the increasing significance of agriculture and cultivation of cereals. Cereals were harvested using sickles consisting of numerous short blades or geometric microliths obliquely embedded in a haft, or using composite knives. The knives consisted of one or two long blades embedded parallel to the handle axis (Šarić 2014: 186). The microlithic component of the Starčevo culture is an element of the Tardenoisian influences that were widespread in the Balkan area. The influence of the old Mesolithic traditions is most evident at Donja Branjevina based on the presence of numerous microblades and a well-developed industry of geometric microliths.

Ground stone tools. In contrast to the Danube Gorges, the ground stone industry outside the Gorges was an entirely developed industry, characterized by clearly defined and mature types of tools (Antonović 2003). The tools were mostly made of fine-grained rocks and metamorphic rocks of grey and grey-green colour, light white stone, igneous and other rocks (e.g. calcite, jadeite). Mold and tongue-shaped axes, chisels and adzes are the most frequent types, followed by hammers, picks, grindstones, pounders, mallets and weights (Antonović 2003). The main purpose of axes was tree cutting; adzes were used for wood working which is evident from the characteristic microwear traces on these ground stone tools. Besides wood working, Starčevo ground stone tools could also have been used in manufacture of other tools out of stone, bone and horn; for milling of cereals grains and other plant parts; for leather cultivating (tanning); and in soil working (Antonović 2003). Considering the traces of use, these ground stone tools were very rarely used in farming. Neolithic agricultural tools (e.g. hoes, axes, hammer-axes, pickaxe, plowshares, planters, saws, trashing tools, millstones and grinding slabs) have been found in small numbers and do not shed much light on the nature of agriculture in the Early Neolithic.

Osseous tools. The bone industry of Starčevo communities is similar to the concurrent bone industries in the region (Vitezović 2010). Although Mesolithic traditions were maintained, there were some new features of Near Eastern origin. Bone raw materials included different vertebral bones, antlers of cervides, teeth of different animals and mollusc shells. All of these materials, except *Spondylus* shell, were available locally. There are differences in the bone: antler ratio between the sites suggesting that, perhaps, antler was not abundant or not available at some sites, and was obtained through some form of short-distance exchange (Vitezović 2011a: 6). The analysis indicates narrow choice of the available raw materials in terms of the species and the skeletal elements. The typological repertoire was very diverse: awls, points, projectile points, needles, fishhooks, harpoons, chisels, wedges, burnishers/wedges, burnishers, punches, hafts, spatulas, spatula-spoons, scrapers, decorative objects (such as pendants, beads, bracelets). Traces of use observed on these tools suggest that they could have been used for various activities such as processing hide, clay, plant fibres and wood (Vitezović 2010). Among them, the most conspicuous tool type is spatula-spoons made from cattle metapodials and found at almost all of the analysed sites; they are especially numerous at Donja Branjevina and Starčevo (Vitezović 2011a). They are also recorded at other Neolithic sites in the region as well as in the Near East. The surface of these objects appears highly polished and has dense lines and striations deriving from their use. The frequency of the traces signals that they were not decorative or ritual objects but were used in everyday life (Vitezović 2011a: 17). Some studies suggest that the traces could originate from prolonged contact with soft organic materials (e.g. animal and plant) (Legrand 2007, cited in Vitezović 2011a). Based on their flattened surface and variable size, they are rarely interpreted as spoons used in eating. However, a new study by Stefanović et al. (in preparation) offered a completely new interpretation. Namely, on some of the spatula-spoons imprints of human deciduous teeth were found revealing that the spatula spoons-could have been used in weaning process.

1.4.2. Mortuary practice

1.4.2.1. General characteristics

Throughout southeast European Early Neolithic, including the Starčevo culture, burials are seldom found (Aranđelović-Garašanin 1954; Leković 1985; Borić 2014). Where present, they are mostly in the form of single inhumations located within the settlement, without any grave goods (Гарашанин 1973). Whilst at some of the sites there is continual burying of the deceased over time, at many others there is often only one or two inhumations from a short period of time. The rather ephemeral settlement traces and the destruction of above-ground buildings at Starčevo culture sites could suggest that the site abandonment may have been related to taboos surrounding death (Chapman 1994; Borić 2014).

Although more than 600 Starčevo settlements have been registered, at only ca. 15% of them have human skeletal remains been discovered (Premk et al. 1984; Stanković 1986, 1992; Stalio 1986; Mikić 1988a, 1988b, 1989; Trajković 1988; Karmanski 2005; Marinković 2006; Minichreiter and Botić 2010; Стефановић and Порчић 2015; Stefanović in press; Марковић et al. in preparation). The reasons for the limited number of human burials can perhaps be found in the limited archaeological excavations or, more likely, in the possibility that only a small part of the population was buried within the settlement. Since excavations explain this situation only partially, there could have been other ways of disposing the dead.

All of the burials were encountered within the settlement or adjacent to the settlement. The deceased were usually interred in the following ways: (1) in pits where other cultural material was also deposited, like at Golokut-Vizić (Петровић 1984-1985; Petrović 1987), Blagotin (Stanković 1992), Donja Branjevina (Karmanski 2005) and Zlatara (Leković 1985); (2) under the floors of building, as at e.g. Lepenski Vir (Stefanović and Borić 2008) or within cultural layers of the settlements, such as at Bataševo (Марковић et al. in prep.). Special grave structures did not exist, although there are examples of some burial construction elements: at Lepenski Vir some burials were covered or encircled by stone blocks (Borić 2011); at Zlatara there were two (A and B) burial chambers with a ramp (Leković 1985). The burials represent inhumations, both primary and secondary as well as partial (Leković 1985). The main position of the body is flexed position, on the left or the right side. There is no preference in orientation, although there are slightly more burials where the head is pointing toward north-east. So far, no connection between sex, age and burial position has been detected. Sometimes the individual is placed on their back or front and in extended position, and this is documented only in the Danube Gorges region (at Lepenski Vir – Borić 2011). Furthermore, there are instances of burials containing burned bones, secondary burials of disarticulated skulls, as well as burials without skulls (Stefanović in press). Some of the individuals, especially children, may have been wrapped before the burial (e.g. at Lepenski Vir – Borić and Stefanović 2004).

Grave goods are rare and it is generally difficult to distinguish between grave offerings and the objects present in the cultural layer. However, there are usually some objects located adjacent to the body of the deceased, such as one or few pottery vessels generally placed near the head, like at Golokut Vizić (Петровић 1984-1985; Petrović 1987), Zlatara (Leković 1985) and Tečić (Galović 1967); chipped stone tools found at Zlatara (Leković 1985) and Sremski Karlovci[5]; bone awls, spondylus beads, pendants such as those from, Zlatara (Leković 1985) and Lepenski Vir (Borić 2011); and animal bones (e.g. on top of the left hand of the women buried at Golokut-Vizić was a complete auroch skull with horn cores – Borić 1999). Fragments of ceramic pots sometimes cover the burial (e.g. Lepenski Vir, Šašinci). Across the documented graves, adult women are much more numerous than males and more than a quarter of the burials belong to children (Lichter 2001; Borić 2014). Group burials were discovered at some of the sites: Zlatara (Leković 1985), Vinča (Васић 1932, 1934[6]), Jaričište (Стефановић and Порчић 2015), Ajmana (Stalio 1992), Velesnica (Vasić 2008), Lepenski Vir (Stefanović in press). Noteworthy, whenever two or more individuals were found buried together, children were frequently buried with them (e.g. Zlatara, Jaričište, Ajmana, Velesnica). The exception is the group burial at the Vinča site where only adult individuals were found. The burial at Vinča was termed "ossuary'", pit-dwelling "Z", or tomb with entrance hall – "dromos". Since its discovery in 1931, many authors (Васић 1932, 1936; Letica 1968; Tasić et al. 1990; Perić and Nikolić 2006) discussed its architecture but none questioned whether this indeed was a group burial. However, a recently conducted detailed inspection of the original field photo-documentation (available from the Archaeological Collection, Faculty of Philosophy, University of Belgrade) led to a completely different interpretation of this collective grave (Стефановић et al. 2016) suggesting that this could be a Neolithic 'crime scene'.

[5] Field diary, Archive of the City Museum of Novi Sad
[6] Field diary, Center for Digital Archaeology, Faculty of Philosophy, University of Belgrade

1.4.2.2. Interpretations

Although mortuary practices observed at the Starčevo culture sites have a lot in common, there are regional differences, mostly in the Danube Gorges region. The best example as to how Mesolithic funerary traditions were preserved in the Neolithic can be found in the Danube Gorges. At the beginning of the Neolithic, at the sites of Lepenski Vir, Padina and Hajdučka Vodenica, burial practices comply to the Late Mesolithic tradition of extended supine position of the body decorated with typical Mesolithic adornments – carp teeth ornaments (Radovanović 1997; Borić 2005; Borić et al. 2009). Such ornaments often occur in the same burials with *Spondylus* beads, which are element of the Neolithic funerary practice, indicating a revival or continuity of decorative traditions common in the Mesolithic (Borić et al. 2014).

Some new burial-related features also appear in the Early Neolithic. At the site of Lepenski Vir, forty neonate burials were found under floors of the trapezoidal buildings. This practice is also known in the Balkans and Anatolia and could have been introduced to the Danube Gorges through contacts with Balkan and/or Anatolian Neolithic communities (Borić and Stefanović 2004; Stefanović and Borić 2008). However, in the later Early Neolithic phase (after 5900 BC) at Lepenski Vir, after the appearance of domesticates, the dominant burial position was the flexed position. Several of the Neolithic burials at Lepenski Vir belong to non-local individuals (Borić and Price 2013).

Since only a small part of the population was buried inside the Early Neolithic settlements, there are doubts as to who the individuals selected for intramural interments were and what alternative ways of disposal of the dead were in place? Although some scholars (Гарашанин 1973) suggest that Starčevo humans did not pay respect to the deceased and were throwing them in waste pits, this is disputable. The general scarcity of grave goods may indicate that wealth, gender or age differences were not reflected in the mortuary domain, which is in contrast to the both earlier and later periods (Borić 2014: 7). However, some differences in the treatment of the deceased perhaps suggest a kind of hierarchical social organization (Leković 1985). Apart from the fact that some of the adult burials contained grave goods, differences between child burials also point at the existence of some form of differentiation. A good example comes from the site of Zlatara where a child was interred in a complex grave construction, previously used for the burial of an adult male, into which chunks of quartzite and various animal bones were deposited with the child (Leković 1985). This could suggest the existence of a vertical social differentiation and a higher social status of those buried in this particular location (Leković 1985; Borić 2014). It may also indicate possible inheritance rights of the child buried at Zlatara (Borić 2014).

Although data on the Starčevo culture burial customs are generally limited, the observed instances provide some information on the mortuary practice and possibly also social aspects of Starčevo communities, whereas they also reveal the persistence of Mesolithic funerary traditions at the outset of the Early Neolithic of the Central Balkans.

1.4.3. Overview of the previous bioanthropological research

Regarding the bioanthropological analysis in the context of the Mesolithic-Neolithic transition in the studied regions, the Danube Gorges anthropological collection is one of the best documented. In contrast, the data for Early Neolithic sites outside the Gorges are very scarce.

1.4.3.1. The Danube Gorges anthropological collection

The Danube Gorges anthropological collection consists of more than 500 hundred skeletons dated to the period 9500-5500 BC. They derived from the sites located on the Danube's right bank (Padina, Lepenski Vir, Vlasac, Hajdučka Vodenica, Ajmana, Velesnica, Kula) and the left bank (Climente, Icoana, Cuina Turcului, Schela Cladovei). It is one of the largest collections from this period and has an important role in understanding of the process of Neolithisation in Europe. Since its discovery in the 1960's-70's, many scientists have studied this rich human osteological archive.

The first analyses were carried out by J. Nemeskéri and Z. Zoffmann (Zoffmann 1983; Nemeskéri 1969). Subsequently, Ž. Mikić in his study from 1981 explored patterns of gracilization during the Mesolithic-Neolithic transitional period in the Central Balkans (Mikić 1981). Dental analysis was conducted by Đ. Grga (1996); he analyzed teeth of all the Mesolithic and Neolithic individuals from the Danube Gorges. M. Radović (2013) examined the teeth for traces of non-masticatory activities. M.

Roksandić examined non-metric anatomical variants (1999, 2000) and traces of violence (2004) on all of the Mesolithic and Neolithic skeletal remains from the Danube Gorges. As part of her study, she also re-determined sex and age for all of the burials (Roksandić 1999). S. Stefanović conducted a detailed study of the taphonomy of human skeletal remains, re-examination of sex and age (Stefanović in press), investigation of pathological conditions (Стефановић 2012) and musculo-skeletal stress markers (Stefanović and Porčić 2009), as well as the analysis of neonates (Borić and Stefanović 2004; Stefanović and Borić 2008). S. Stefanović and M. Radović conducted pathological analysis (Radović and Stefanović 2013). De Becdelièvre and his co-workers (2013a, 2015a, 2016) carried out analysis of musculo-skeletal stress markers and applied a new technique of morphometric mappings in order to investigate how the process of Neolithisation affected activity patterns of the examined individuals.

Recent paleodemographic research, based on the several independent indicators (C^{14} demography, skeletal demography, archaeo-ethnographic demographic inferences), suggests that the intensity of occupation in the Gorges increased from the Late Mesolithic onwards (de Becdelièvre et al. 2013b; Porčić et al. 2014), whilst the population of Lepenski Vir experienced important growth rate during the transition to the Neolithic (Porčić and Nikolić 2016).

A great number of archaeometric analyses have also been performed on the anthropological material including: direct AMS-dating of human remains or other osteological material found in the burial contexts (Bonsall et al. 1997, 2000, 2004; Cook et al. 2002; Borić and Dimitrijević 2007, 2009; Borić and Price 2013); stable isotope analysis aimed at assessing the diet of the Danube Gorges communities (Bonsall et al. 1997; Grupe et al. 2003; Borić et al. 2004; Jovanović et al. submitted; de Becdelièvre et al. 2015a; de Becdelièvre et al. in preparation) and the length of breastfeeding (de Becdelièvre et al. 2015b; Јовановић et al. 2015); analysis of individual mobility based on strontium isotope signature (Borić and Price 2013); DNA analyses of neonate burials (Čuljković et al. 2008); and tooth cementum analysis as a proxy for determining individual age (Roksandić et al. 2009; Radović 2012; Penezić et al. 2016).

1.4.3.2. Bioantropology of the Early Neolithic communities outside the Danube Gorges in Serbia – overview of the completed analysis

The number of human skeletal remains recovered at Early Neolithic sites in Serbia outside the Gorges is extremely small. This is partially due to the fact that the majority of the remains were not collected during the excavations, or were lost after the excavations (Микић 1989). Thus our knowledge about the physical-anthropological and paleodemographic characteristics of these human groups is severely limited. The analysis carried out on a certain number of skeletons from Starčevo culture sites are primarily basic anthropological examination establishing sex, age and metric data. They were performed for the material from Divostin (Zoffmann 1988), Kudoš-Šašinci (Mikić 1995), Obrež-Baštine (Zoffmann 1976, 2004), Odžaci-Donja Branjevina (Zoffmann 1982-1983), Vinča (Schwidetzky 1971-1972), Golokut-Vizić (Zoffmann 1980, 1986-1987, 1999-2000) and Zlatara near Ruma (Mikić 1995). Recently, Стефановић and Порчић (2015) published detailed analysis of human skeletal remains found at the Early Neolithic site of Jaričište. Besides the basic anthropological analysis, Whittle and his team carried out C^{14} and stable isotopic analysis on human and animal remains from several Early Neolithic sites in central and northern Serbia (Whittle et al. 2002).

The new and additional analytical work on the Starčevo human skeletal remains carried out within this thesis is of high importance, because it provides better understanding of the lifeways of Early Neolithic communities in the study regions.

2. ARCHAEOLOGICAL BACKGROUND TO THE SITES

Human skeletal remains analyzed in this thesis originated from 14 Mesolithic-Neolithic sites spanning the period 9500-5500 cal BC and located in the Balkan Peninsula in southeast Europe. More specifically, the sites are situated in the southern part of the Great Hungarian Plain and the central Balkan area (Fig. 2.1)[7]. Five of them are located in the Danube Gorges region (Padina, Lepenski Vir, Vlasac, Hajdučka Vodenica, Ajmana) situated in the eastern part of Serbia, whilst nine are situated to the

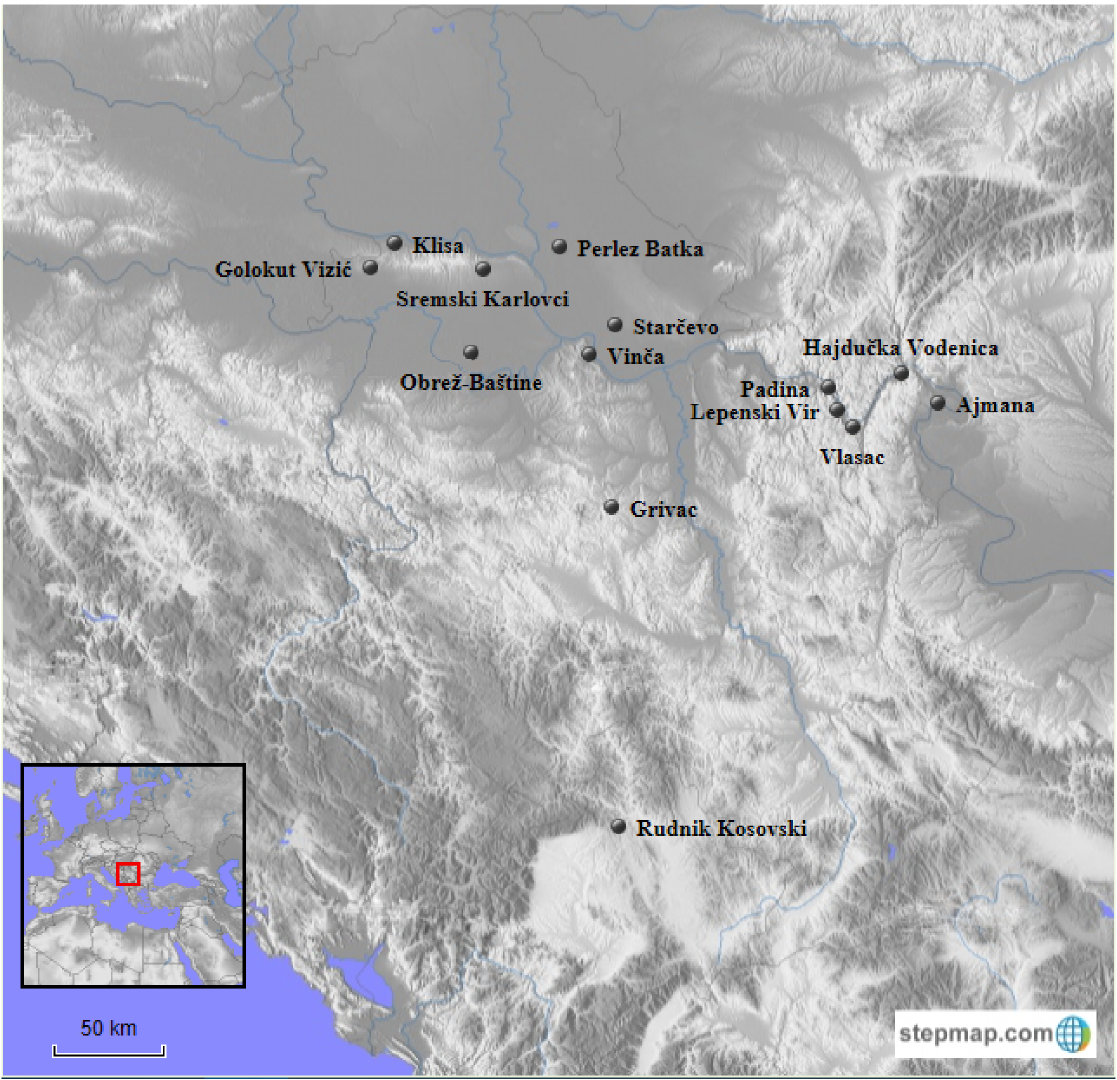

Figure 2.1. Location of the sites from which material used in this study originated

[7] Although some of the sites are located in the southern part of the Great Hungarian Plain, they are close to the Danube River which represents a natural border between the southern part of the Great Panonnian Plain and the Central Balkans.

west from the Danube Gorges, in the regions of Vojvodina (Golokut-Vizić, Klisa, Sremski Karlovci, Perlez-Batka, Obrež-Baštine, Starčevo), Šumadija (Vinča, Grivac) and Kosovo (Rudnik Kosovski)[8]. In this chapter, an introduction is provided to the archaeological sites from which human skeletal remains analyzed in this thesis derived. First, the sites located in the Danube Gorges will be presented and then the sites located to the west from this region.

2.1. Sites in the Danube Gorges

During two large projects of construction of the hydroelectric power plant ("Đerdap I and II") several sites in the Danube Gorges were discovered. The sites of Padina, Vlasac, Hajdučka Vodenica and Lepenski Vir were discovered in the 1960's during the construction of the Đerdap I plant[9]. The site of Ajmana was discovered in the 1980's during the construction of the Đerdap II plant (Stalio 1986). Rescue excavations in the area were conducted by different institutions such as the Faculty of Philosophy, University of Belgrade (Srejović 1969, 1972, 1981; Srejović and Letica 1978), Archaeological Institute in Belgrade (Jovanović1969, 1987) and the National Museum in Belgrade (Stalio 1986).

In the Gorges[10], two different areas can be distinguished: (1) in the Upper and the Lower Gorges the sites of Padina, Lepenski Vir, Vlasac and Hajdučka Vodenica are situated on the river terraces, in the vicinity of whirlpools which provided both good hunting and fishing spots (Borić 2002a; Živaljević 2012); (2) downstream from these sites, at the exit to the Gorges, the site of Ajmana is located in a hilly landscape open to the Wallachian plain, in an environment more suitable for agricultural production.

2.1.1. Padina

The site of Padina is located in the Danube Gorges, downstream from Gospođin Vir (Jovanović 2008). It was excavated between 1968 and 1970 under the direction of

[8] Since one of the aims of this thesis is to assess regional variability of human groups that lived in the Danube Gorges and the communities that occupied the regions to the west from the Gorges (Vojvodina, Šumadija and Kosovo), the latter will be, denoted as communities outside the Gorges.
[9] Đerdap is the Serbian name for the Danube Gorges region.
[10] Only the sites on the Serbian side of the Danube Gorges are considered in this study.

B. Jovanović of the Archaeological Institute in Belgrade. An area of 2325m^2 was excavated within three sectors, all with complex stratigraphies (Jovanović 1969, 1987). The archaeological finds and the radiocarbon dates showed that Padina was inhabited from the Early Mesolithic to the Transitional-Early Middle Neolithic phase (Radovanović 1992; Jovanović 2008; Borić 2011). The absolute dates for Padina range from 9221-8548 cal BC to 5930-5700 cal BC (Borić 2011). The site was also occupied during the Late Neolithic, Iron Age, Roman and Medieval period.

Within the Mesolithic-Neolithic occupation sequence, 21 settlement structures (of which 17 trapezoidal in shape), pottery, dwellings and pit dwellings, hearths, graves and animal bones were found.

Small finds

Typical Starčevo pottery was found only in the Neolithic layers and is mostly represented by fine monochrome examples, while barbotine and painted pottery is absent. Besides spheroid bowls and various biconical shapes, characteristic are open vessels on hollow foot (Jovanović 1974, 1987). Concerning chipped stone industry, unretouched blades, retouched blades, perforators, truncations with abrupt retouch and geometric microliths were found (Radovanović 1981). The essential raw materials for chipped stone industry of the Mesolithic were of local origin, whilst yellow spotted Balkan flint appears in the Neolithic. An important difference between the Mesolithic and Neolithic layers is the increase in retouched blades and decrease in geometric microliths with the advent of the Neolithic (Šarić 2014). However, local Mesolithic traditions remained important throughout the Neolithic sequence (Radovanović 1995). The ground stone industry is represented by cutting tools, mallets, anvils, pounders, hammer stones, querns, altars, grinding/polishing stone tools, axes, tranchets, sceptres, sling balls weights. The cutting tools, mostly used for woodworking, are more frequent in the Neolithic period (Antonović 2003). Bone tools were mostly made from antler, whilst large- and medium-sized ungulate bones were also used. There are finds of various pointed tools, awls, chisels, scrapers, projectiles, hoes (Bačkalov 1979; Jovanović 2008).

Archaeozoological analysis

Archaeozoological analysis shows prevalence of wild animal species throughout the sequence (red deer, wild boar, aurochs, roe deer). Remains of domestic animals (cattle, pig, caprines) appear in Neolithic (except dog) and were not numerous (Clason 1980). Concerning fish remains, the most abundant are catfish, followed by carp, vyrezub, sturgeons (such as beluga, sterlet) and huchen from Trout family (Živaljević submitted).

Stable isotope analysis

Stable isotope analysis of carbon, nitrogen and sulphur (on human and animal bone/teeth collagen) which have been carried out in order to reconstruct paleodietary behaviours (Nehlich et al. 2010; Borić and Price 2013; de Becdelièvre et al. 2015a, 2015b; in prep.; Jovanović et al. submitted) shows that consumption of aquatic products was very important throughout entire Mesolithic-Neolithic sequence. Although, with advent of Neolithic on other Danube Gorges sites (e.g. Lepenski Vir) humans shifted towards more terrestrial diet, whereas on Padina they were still strongly relying on aquatic products.

Burials

Concerning burials, most of them were found around the stone constructions or surrounding later trapezoidal dwellings (Roksandić 1999). In Mesolithic, burial positions are extended supine inhumations or in a sitting position with crossed legs, while in Neolithic they are mostly in flexed position. There are also examples of disarticulated body parts throughout the sequence. According to Roksandić (1999) minimal number of individuals is 52 from defined contexts. There are also 73 fragments of disarticulated bones scattered across the site found during archaeozoological analysis which could belong to these 52 individuals (Clason 1980; Roksandić 1999). Regarding 52 individuals, 26 were buried in single, 14 in double graves, while three grave units had three, four and five individuals each (Roksandić 1999).

Previous bioanthropological analysis

First anthropological analysis of the skeletons was carried out by S. Živanović (1975a, 1975b, 1975c, 1976a, 1979, 1988). M. Roksandić analysed epigenetic variations and did a re-examination of sex and age determinations (Roksandić 1999). After Roksandić, S.Stefanović analyzed skeletal remains for traces of treponemal infections (Стефановић 2012). M. Radović analyzed traces of non-masticatory activities (Радовић 2013). Analysis of musculo-skeletal stress markers and mobility patterns was done by C. de Becdelièvre and his colleagues (2013a, 2015a, 2016). Beside this, stable isotope analysis of carbon, nitrogen and sulphur which have been carried out in order to reconstruct paleodietary behaviours (Nehlich et al. 2010; Borić and Price 2013; de Becdelièvre et al. 2015a, 2015b; in prep.; Jovanović et al. submitted) and length of lactation (de Becdelièvre et al. 2014, 2015b; de Becdelièvre in prep., Jovanović et al. 2014, 2015a; Јовановић et al. 2015). Also, strontium isotope analyses were conducted in order to access the patterns of individual and group mobility (Borić and Price 2013)[11]. Tooth cementum annulation analyses were done to reconstruct individual age and ageing models for this population (Roksandić et al. 2009; Radović 2012; Penezić et al. 2016).

From this site 35 individuals were analyzed in this thesis.

2.1.2. Lepenski Vir

The site of Lepenski Vir is situated in the Upper Gorge, between right bank of the Danube and slope of Koršo hill, near the confluence of Boljetin river. This is a hardly accessible area of the Gorges due to the height of the hills (up to 500m) and narrowing of the Danube. It is located between Padina and Vlasac sites. The site was discovered in the 1960s, prior to the construction of a hydroelectric dam in Danube Gorges area. D. Srejović and his team from Faculty of Philosophy, University of

[11] Strontium is an isotope which exists naturally in water, sediments and soils, enters human body through the food chain (Bentley 2006). The signal of strontium is therefore recorded in human bones and teeth. As tooth enamel is forming during early childhood, it would always reflect geographic signature of an individual’s place of birth (Bentley 2006). By comparing this signature with local strontium values, it is possible to infer geographic origin of individuals and thus hypothesized local and nonlocal people (Bentley 2006). However, one should be careful when interpreting this data and the presence of non-local individuals since there is no adequate geological map for the region of the Central Balkans, meaning these non-locals could have come from approximately 50 km distances.

Belgrade conducted excavations at the site from 1965 to 1970 (Srejović 1969, 1972, 1981). An area of 2500 m^2 was excavated with the archaeological layers of 3.5 m deep on average. However, some 1700m^2 of the eastern part of the site was destroyed by Danube and another 3000m^2 of the site remained unexcavated. In 1969, one of the ground plans of excavated portion of the site was cut into blocks and reconstructed on the terrace some 30 meters above its original position.

The stratigraphy of Lepenski Vir is very well documented since it is among the best C14 dated sites of the period in the region (Bonsall et al. 1997, 2000, 2008, 2015a, 2015b; Borić 2002b, 2011; Borić and Dimitrijević 2005, 2007, 2009; Cook et al. 2009; Borić and Price 2013). Those dates had shown that site was inhabited from Mesolithic through Early Neolithic sequence, as well as during Eneolithic (Летица 1970), Roman and Medieval times.

During Mesolithic (9400 to 7400 cal BC) remains of dwellings, stone hearths, various artefacts, and occasional burials are attested. The main characteristic of this period are the earliest known form of rectangular stone hearths, maybe central part of dwelling constructions. Radiocarbon dates shown that Lepenski Vir was not inhabited during the Late Mesolithic (7400-6200 cal BC). However, on many other sites in the Gorges, including sites of Padina and Vlasac, there is intensive occupation during Late Mesolithic period (Borić 2011).

The site is settled again during the Transitional Period or Mesolithic/Neolithic Transformation phase (6200-5900 cal BC). It is the time when site expressed its fullest development with more numerous and complex trapezoidal dwellings followed by findings of rectangular stone hearths being placed in the centre of each dwelling. There are also findings of extraordinary artistic expressions, especially sculpted sandstone boulders of anthropomorphic fish (Srejović 1981; Borić and Stefanović 2004). In this period non-local people (n=5) started to settle in, as evidenced by strontium ratios (Borić and Price 2013). However, one of the most important changes of this period is the appearance of Early Neolithic technologies such as pottery, polished stone axes, yellow-spotted Balkan flints (Borić 1999; Garašanin and Radovanović 2001; Srejović 1971; Antonović 2006; Borić 1999; Kozlowski & Kozlowski 1984) as well as typical Neolithic *Spondylus* beads (Borić 2011). As suggested by Borić (2011), this is also another line of evidence that intensive contacts existed between Neolithic people in the

Gorges with Early Neolithic communities across the region. Another Neolithic phase lasted from 5950-5550 cal BC, when important changes occurred in the lifestyles of Lepenski Vir communities. The old Mesolithic cultural elements disappeared (Borić and Price 2013) and almost all the trapezoidal buildings have been abandoned. Findings of several domed ovens as well as pits filled with daub and wattle fragments implies to the new kind of architecture. Also, this is the time when the highest number of the non-local individuals appeared, mostly females (Borić and Price 2013).

Small finds

Chipped stone tools were made mostly from flint, quartz, quartzite, and obsidian. At the advent of Neolithic so called „yellow spotted Balkan flint“ appears. Tools types are various: retouched and unretouched blades, perforators, sidescrapers, endscarpers, wedges, tranchets (Kozlowski and Kozlowski 1984, Radovanović 1996; Šarić 2014). The appearance of long blades in remarkable numbers, which are main characteristic of the Starčevo culture, could be explained as indicator of contacts with farming communities in the Balkans. However, although some new Neolithic elements appear, some local Mesolithic traditions are still pronounced, which can be observed in findings of tranchets, whereas, as a survived element in the Starčevo material, they can be found at Lepenski Vir exclusively (Radovanović 1996, Šarić 2014). Ground stone industry was represented by various chisels, axes, adzes, hammers, sceptres, grinders/polishers, ponders, ground edge tools, mallets, anvils, pounders, hammerstones, amulets, weights, tranchets (Antonović 2008). They were made from sandstone, limestone, fine grained rocks, basic magmatic rocks, nephrite, malachite, etc… Ground edge tools which were mostly used for woodworking are more present in Neolithic period (Antonović 2008). Concerning the osseous industry, tools were mostly made from antler while large and medium sized ungulate bones were also used. There are findings of various pointed tools, awls, chisels, scrapers, projectiles, hoes (Bačkalov 1979; Radovanović 1996).

Archaeozoological analysis

From archaeozoological record, the most dominant animal species through entire Mesolithic-Neolithic sequence are red and roe deer, wild boar and various fishes (cyprinides such as carp, vyrezub; Acipenseridae such as russian sturgeon, sterlet, beluga; and others such as catfish and huchen) (Bökönyi 1969, Dimitrijević 2000, 2008; Živaljević submitted). Dog has been locally domesticated during the Mesolithic (Dimitrijević and Vuković 2015). There are traces of cutmarks and burning on dog remains suggesting people could have used them for food. One of the most important changes concerning faunal remains is noted around 5900 cal BC with the appearance of domesticated animals, such as cattle, sheep/goat, and pig (Borić and Dimitrijević 2007). However, remains of fish and wild animals remain very abundant in the faunal spectrum suggesting that diet was based on an intensive fishing and hunting at the start of Neolithic.

Archaeobotanical analysis

Archaeobotanical analysis show the presence of mixed oak forests and pine forests, while no seed or fruit remains were found, except two seeds of elderberry (Allué et al. 2015). The palynological study which was carried out in 1969 (Gigov) shows no evidence for cereal and plant cultivation. For a long time, this lack of plant remains has been interpreted by scholars as evidence that hunter-fisher-gatherers were resisting to the introduction of the new farming system, but may simply be due to the fact that the Gorges are not a suitable environment for development of such cultures (Borić 2011). However, a new analysis of microremains in human dental calculus shows presence of starch grains which probably belong to wheat (Filipović et al. 2016). Thus, the latter hypothesis should be reexamined.

Stable isotope analysis

Many stable isotope studies on carbon, nitrogen and sulphur have been carried out in order to reconstruct paleodietary behaviours (Bonsall et al. 1997, 2000, 2002, 2004; Borić et al. 2004; Grupe et al. 2003; Nehlich et al. 2010; de Becdelièvre et al. 2014, 2015a, 2015b; Jovanović et al. 2015a, submitted). Analyses show that during Mesolithic period inhabitants of Lepenski Vir were strongly relying on aquatic products and hunted game. However, at the beginning of 7th millennium they experienced time of change with an increase in the consumption of terrestrial resources (less aquatic proteins, possibly more carbohydrates). This was a gradual process since lots of Neolithic individuals were still relying on aquatic products (Grupe et al. 2003; Borić et al. 2004; Nehlich et al. 2010; Jovanović et al. submitted). Nonetheless, diet of Neolithic humans from Lepenski Vir differs from their counterparts living in other sites in the Gorges (e.g. humans at Ajmana had more terrestrial diet while on Padina and Hajdučka Vodenica they had more aquatic diet) (Jovanović et al. submitted).

Burials

At Lepenski Vir 134 graves with minimum number of 190 individuals have been excavated (Roksandić 1999). Also, 42 more individuals have been detected but from different unidentified archaeological contexts (Roksandić 1999). In funerary practice during the Mesolithic period the most representative are extended supine inhumations, but there is also a few seated burials in lotus position or with crossed legs. At the advent of Neolithic, around 6200 cal BC in the burial rite, there is continuity with previous Mesolithic practices of extended supine position parallel to the Danube, often placed in burial pits cut through the floors of trapezoidal buildings. However, a major change is observed in children funerary practices. They are buried as single inhumations beneath the red-plastered floors of Lepenski Vir. Around 40 neonates have been discovered and they are often found close to the hearths or in the rear part of the houses (Stefanović and Borić 2008). Infant burials inside the dwelling structures appear also during Neolithic throughout the Balkans and eastern Mediterranean (Stefanović and Borić 2008). However, around 5900 cal BC there are significant changes in mortuary practice when the first flexed inhumations appeared, which is linked to typical Neolithic mortuary rite. This could be connected with intensive contacts that local people in the Gorges had with farming communities, which settled in the Balkans around 6200 cal BC (Borić and Price 2013).

Previous bioanthropological analysis

First anthropological analysis of the skeletons was carried out in 70-ies. J. Nemeskéri, Z. Zoffmann and Ž. Mikić were among the first who analyzed skeletal remains from this site (Nemeskéri 1969; Zoffmann 1983; Mikić 1981). Đ. Grga performed dental analysis (Grga 1996). M. Roksandić analyzed epigenetic variations and also she did a re-examination of sex and age determinations (Roksandić 1999). S.Stefanović analyzed skeletal remains of neonates and children from Lepenski Vir (Borić and Stefanović 2004; Stefanović and Borić 2008, Pinhasi et al. 2011), and she also did re-examination of sex and age (Stefanović in press), pathological analysis (Стефановић 2012), and musculo-skeletal stress markers (Stefanović and Porčić 2009). Stable isotope analysis of carbon, nitrogen and sulphur have been carried out in order to reconstruct paleodietary behaviours (Bonsall et al. 1997, 2000, 2002, 2004; Borić et al. 2004; Grupe et al 2003; Nehlich et al. 2010; de Becdelièvre et al. 2015a, 2015b; Jovanović et al. 2014) and length of lactation (de Becdelièvre et al. 2014, 2015b; Jovanović et al. 2014; Јовановић et al. 2015). Also, strontium isotope analyses were performed to access the patterns of individual mobility (Borić and Price 2013). B. Čuljković performed ancient DNA analysis of neonates (Čuljković et al., 2008). Tooth cementum annulation analyses were conducted to reconstruct individual age and ageing models in this population (Roksandić et al. 2009; Radović 2012; Penezić et al. 2016).

From this site 75 individuals have been analyzed in this thesis.

2.1.3. Vlasac

Vlasac is situated in the Upper Gorge, on the right bank of the Danube river. Absolute dates for Vlasac range from 7035-6698 cal BC to 5700-5500 cal BC (Borić et.al 2014). D. Srejović and Z. Letica conducted the first excavations of Vlasac in 1970-1971 (Srejović and Letica 1978). An area of 640 m^2 was investigated with various findings from Mesolithic, Neolithic and Eneolithic periods. After, the site was flooded with the construction of the Đerdap Dam I leaving a big lake behind. However, in 2006 the water level dropped and created a small riverbank which enabled new excavations at this spot (Borić 2014). The new excavations lasted from 2006-2009 under the direction of D. Borić. An area of 326 m^2 was investigated, which probably represents the southernmost part of the site.

Vlasac was inhabited from the late Mesolithic through Early Neolithic. During the old excavations five dwellings with floors of reddish crushed limestone mixed with sand, 26 rectangular stone hearths as well as 17 stone constructions of unclear functions have been discovered (Srejović and Letica 1978). Additionally, a vast number of portable findings and 87 graves were also investigated (Bökönyi 1978, Srejović i Letica 1978, Nemeskery and Szatmary 1978, Roksandić 1999). During the new excavations (Borić 2006, 2008; Borić et. al 2014) an area of 326 m^2 was explored. In this context, two dugout features (possibly dwellings), several cremation pits with burnt human remains, as well as 16 inhumation burials and scattered human remains, have been discovered. Also, Early Neolithic Starčevo pottery was found at Vlasac, and C14 dates indicate it probably did not have reached Vlasac before ca. 6000 cal BC (Borić et al. 2014).

Small findings

The chipped stone industry is represented by retouched and unretouched blades, truncations, irregular scrapers, chisel-like tools, splintered pieces, perforators and microliths, such as backed pieces, micro-retouched bladelets, and trapezes (Kozlowski and Kozlowski 1982; Srejović and Letica 1978; Borić et al. 2014). The most common raw materials are quartz and occasionally yellow spotted Balkan flint. Usewear analysis showed traces of various materials such as wood, bone, hide and meat (Borić and al. 2014). The ground stone tools were made from sandstone boulders, amphibolites, aplite, micaschist and chert. These raw materials are similar as in the other sites in the region and are locally available (Antonović 2006). Anvil is the most frequent tool, followed by hammerstones, fishstunners, massive blunt axes (Srejović and Letica 1978; Borić et al. 2014). Traces of usewear showed hammerstones were used for flintknapping, or to make borers and shaft-straighteners, which were possibly used for bone tool manufacturing or bead making (Borić et al. 2014: 18). There is also a finding of one small polished shoe-last stone adze, which is a typical Neolithic tool. Residue analysis detected presence of starches on two hammerstones, indicating they could be used for crushing nut kernels.

Osseous tools were made from bone, antler and ivory (Srejović and Letica 1978; Borić et al. 2014; Cristiani and Borić in press). The most important raw materials were bones and antlers of red deer, followed by wild boar lower canines/tusks. There are various types of tools: pointed tools (awls and curated points), edged tools (blade axes,

axes, straight wedges on bone splinters), and lateral cutting edged tools (knives and gorges). Manufacturing debitage has also been identified. Usewear traces and tool morphology indicate that these tools were used in different activities such as woodworking, hunting and fishing. The traces of woodworking can be assigned to the long term occupation of the site. This also, along with other tools, indicates wood could be used for possible construction of dwellings or in making canoes (Borić et al. 2014). Similar osseous repertoire is present on other Late Mesolithic sites in the Danube Gorges (Beldiman 2005; Dinu et al. 2007). However, no changes in osseous tools have been detected with advent of Neolithic, as it is the case with Lepenski Vir site (Borić and Cristiani 2016). One of the possible reasons as proposed by Borić and Cristiani (2016) lies in the changing nature of the site at the end of 7th millennium BC, when the site started to be used primarily as a burial ground.

Archaeozoological analysis

Concerning faunal remains, the most abundant are remains of red deer, followed by dog, wild boar, roe deer, while less than 2% of the sample comprises of all other species: aurochs, various carnivores (brown bear, wolf, red fox, marten, badger, wild cat), hare, and beaver (Bökönyi 1978; Borić et. al 2014). Traces of burning and cutmarks were detected on dog remains suggesting their dismemberment and/or defleshing by humans. There are also bird remains, but only two have been positively identified as a white-tailed and imperial eagle, probably hunted for their feathers which could be used for body decoration (Borić et al. 2014). Among fish remains Cyprinids family (various species of carp, vyrezub, bream) are the most numerous along with catfish, pike, pike, pearch, huchen and sturgeons (Živaljević submitted). Cyprinid pharyngeal teeth, perforated or unmodified, were often used as ornaments in burials (Borić et al. 2014).

Archaeobotanical analysis

Macrobotanical analysis showed that most abundant taxon was Cornelian cherry (Cornus mas L.). Concerning charcoal remains, the most significant taxa are *Cornus*, *Quercus* sp. deciduous, *Prunus*, *Quercus* ssp. deciduous, *Corylus*, and *Cotinus* (Allué et al. in press; Filipović et al. 2010). It seems that Oaks comprised the main part of the forest. Pollen analysis from human coprolites showed pollen grains from species with potentially edible parts (e.g., *Pinus*, *Quercus*, *Juglans*, *Corylus*) (Cărciumaru 1978). This indicates they could be selected for food, which in that case could represent good sources of valuable vitamins and minerals (Borić et al. 2014).

Stable isotope analysis

Stable isotope ratios documented that during the whole Mesolithic-Neolithic sequence, humans at Vlasac were strongly relying on fish consumption (high $\delta^{15}N$) (Borić et al. 2004; Nehlich et al. 2010; Jovanović et al. submitted). Furthermore, changes in $\delta^{34}S$ and $\delta^{13}C$ values also suggest that Late Mesolithic groups may have included more anadromous and potamodromous species of fish in their diet (Jovanović et al. submitted).

Burials

During the old excavations 87 graves with 164 individuals (Roksandić 1999) were excavated at Vlasac. In the course of new excavations 16 individuals from both primary and secondary inhumations along with seven cremation burials have been investigated (Borić et al. 2014). Burial customs remained almost unchanged through entire Mesolithic-Neolithic period. During the Mesolithic period main burial position is extended supine parallel to the River Danube and with the heads largely pointing downstream (Borić et al. 2014). This position also appears at many other Late Mesolithic sites in the region. Together with burials there are often findings of perforated/unmodified pharyngeal carp teeth (they were probably attached to the some sort of cloak) as well as exotic materials such as beads made of *Cyclope neritea* and *Columbella rustica* marine gastropods (Borić et al. 2014). Furthermore, there was also a practice of exhuming skeletal elements of already decomposed bodies, their additional fragmentation and burning in nearby pits (Borić et al. 2014). Sometimes bodies are covered with stone blocks. There are also burials of neonates beneath the red-plastered floors (Borić and Stefanović 2004; Stefanović and Borić 2008).

Although these burial rites remained almost unchanged with the advent of Neolithic, some new elements also appear. A typical Neolithic ornaments in Vlasac burials started to replace old Mesolithic body decorations (carp teeth, marine gastropod beads) (Borić et al. 2014). Even though, sometimes new and old body decoration appears together, illustrating the contacts between local foragers and first farming communities that settled the Balkans (Borić et al. 2014). New ornament features are characterized by ovoid shaped *Spondylus* shell beads, white and red discoid limestone beads. These new forms are coming to the local foragers from Neolithic cultural repertoire through the network of social interactions (Borić et al. 2014).

Previous bioanthropological analysis

First anthropological analysis of the skeletons was carried out by Nemeskery and Szatmary (1978). After, M. Roksandić analyzed epigenetic variations and did a re-examination of sex and age determinations (Roksandić 1999). Soon after, Roksandić (2004) examined traces of violence on human skeletal remains. After Roksandić, S.Stefanović analyzed skeletal remains for traces of treponemal infections (Стефановић 2012). M. Radović analyzed traces of non-masticatory activities (Радовић 2013). Analysis of musculo-skeletal stress markers and mobility patterns was done by de Becdelièvre and his colleagues (2013a, 2016). Beside this, stable isotope analysis of carbon, nitrogen and sulphur have been carried out in order to reconstruct paleodietary behaviours (Nehlich et al. 2010; Borić and Price 2013; de Becdelièvre et al. 2014, 2015a, 2015b; Jovanović et al. 2015a, 2015b, submitted) and length of lactation (de Becdelièvre et al. 2014, 2015b, 2015c; Jovanović et al. 2014, 2015; Јовановић et al. 2015a). B. Čuljković performed ancient DNA analysis of neonates (Čuljković et al. 2008). Also, strontium isotope analyses were conducted to obtain results of geographic origin and access mobility patterns (Borić and Price 2013). TCA (Tooth cementum annulations) analyses were performed to reconstruct individual age and ageing models in this population (Roksandić et al. 2009; Radović 2012; Penezić et al. 2016).

In this thesis 83 individuals from the site of Vlasac (old excavations) were analysed.

2.1.4. Hajdučka Vodenica

The site is situated in the Lower Gorge on the right bank of the Danube, between Vlasac and Ajmana. It was excavated in the course of rescue excavation between 1965 and 1969. An area of 630 m^2 was investigated (Jovanović 1969; Јовановић 1984). Absolute dates for Hajdučka Vodenica range from 7076-6699 cal BC to 6016-5726 cal BC, which indicate that site was occupied from Late Mesolithic to Early Neolithic period (Borić and Miracle 2004). The site was also occupied during the Iron Age, Roman and Medieval periods.

The Mesolithic-Neolithic settlement can be situated in the middle of the cove near a spring. There are two different areas of the site which can be attributed to the Mesolithic-Neolithic period (Jovanović 2008). The first involves settlement area where rectangular stone hearths were found, as well as a large number of bone tools, and shallow pits with traces of burning. Starčevo pottery was also detected (Jovanović 1968, 1969). These are mainly monochrome vessels, especially bowls and pots-amphorae (Jovanović 2008). The second area consists of burials where a number of individuals were placed in extended positions underneath and associated with a specifically constructed rectangular hearth, which was surrounded by a packed flooring of red burned earth (Jovanović 1984).

Chipped stone tools were generally absent and there are only cores and debitage products (Jovanović 2008). Ground stone tools were not numerous. There are findings of mallet-scepters, mallet-weights, hammerstones, anvils and pounders which were made from locally available materials (Radovanović 1996; Antonović 2008). Osseous industry was represented by various tools: anvils, hammerstones, points, awls, chisels, scrapers, projectiles, and small hoes made from antler, large and medium sized ungulate bones (Jovanović 2008).

Archaeozoological analysis

Archaeozoological analysis showed high prevalence of wild species (red deer, wild boar, aurochs) through entire Mesolithic-Neolithic sequence (Greenfield 2008). In Neolithic domestic animals appeared (cattle, pig). Dog was also present from Mesolithic time. Surprisingly, there was small amount of fish remains, which is not the case at other Mesolithic-Neolithic sites in the Gorges.

Stable isotope analysis

Stable isotope analysis of carbon, nitrogen and sulphur have been carried out in order to reconstruct paleodietary behaviours (Borić et al. 2004; Nehlich et al. 2010; de Becdelièvre et al. 2014, 2015a,b,c; Jovanović et al. 2015a,b; Jovanović et al. submitted). Humans at Hajdučka Vodenica had strong reliance on aquatic products throughout the Mesolithic-Neolithic sequence. Although at some of the sites (e.g. Lepenski Vir) some humans turned their diet toward more consumption of terrestrial products with advent of Neolithic, at Hajdučka Vodenica people continue to eat mostly aquatic products.

Burials

Concerning burials, they were extended inhumations placed parallel to Danube with the heads pointing downstream. They were buried in single, double or multiple burials (Roksandić 1999). There were no grave goods and only a massive red deer antler was found placed at the entrance to the burial chamber. The total number of 32 burials was identified containing at least 46 individual skeletal remains (Roksandić 1999). The main burial position is extended supine.

Previous bioanthropological analysis

First anthropological analysis of this material was conducted by S. Živanović (1976b). M. Roksandić analyzed epigenetic variations and also she did a re-examination of sex and age determinations (Roksandić 1999). S. Stefanović did pathological analysis (Стефановић 2012). Stable isotope analysis of carbon, nitrogen and sulphur have been carried out in order to reconstruct paleodietary behaviours (Borić et al. 2004; Nehlich et al. 2010; de Becdelièvre et al. 2014, 2015a, 2015c; Jovanović et al. 2015b, submitted) and length of lactation (de Becdelièvre et al. 2014, 2015b, in prep.; Jovanović et al. 2014, 2015a; Јовановић et al. 2015). Also, strontium isotope analyses were conducted (Borić and Price 2013). Tooth cementum annulation analysis was performed in order to reconstruct individual age and ageing models in this population (Roksandić et al. 2009; Radović 2012).

In this thesis 37 individuals from the site of Hajdučka Vodenica were analyzed.

2.1.5. Ajmana

The site of Ajmana is located at the downstream exit of the Danube Gorges, on the slope of the Danube River, in the village of Mala Vrbica (Stalio 1986). On the opposite bank of the Danube, across Ajmana, in the direction of north-west there is another Mesolithic-Neolithic site of Schela Cladovei. It is situated in a landscape more suitable for agricultural practices downstream from the main Mesolithic-Neolithic sites in the Danube Gorges area. Excavations were carried out in 1981, 1982 and 1984 under the direction of Blaženka Stalio (Stalio 1986; 1992). The area of 701 m^2 has been investigated and 29 trenches have been discovered. The thickness of the cultural layer varies from 1.20 to 1.80 m, reaching up to 2.26 m. The site was occupied several times from the Early Neolithic through Eneolithic, Bronze Age, Iron Age, Roman period to the Medieval period. Most of the features at the site are related to the Early Neolithic occupation on the basis of the abundant Starčevo culture pottery. Radiocarbon dates (6214-6008 cal BC to 6030-5842 cal BC) confirms Early Neolithic sequence of the site which range (Borić and Price 2013) and suggest the existence of a newly founded fully Neolithic settlement which is contemporaneous with hunter-fisher-gatherers' sites in the upstream area (Borić and Price 2013). Several pits with pottery, collective burial, one house, remains of oven and daub have been discovered during the excavations.

Small finds

Coarse pottery is the most representative and among it the most common shapes are spherical and semi-spherical bowls. Pottery is decorated in barbotine technique with finger imprints and nail pinching. The most common shapes of the fine pottery are conical and semispherical bowls without decoration. The painted pottery is the least represented and it is ornamented with red painted linear and other curvilinear motifs on a white slip. Regarding these pottery finds, the Ajmana settlement can be dated to the late phase of the Starčevo culture (Stalio 1986). In addition to a standard pottery assemblage, the site yielded pottery objects of special function, namely altars with rectangular base and circular recipients. Clay weights and spindle whorls were also found (Stalio 1986).

Ground stone tools were represented by mallet-weights, grinders, ground edge tools such as axes, adzes and chisels (Stalio 1986). The local workshop for producing stone axes was also discovered. There are also findings of various chipped stone and osseous tools (Stalio 1986). Wild animal bones and remains of shells were also found (Stalio 1986). However, a detail archaeozoological anaylsis has not been carried out yet.

Stable isotope analysis

Stable isotope analysis of carbon, nitrogen and sulphur document mostly terrestrial dietary pattern with a little input of aquatic resources (Borić 2011; Jovanović et al. submitted). It is interesting to note that, although on other sites in the Gorges (e.g. Lepenski Vir, Padina, Hajdučka Vodenica) humans are mostly relying on aquatic products, at Ajmana situation is different and the main dietary focus is on terrestrial food resources.

The collective burial, circular in shape (2.5 x 1.8 m) was discovered in trenches XVIII and XXI with 17 individuals placed in several levels one on top of the other. They were buried in flexed position with no grave goods (Stalio 1986; Radosavljević-Krunić 1986). First anthropological analysis was conducted by S. Radosavljević-Krunić (1986). Strontium isotopic ratios suggest three individuals (graves 2/81, 7, and 15) had non-local origin (Borić and Price 2013). However, although graves 7 and 15 belong to Early Neolithic period, burial 2/81 belongs to Iron Age[12].

In this thesis 15 individuals belonging to the Neolithic period were analyzed.

2.2. Sites outside the Danube Gorges

2.2.1. Golokut- Vizić

The site of Golokut is situated on glade bordered by trees, on an altitude of 195-200 m.asl at the western part of Fruška Gora Mountain, in Srem region (Petrović 1984-5). It is located 2 km southwest of small village of Vizić, 5 km from village Neštin and 6.5 km from the Danube river. It has been discovered by archaeological field survey in

[12] Due to presence of green colour (usually obtained in contact with metal objects) on the bones of individuals (2/81 and 2/82) and detailed examination of available literature these individuals do not belong to Early Neolithic period.

1965, and soon after, in 1973, the Museum of Vojvodina started excavations under the direction of Jelka Petrović. The excavations lasted until 2003 with minor interruptions, with more than 50 explored trenches. Two occupation layers have been identified, both belonging to one phase of Starčevo culture. Beside Starčevo phase, occupation layers from Vučedol and Vinkovci culture have also been detected here (Petrović 1976, 1978, 1984-5, 1985, 1987, 1990, 1999-2000).

The site has been radiocarbon dated all around the middle of the sixth millennium BC (from 5630-5470 cal. BC to 5560-5360 cal. BC) (Whittle et al. 2002: 108). Concerning Starčevo layer, several pits with pottery and osteological finds, dug in dwellings, above ground constructions, remains of hearths and ovens, as well as 6 graves, have been discovered during the excavations. In one surface deposit there was a concentration of floor and wall remains.

Small finds

Pottery finds are mainly spherical and semi-spherical bowls with flat bottoms and fine beakers with high hollow pedestals, decorated in coarse barbotine technique, painted with dark spiraloid and other curvilinear and straight designs on red surface. Barbotine decoration is very common, but monochrome finish and nail pinching decoration were not frequent here. In addition to a standard pottery assemblage, the site yielded pottery objects of special function, namely altars on four legs (Petrović 1984-5, 1987). Chipped stone tools are not numerous. The most representative are uni- and bilaterally retouched blades, made from obsidian, cherts, red radiolarite and so called “pre-Balkan platform flint“ (Šarić 2014; Kaczanowska and Kozlowski 1984-5). Concerning ground stone industry, there are findings of typical Neolithic mould and tongue-like axes and chisels, as well as querns (Petrović 1984-5, 1987). The bone industry was represented by more than 30 artefacts: awls, needles, various burnishing tools, several decorative objects, and one spatula-spoon (Vitezović 2010). Although, the collected bone artefacts are not numerous, variety of artefact types, as well as traces of working and usewear on them, show that inhabitants of Golokut could be involved in different activities such as processing of leather, plant fibres, clay, and preparation of food (Vitezović 2010: 135).

Archaeozoological analysis

Archaeozoological analysis showed that wild species were much more numerous than domestic ones. In particular, 60-75% belongs to wild animals, and 25-40% are faunal remains from domestic species (Blažić 1985). Cattle are the most representative domestic species, followed by ovicaprines, while pig and dog bones are noted in a small percentage. Among wild species, the most numerous are remains of deer, roe deer, aurochs and in a small numbers remains of wild boar and hare. Also, mollusc shells were discovered from the genuses *Helix* and *Unio* (Blažić 1985). Since the wild species are more abundant at this site, particularly red and roe deer, it can be concluded that hunting was more significant than animal husbandry.

Burials

Concerning human skeletal remains, the first two graves which belong to Starčevo culture were excavated during 1980's: grave 2 in trench 25-25a and grave 3 in trench 30. At that time, excavator of the site was of opinion that individual buried in grave 3 does not belong to Starčevo culture because of its extended position, which is not characteristic for this culture (Petrović 1985). However, almost 20 years after, radiocarbon dating showed it does belong to Early Neolithic period (Whittle et al. 2002). In the paper of Whittle and his colleagues there is a small confusion between female buried in grave 2 (trench 25-25a) and female buried in grave 3 (trench 30). Namely, they wrote that a woman in trench 30 is buried with aurochs skull with horncores, and it is actually women from the grave 2 (trench 25-25a). Beside these two graves, in 1987 dislocated human skeletal remains were discovered in trench 50 which also belongs to Starčevo culture.

Four more graves have been discovered in 2003: three of them (graves 1, 2, and 3) in trench 72, pit 27 and one in trench 78, pit 31 (grave 4). During the anthropological analysis several bones of a child have been observed in one bag marked "grave?" (trench 78, pit 31), but they are not mentioned in the field diary. The main burial position is flexed. Concerning grave goods, only in grave 2/1984 excavators could detect presence of grave goods (which in this case are fragments of aurochs). In all other graves there were often findings of pottery or animal bones, but however it was not possible to assign them securely as a grave good, because they could rather present findings from the cultural layer[13].

Previous bioanthropological analysis

First anthropological analysis was conducted by Z. Zoffmann (1986-87; 2004). For the purpose of this thesis a new anthropological analysis was done and detail anthropological report is available in the catalogue (Appendix 1). The individual discovered in trench 50 in 1987 (inventory number k.46 in Museum of Vojvodina) was not available for this study. The previous analysis conducted by Zoffmann (1999-2000) showed that skeletal remains found in trench 50 belong to female aged 16-17 years, with a healed fracture on the nasal bone and in glabelar region.

From the site of Golokut-Vizić 7 individuals were analysed in this thesis.

2.2.2. Klisa

Klisa is situated in the northern part of Novi Sad, in Bačka region. It is located in the southern part of Pannonian plain, 10 km from the left bank of Danube river. The site is located around 2 km to north-west from Temerinska petlja and highway E-75. The Provincial Institute for the Heritage Protection started rescue excavations in the course of the construction of the pipeline route Gospođinci-Futog in 2000, under the direction of Dragan Anđelić[14]. The site was occupied several times from the Early Neolithic through Bronze Age, Iron Age, Roman and Medieval periods.

Concerning Starčevo layer, numerous pits with pottery and animal bones, dug in dwellings, above ground constructions, bone and chipped stone tools, remains of daub and 5 graves have been discovered during the excavations[15]. There are also findings of mollusc shells from the genus *Helix* and *Unio*.

For the purpose of this thesis three individuals[16] were analysed and their detail anthropological analysis is available in Appendix 1.

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[13] Field diary, documentation of Museum of Vojvodina

[14] Field diary, documentation of the Provincial Institute for the Protection of Cultural Monuments

[15] Field diary, documentation of the Provincial Institute for the Protection of Cultural Monuments

[16] Although five graves have been discovered, only three were available for analysis.

2.2.3. Sremski Karlovci

Sremski Karlovci is a town in Srem, situated on the right bank of Danube river, 12 km from Novi Sad. It lies on the northeastern slopes of Fruška Gora mountain. There are findings from the Early Neolithic through Roman and Medieval periods. In 1997 during the construction of sewerage network in the street Sonje Marinković, around the house number 1, a human skeleton has been discovered[17]. This street is located on the slope of "Stari Breg", on the old bank of the Danube River. Based on pottery finds in the grave, the curator of City Museum of Novi Sad, Divna Gačić, concluded that skeleton belongs to the Starčevo culture[18]. Soon after, the Provincial Institute for the Heritage Protection started small rescue excavations under the direction of Ljiljana Tadin.

Two trenches, 1 and 2 have been explored with dimensions 3.40x0.60m and 1.90x0.60m. One object with the construction made of shells and snails and two graves have been discovered in trench 1. Beside this, a lot of pottery, animal bones, chipped stone tools, mold and tongue-like axes, bone tools and mollusc shells have been discovered during the excavations. In trench 2 only pottery fragments were found. The site yielded ceramic finds typical for the Starčevo culture: coarse pottery decorated in barbotine and impresso technique, fine monochrome and red painted pottery. The most common shapes are conical and semispherical bowls, pots, beakers and altars.

Beside grave 1, two more graves were found. They were subsequently buried inside the object in trench 1. Since they did not contain any grave goods, their chronological determination was not possible. They could belong to the medieval period, given that medieval monastery was found in the vicinity[19].

Thus, only grave 1 which belongs to Starčevo culture is analysed in this thesis and the detail anthropological analysis is available in Appendix 1.

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[17] Above the skeleton one retouched blade was found, while bellow the skeleton chipped stone tool, little fish vertebrae and several fragments of pottery were found. Concerning grave goods, since the pit inside which burial was found was not fully excavated and the character of the pit couldn't be determined, is it hard to tell whether grave goods are really grave goods or content of the pit.

[18] Field diary, documentation of City Museum of Novi Sad

[19] Field diary, documentation of City Museum of Novi Sad

2.2.4. Perlez Batka

The site of Batka is located on the estate of the same name on the bank of river Begej, between Stajićevo and Perlez, about 7 km long (Marinković 2006:69). It is situated at the edge of an old levée of the Tisza River and its tributary R. Begej (Whittle et al. 2002). It has been discovered by archaeological field survey in 1911. Small systematic excavations were done in 1949, while rescue excavations were done from 1972-1979 and in 1989 under the direction of R. Radišić (Museum of Zrenjanin) in collaboration with P. Medović (Museum of Vojvodina). The site is horizontally indented without a deeper stratigraphy. It was divided into four parts: A, B, C and D (Marinković 2006:69). The site was occupied in the Early and Late Neolithic and Iron Age.

The Starčevo culture layer stretches along the whole area of the site. From this phase a great number of pottery was found together with settlement objects, dwellings, pit dwellings, graves and animal bones. The site has been radiocarbon dated all around to the beginning of the sixth millennium BC (from 6090-5880 cal BC to 5920-5720 cal BC) (Whittle et al. 2002).

The pottery finds were done in rough and fine technique. The fine pottery is represented by spherical and semi-spherical vessels with accentuated neck and bottom, as well as conical ones. Among rough pottery barbotine ornamentation is used, mostly decorated by patterned finger and nail pinching (Radišić 1967; Marinković 1996). Among pottery assemblage, finds of one pitos decorated with nail imprints and pinching, as well as a spherical vessel with four nipple-like holds on a bulge decorated with nail pinching are distinctive. Besides pottery finds, several fragments of sacrificial altars with quadrilateral, arching, and cylindrical recipients were found. There are also findings of flat, round and conical weights, axes and knives (Marinković 2006).

The Perlez Batka “B” yielded one grave belonging to Starčevo culture (Marinković 2006). At the site of Perlez Batka “C” eight burials were found without grave goods. They were all buried in flexed position. Three of them were children’s (Marinković 2006).

For purpose of this thesis only two human skeletons were available (Perlez-Batka “C” grave 1 and Perlez-Batka “B” grave?) and their detailed anthropological analysis is given in the Appendix 1.

2.2.5. Obrež-Baštine

The site Baštine is located near the village Obrež in Srem, on the left bank of Sava River. It lies on the loess terrace which rises towards the northeast banks of Obedska bara. It has been discovered by archaeological field survey in 1951 done by Museum of Vojvodina. In 1960 Museum of Vojvodina started small rescue excavations under the direction of Bogdan Brukner. Two trenches, I and II, have been explored and according to examined material the site belongs to Starčevo culture. Dimensions were 10x4, with a total area of 80 m^2. The maximum thickness of the cultural layer is 1.17 m (Брукнер 1960; Brukner 1960a, 1960b.).

Several pits with pottery and osteological finds, remains of hearths and daub, and one grave have been discovered during the excavations. Although, houses were not discovered, remains of daub, together with continuity of layer and content of pits can indicate existence of above ground constructions (Брукнер 1960a: 83).

Small finds

Among coarse pottery the most representative are globular vessels. Finger imprints and nail pinching decoration was very frequent. The most common shapes of the fine pottery are conical and semispherical bowls. Red and yellow painted pottery is ornamented with dark painted spiraloid, linear and other curvilinear motifs. Those pottery finds are placing this settlement in late phase of the Starčevo culture- Starčevo II or Starčevo III (Brukner 1960b). Also, different clay, flint and stone objects were discovered (Brukner et al. 1974). The site yielded pottery objects of special function, namely altars on four and three legs (Brukner 1960b.). There are also findings of clay weights, spindle whorls and querns. The most representative chipped stone tools are retouched blades, and one of them was made from obsidian. Concerning ground stone industry, there are findings of typical Neolithic mold and tongue-like axes. The bone industry was represented by twenty-seven artefacts: awls, needles, projectile points, wedges, burnishers, hafts and sleeves, as well as some decorative objects (discs, buckles) and objects of special use (spatula-spoons) (Vitezović 2010). The collected bone artefacts are typical for Early Neolithic period. Finds of unfinished objects and manufacture debris suggest that bone objects were manufactured at the site (Vitezović 2010: 142). Variety of artefact types, as well as traces of working and usewear on them, showed that inhabitants of Obrež-Baštine could be involved in different activities such as processing of leather, plant fibres, bone tool manufacturing and likely woodworking (Vitezović 2010:135).

Among animal skeletal remains the most frequent are remains of cattle, sheep/goat and deer. The most representative mollusc shells are from the genus *Helix* and *Unio*, but there are also findings of *Limnaea*, *Planorbis* and *Vivipara* (Брукнер 1960; Brukner 1960b).

The only grave from this site is grave 1 which is analysed in this thesis. The detailed anthropological analysis of one individual find in this grave is available in the catalogue (Appendix 1).

2.2.6. Starčevo

The site Starčevo-Grad is a type site of Starčevo culture. It is situated on the left bank of Danube River, on an irregular surface that slopes towards a lower area which was probably marshy and prone to flooding in the past. It is located at the entrance to the modern village Starčevo, 8 km southeast from Pančevo, and just across the river from the Late Neolithic site of Vinča (Живковић 2008). Several excavation campaigns have been carried out in past 100 years. First rescue excavations were carried out in the period 1928-1931 when area threatened by a brick factory was explored. During the first year of excavations, under the direction of M. Grbić seven pits have been discovered. Few years after, Vladimir Fewkes joined M. Grbić and they excavated one trench with dimensions 18.75 x 6.75 m. Two graves were found in two pits (marked as 1 and 2), which were discovered inside the trench. Soon after excavations all content of pits was sent to Harvard University and today it is a part of collection of Peabody Museum of Harvard University (Aranđelović-Garašanin 1954; Ehrich 1977). In 1932 Fewkes started new excavations with the help of Harvard University as well as with the support of American school of prehistoric research. They explored a surface triangular in shape with irregular edges and opened two trenches (1932A i B), with dimensions 13.75 x 7.60 m, and 10 x 2.5 m (Ehrich 1977; Clason 1980). During 1969 and 1970 National Museum in Belgrade started collaboration with American archaeologists and conducted small trench excavations under the direction of Draga Garašanin and Robert Ehrich. In 2003 and 2004 the Institute for the Heritage Protection in Pančevo carried out small trench excavations and total researched area was around 70 m^2. The site has been radiocarbon dated all around to the first half of the sixth millennium BC (from 5930-5720 cal BC to 5540-5310 cal BC) (Whittle et al. 2002).

During all those excavation campaigns several pits and graves were discovered, with a rich inventory of portable finds-pottery, flint, stone and antler artefacts, figurines, altars, etc.

Small finds

Pottery is represented by rough pottery, fine monochrome and painted pottery (Aranđelović-Garašanin 1954). Pottery assemblage consists mainly of globular and semi-globular vessels, sometimes on a pedestal, bowls, altars (Aranđelović-Garašanin 1954). Regarding chipped stone tools, retouched and unretouched blades, long blades, endscrapers, sidescrapers, perforators, geometrical microliths, combined tools, projectiles (Živković et al. 2011). They were made from various raw materials such as obsidian, radiolarite, yellow spotted pre-Balkan platform flint and other silicate rocks. Most of these raw materials were perhaps obtained from central Serbia or more distant places (Živković et al. 2011). Ground stone industry is represented by various axes, adzes, chisels, grindstones, querns made from metamorphic and sedimentary rocks (Živković et al. 2011). Concerning bone industry, a total number of 250 objects was collected, from bone, antler, and boar tusks, including also several artefacts from mollusc shell (Bačkalov 1979; Vitezović 2010). Diverse typological repertoire include various awls, needles, projectile points, chisels, assorted burnishing tools, punches and hammers, hafts, and decorative objects. Finds also included several unfinished pieces and manufacture debris. This indicate that the tools were made within the settlement where people could be involved in different activities such as processing of leather, wood, plant fibres, and preparation of food (Vitezović 2010).

<u>Archeozoological analysis</u>

Archeozoological analysis showed domestic species were much more numerous than wild ones. Specifically, 65% belongs to domestic animals, and 25 are faunal remains from wild species (Clason 1980). Cattle are the most representative domestic species (66 %), followed by ovicaprines (30%), while pig and dog bones are noted in a small percentage. Among wild species, the most numerous are remains of deer, wild boar and aurochs, and in small numbers remains of wild horse (*Equus przewalski*), beaver and otter. According to Clason (1980) a small percentage of pigs can be explained by the fact that Starčevo area was marshy and therefore more suitable for wild boar hunting. Also, remains of fishes, birds and mollusc shells from the genus *Helix* and *Unio* were discovered (Clason 1980).

<u>Burials</u>

During the old excavations 5 burials have been discovered: two children graves, three other graves and additional skull fragments in the burnt layer of pit 5A (Fewkes et al. 1933, cited in Aranđelović-Garašanin 1954). Two children graves were found during the first excavation campaign, inside a pit, but there is no description about position or possible grave goods. The other three graves were found in 1932. Individuals were buried in flexed position with no grave goods. Arandjelović-Garašanin (1954) noted there is no information about exact position of those graves inside the settlement and that some of the human bones are present in pit 3. However, in the study of Whittle et al. (2002) it has been noted that two of those graves, marked as graves 5 and 6 are coming from trench A/1932. Both graves were radiocarbon dated to the Early Neolithic period (Whittle et al. 2002), despite previous doubts about their chronological distribution (Aranđelović-Garašanin 1954). In 2004 one grave was found at the bottom of the pit dwelling in trench 5/2004 (Živković 2008). Since skeletons from old excavations were not available, only grave 1 (found in 2004) which contained two individuals is analysed in this thesis (Appendix 1).

2.2.7. Vinča-Belo Brdo

The site of Belo Brdo in Vinča is situated on the right bank of the Danube River, some 14 km downstream from Belgrade (Tasić 2008). It is located in Šumadija region, on an alluvial terrace of the Boleččica river, made of re-deposited loess (Rundić et al. 2012). The position of the site was probably very attractive for Neolithic communities, since it is located between the Danube River and the Boleččica River, close to its confluence to the Danube. The area was rich in minerals and ores, with hinterland abundant in wild animals and fertile land. As one of the largest tell sites in the Balkans it covers an area of 10 hectares with 9 meters of cultural deposits and a total height of 10.5 m (Chapman 1981; Tasić et al. 1990), where it should be noted that vast part of the tell was eroded by the Danube. The site was occupied several times from the Early Neolithic through Late Neolithic, Copper Age, Bronze Age, Iron Age to the Medieval period. Vinča is the most known for its substantial archaeological deposits from the Neolithic-Eneolithic Vinča culture (Tasić et al. 1990). It is the eponymous site for the whole Vinča culture group.

The first archaeological excavations in Vinča were undertaken by M. Vasić in 1908 (Vasić 1910). Those excavations lasted until 1934 (with some breaks due to Balkan wars and First World War). Excavations were renewed in 1978 and lasted until 1986 under the direction of D. Srejović, N. Tasić, J. Todorović, M. Garašanin and G. Marjanović-Vujović. In 1998 excavations were renewed once again under the direction of N. N. Tasić. New excavation techniques and new recording procedures have been applied using modern surveying technologies and IT.

The earliest occupation at Vinča dates to the middle of VI millennium BC (Letica 1968; Garašanin 1984; Borić 2009; Tasić et al. 2016). Evidence for this phase of occupation is scarce since later Vinča settlement damaged Starčevo layer. From this Early Neolithic phase only one damaged pit and a pit with human skeletal remains are preserved, followed by presence of Starčevo ceramics. This feature with human skeletons has been discovered during the excavations in 1931 under the direction of M. Vasić (Васић 1932). It is also known as "ossuary", pit-dwelling "Z" or tomb with entrance hall – dromos (Васић 1932; Vasić 1936; Letica 1968; Perić and Nikolić 2006). It was found in the central part of the excavated area in 1931 (Tasić et al. 1990) and has an access path. One of the preserved skulls (marked as R1) from this "ossuary" has been dated to 5624 - 5486 cal BC (Borić 2009). The obtained date can be associated with the terminal phase of the Starčevo culture and confirms previous conclusions on the date of this feature, which were based on a presence of Starčevo pottery inside the pit Z (Borić 2009). Pits and pottery findings are the same like those found in other Starčevo sites. Coarse pottery is decorated in barbotine technique with finger imprints and nail pinching. There are also findings of fine and painted pottery ornamented with red painted linear and other curvilinear motifs on a white background.

Burials

Collective burials are rare in Early Neolithic period, especially in Starčevo culture sites where individual inhumations are the norm (Chapman 1983; Tasić et al. 1990; Chapman 2006). Since it was first published in 1932 many scholars have debated about its architecture (Васић 1932; Vasić 1936; Letica 1968; Perić and Nikolić 2006) without questioning does it really represent a burial place. However, during the excavation of this feature, Vasić noted in the field diary based on huge number of scattered human remains that this place probably does not represent a typical burial place (Vasić 1932). In the following years he changed his previous statement by saying that those graves were made "in the shape of house for living people" (Vasić 1931)[20] e.g. pit dwellings.

Burials and previous anthropological analysis

First anthropological analysis of human skeletal remains found in this pit was conducted by I. Schwidetzky in 1937. Since the skeletons were heavily damaged after bombing of Belgrade in the II World War, Schwidetzky did revision anthropological analysis in 1957 and 1971/72. During the revised analysis it has been determined that all skulls were much damaged, and their remains were identified with the help of previous marks on them. They are marked from I-IX. Postcranial bones were pretty damaged after bombing and only few fragments have been preserved and mixed, so it was impossible to know to which individual they belong. I. Schwidetzky took measurements of some long bones before bombing which enable to obtain information on average

[20] Field diary, Center for Digital Archaeology, Faculty of Philosophy, University of Belgrade

stature, which was 161 cm (Schwidetzky 1971-1972; Mikić 1988). Nine out of ten individuals have been found inside the pit and one was found in the entrance hall. One of the possible causes for the death of those people may be a fire at the roof part of the pit (Korošec 1950; Mikić 1988). However, in those skeletal remains pathological changes have not been detected during previous analysis (Mikić 1988).

A recent study and a new perspective

In order to investigate what does this feature represents, a new study was conducted. Namely, Stefanović and her colleagues (2016) examined digital photo documentation as well as field diaries. For the purpose of this study as well as for this thesis re-analysis of human skeletal remains was done. It showed that minimal number of individuals was 12, not 9 like previously observed. Based on this new data, the ideal reconstruction of burial positions was made (Fig. 2.2). Meanwhile, Tasić and colleagues (2015) dated these 9 skeletons that provided absolute dates from 5700 to 5500 cal BC. Only one individual is dated to 5700 cal BC, while others are in the range from 5600-5500 cal BC. Although some of the deceased were buried almost at the same time it is however clear that the burial of these 12 individuals does not represent one single event.

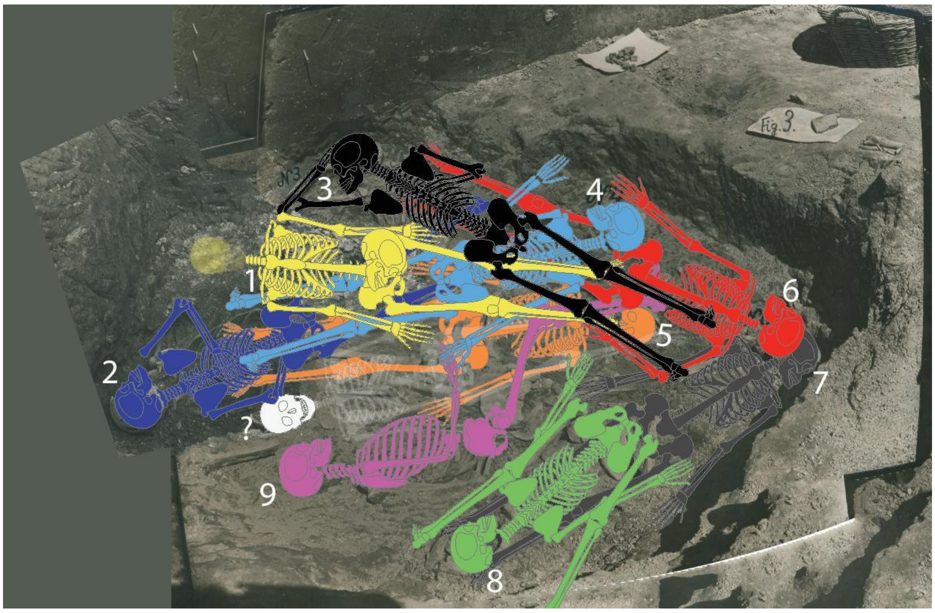

Fig. 2.2. Ideal reconstruction of the individual positions of Vinča burials (reconstruction made by: S. Živanović; from: Стефановић et al. 2016)

A re-analysis of these human skeletal remains done for the purpose of this thesis showed that 2 females, one male and 9 individuals for which sex could not be determined were buried here. The youngest individual was 15-18 years old, while all others are in the range between 20-40 years old. A detail anthropological analysis is available in the catalogue (Appendix 1). Analysis of photo documentation showed none of the deceased was buried in flexed position typical for Starčevo culture (Fig 2.3). Seven individuals were buried in extended position and only one is buried on the side but not in flexed position. All this suggest that this feature with skeletons was not place for burying the deceased. Furthermore, some of the skeletons (II, III, IX) were placed with a face and chest toward the ground which is commonly associated with expression of rejection and taking away dignity of the deceased. One of the alternative scenarios is that maybe those individuals died during sleep due to the suffocation which resulted from fire. However, this scenario is questionable since there are no traces of burning, except on the skeleton I. For this skeleton Vasić also noticed that skull has traces of burning and he is also mentioning a charred beam. During the anthropological analysis for the purpose of this thesis additional traces of burning were also noticed on skull I and one vertebra. All those traces look like they occurred post-mortem.

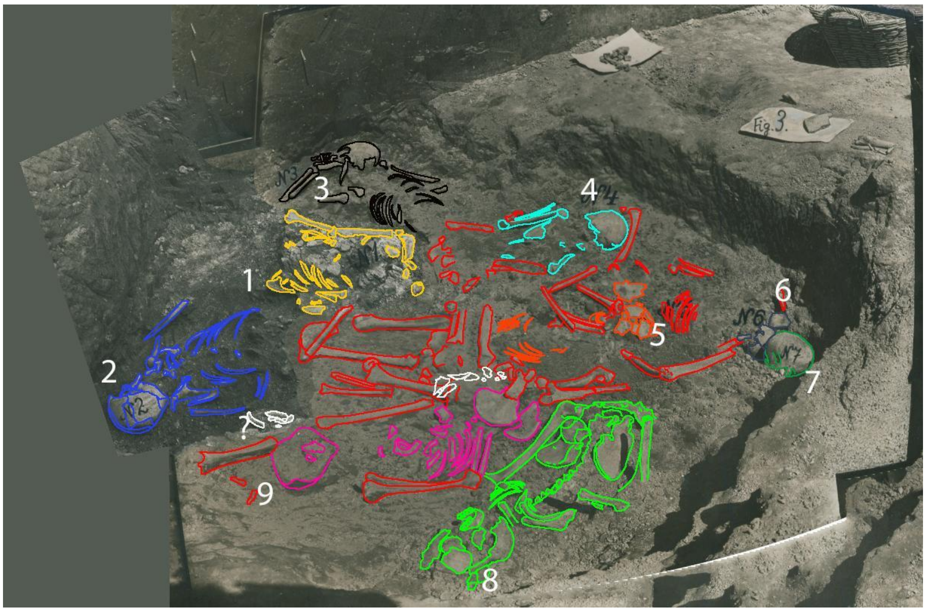

Fig. 2.3. Reconstruction of the individual positions of Vinča burials (reconstruction made by: S. Živanović; from: Стефановић et al. 2016)

However, other evidences pinpoint that Starčevo mass burial could be a „crime scene“. Namely, traces of violence were detected on skull II, VI and VIII. On the skull VI there is a trace of blunt forced trauma on left parietal bone, which was not detected during the first anthropological analysis by I. Schwidetzky. Since today skull II is not preserved as it was during the first anthropological analysis, by analysing photo documentation a small fracture on the occipital bone was detected. The secure evidences of violence are evidenced on individual VIII. This deceased was placed with the chest toward the ground and its left leg placed on the back, which was not possible without dismembering the leg. Right leg was contracted with a broken femur. Furthermore, its skull was dislocated. These three individuals with traces of violence suggest this was maybe a place of Neolithic crime scene. Nevertheless, weather it was the crime scene or not, this new study showed this was not typical Starčevo burial place.

From this site 12 individuals were analysed for the purpose of this thesis.

2.2.8. Grivac

The site Grivac is located 20 km southwest from Kragujevac, on the left bank of river Gruža. The prehistoric settlements in Grivac are located on both banks of the Grivac stream, from "Salty" spring to the confluence of the Gruža River. The site has been discovered during archaeological field survey in 1952. Since then there were several excavation campaigns. First excavations were conducted in 1953 and 1954 under the direction of B. Gavela when blocks Barice IA, Barice IB, Gruža I and Gruža II were explored (Гавела 1956-7:237-238; Bogdanović 2004:9-16).

During the 1950s the area of 282 m^2 has been investigated at the sites of Barice and Gruža. The thickness of cultural layer was up to 2.8 m. Excavations continued in 1969 when two trenches, measuring approximately 100 m^2 were opened (Bogdanović 2004). One small trench was investigated in 1989 on the site of Barice (Станковић 1990). Control trenches, with a total area of 65 m^2, were explored at Gruža site in 1990 and 1994. The thickness of cultural layer was 1.2 - 1.6 m at the site of Barice and at the Grivac site 1.6 - 2 m, reaching up to 3.2 m within subterranean dwellings. The site contained several phases of occupation, Grivac I, II and III, assigned to the Starčevo culture, and Grivac IV, VA, VB and VI, which belong to the Vinča culture. Well preserved architecture (pit-dwellings, hearths, rubbish pits) has been discovered in all horizons. The remains of material culture- pottery, altars, figurines, stone and flint tools are also numerous (Bogdanović 2004).

At the site Barice IA and IB more than five oval and ellipsoid in shape pit dwellings were found. In addition, findings of stone hearth with were also attested (Гавела 1956-7; Станковић 1990; Bogdanović 2004).

Small finds

Pottery finds are mainly spherical and semi-spherical bowls with flat bottoms, decorated in coarse barbotine technique, painted with dark spiraloid and other curvilinear and straight designs on red surface. Barbotine decoration is very common, and monochrome finish and nail pinching decoration were very frequent here. Red and yellow painted pottery is ornamented with dark painted spiraloid, linear and other curvilinear motifs. Regarding this pottery finds, the Grivac settlement can be dated to the earliest phases of the Starčevo culture. In addition to a standard pottery assemblage, the site yielded ceramic objects of special function, namely altars on four legs, anthropomorphic and zoomorphic figurines, and amulets. There are also findings of clay weights and spindle whorls.

Chipped stone tools are mostly represented by uni and bilaterally retouched blades. They were mostly made from quartz, “pre-Balkan platform flint” and chalcedony (Bogosavljević-Petrović 2004:403). A rich stone industry was discovered on Grivac with specific stone tool types, suggesting existence of several workshops or working areas within Grivac settlements (Antonović 2004:450). The most representative are grindstones, different types of axes and hammers made mostly from fine grained rocks and sandstone. There are also findings of tools made from light white stone, jadeite and nephrite (Antonović 2004). There is also one finding of weight or spindle whorl. The bone industry was represented by more than 50 artefacts: awls, chisel, wedge, spatula, scrapers, spatula-chisels, punches and retouching tools, hafts, one spatula-spoon and several decorative objects (Vitezović 2010, 2013). Most of the artefacts are small tools used for different crafts, such as processing of textile, leather, plant fibres and retouching of stone (Vitezović 2010). Inhabitants of Grivac were maybe specialized for producing stone tools and activities related to their use (Antonović 2004).

Human skeletal remains

First human skeletal remains (maxilla, few molars, clavicle and tibia) were found in 1954 at the pit-dwelling "B" level, at the depth of 10th excavation layer (Гавела 1956-7: 243). During the excavations in 1969 few human bones have been found in trenches "A" and "B". Since they were identified during the archaeozoological analysis, there are no data about the context and burial practice. In 1989, in quadrant q, at the level of XI excavation layer, among numerous animal bones, a fragmented human skull has been discovered. At the depth of the same excavation layer, in quadrants w and x additional human bones were found: left femur, fragments of spine, pelvic bones and ribs (Bogdanović 2004: 45). The rest of the skeleton was in the profile of the trenches B-C.

Human remains from Grivac found in 1989 are marked as grave 1. Today only the skull and few fragmented postcranial bones are preserved. This grave is analysed in this thesis, since it is the only grave which was available for analysis. During the analysis, it was determined that at least two individuals are present, and therefore from the site of Grivac two individuals were analysed in this thesis.

2.2.9. Rudnik Kosovski

The site of Rudnik is located 25 km south-west of Kosovska Mitrovica. It lies on the southern slopes of Mokra Gora and Suva mountains and on the slope of the Drenica plateau. By the valley of the Kusavča River the settlement of Rudnik is linked with the Beli Drim River. Excavations were carried out from 1966-1968 and in 1984 under the direction of Jovan Glišić. The cultural layer in Rudnik is divided into four phases (Rudnik I-IV) (Garašanin 1979; Tasić 1998). Several pits with pottery and osteological finds, dug in dwellings, above ground constructions with the wall construction of wooden pegs, without floors as well as 5 graves have been discovered during the excavations. The site was occupied several times from the Early Neolithic through Late Neolithic (Микић 1989; Tasić 1998).

Small finds

Pottery finds are mainly spherical and semi-spherical bowls with flat bottoms decorated in coarse barbotine technique, painted with dark spiraloid and other curvilinear and straight designs on red surface. Beside barbotine decoration, the ornamentation of coarse pottery is dominated by the impresso technique, pinpricking and imprints. In addition to a standard pottery assemblage, interesting finds are vessel with the elliptical belly decorated with a plastic rib and dark painted motifs with paw shaped endings (Tasić 1998).

Burials

During the excavations in 1984 five graves have been discovered. They were found outside of the houses, but inside the settlement. All individuals were buried in flexed position. Graves 1, 2, 3 and 4 were at the bottom of one shallow pit. Grave 1 is well preserved, while graves 2, 3, and 4 were damaged since subsequent settlement layers damaged this Starčevo layer. Beside animal bones found inside the pit, in graves 1, 3 and 4 three pots and one amulet have been discovered and assigned as grave goods near the deceased. The fifth grave was found 20 m away from other graves and it was very damaged (Микић 1989). First anthropological analysis was conducted by Ž. Mikić (1989) who concluded there were skeletal remains of 3 females and one male. They all belong to adults, except one, a female adolescent.

For the purpose of this thesis only one individual from grave 1 was available and detail anthropological analysis is available in the catalogue (Appendix 1).

3. MATERIALS AND METHODS

In this chapter materials and methods used in this study will be presented. First, the distribution of the study sample per site, period, region and demographic category will be introduced. Regarding the study material, which are human skeletal remains, a brief introduction on chemical composition of bones, teeth and the process of remodelling will be given. Consequently, all applied methods and analyses used to assess the impact of the Neolithic transition on the Starčevo population will be presented in detail.

3.1. The study sample

Human skeletal remains analyzed in this thesis originated from 14 Mesolithic and Neolithic sites spanning the period 9500 - 5200 cal BC (Table 3.1).

The Danube Gorges skeletal collection (Padina, Lepenski Vir, Vlasac, Hajdučka Vodenica) and human skeletal remains from Grivac and Rudnik Kosovski are housed in the Laboratory for Bioarcheology of Belgrade University. Individuals from Ajmana are stored at National Museum in Belgrade, while Vinča-Belo Brdo skeletal remains are housed at Archeological collection of Faculty of Philosophy, Belgrade University. Individuals from Perlez Batka site are stored at Zrenjanin National Museum. Individuals from Golokut-Vizić and Obrež-Baštine are housed at Museum of Vojvodina. Human skeletal remains from Klisa are stored at the Provincial Institute for protection of cultural monuments in Vojvodina, while human skeletal remains from Sremski Karlovci are housed at City Museum of Novi Sad. Starčevo individuals are housed at Institute for the protection of cultural monuments in Pančevo.

3.1.1. Sex and age distribution

Analysis was conducted on a total of 267 individuals,[21] of which 114 are Mesolithic, 92 belongs to Neolithic in the Danube Gorges and 31 are originating

[21] Only individuals with preserved cranial bones and teeth were included in this study from the Danube Gorges sites, regarding the methodology of conducted analysis which uses skull and teeth to access dietary and health patterns. However, for the human remains apart from the Danube Gorges a more detailed anthropological analysis was conducted since our knowledge on those Early Neolithic humans is

Table. 3.1. Distribution of analyzed individuals per period and site

Site	**Absolute chronology**	**Relative chronology**	**Total n◦ of analyzed individuals**
Padina	9221-8548 cal BC to 5930-5700 cal BC (Borić 2011)	Mesolithic and Early Neolithic	37
Lepenski Vir	9441-7400 cal BC to 5930-5550 cal BC (Borić 2011)	Mesolithic and Early Neolithic	75
Vlasac	7035–6698 cal BC to 5700 -5500 cal BC (Borić et al. 2014)	Mesolithic and Early Neolithic	83
Hajdučka Vodenica	7076-6699 cal BC to 6016-5726 cal BC (Borić and Miracle 2004)	Mesolithic and Early Neolithic	26
Ajmana	6030–5842 cal BC to 6214–6008 cal BC (Borić and Price 2013)	Early Neolithic	15
Golokut- Vizić	5630-5470 cal BC to 5560-5360 cal BC (Whittle et al. 2002)	Early Neolithic	7
Klisa	-	Early Neolithic	3
Sremski Karlovci	-	Early Neolithic	1
Perlez Batka	6090-5880 cal BC to 5920-5720 cal BC (Whittle et al. 2002)	Early Neolithic	2
Obrež-Baštine	-	Early Neolithic	1
Starčevo	5930-5720 cal BC to 5540-5310 cal BC (Whittle et al. 2002)	Early Neolithic	2
Vinča-Belo Brdo	5660 - 5555 cal BC to 5515-5380 cal BC (Tasić et al. 20015)	Early Neolithic	12
Grivac	-	Early Neolithic	2
Rudnik Kosovski	-	Early Neolithic	1

limited. The anthropological catalogue is available in Appendix 1. The basic information on all analyzed individuals is given in Table 1, Appendix 2.

from the sites located outside the Danube Gorges (Table 3.2). For 11 individuals[22] from the Danube Gorges sites data on age and sex were not available, only their chronological distribution. Therefore, these individuals were included only in the analysis, based on population level.

Out of the 267[23] individuals, 200 were adults and 56 were subadults from 6 month to 19 years of age (Fig 3.1; Table 3.2). Out of the individuals over 19 years of age for whom sex could be determined, 47 (18.35 %) are males or probable males, and 76 (29.69 %) are females or probable females[24]. The remaining individuals (77) are of indeterminate sex, or for whom sex could not be determined due to poor preservation of material.

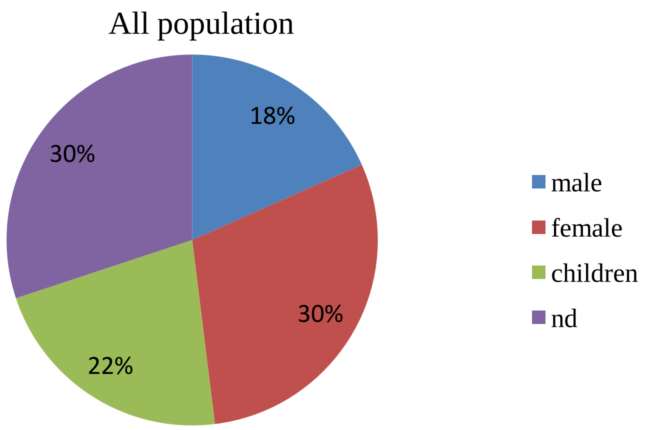

Figure 3.1. Sex and age distribution of the study sample

Table 3.2. Distribution of study sample in relation to age and period

Period	Total number of analyzed individuals	Adults	Children
Mesolithic	n=144	n=119	n=16
Neolithic in the Danube Gorges	n=92	n=62	n=28
Neolithic outside the Danube Gorges	n= 31	n=19	n=12
Total	n= 267	n=200	n=56

[22] Those individuals are: Lepenski Vir 24, Vlasac 20, 27(1), 35 a(2), 39, 54 (2), 69 a(1), 77 (1), Padina 12 (1), Hajdučka Vodenica 24 and 29 (1).
[23] Neonate human remains were not part of this study.
[24] In all analyses, probable females and probable males were grouped together with females and males.

3.1.1.1. Mesolithic

In Mesolithic, among 135 analyzed individuals, 119 belong to adults, while 16 belong to children (Fig 3.2; Table 3.3). Of the individuals over 19 years of age for whom sex could be determined, 30 (22.22 %) are males or probable males, and 49 (36.3 %) are females or probable females. The remaining of 40 individuals were adults of indeterminate sex, or for whom sex could not be determined due to poor preservation of material.

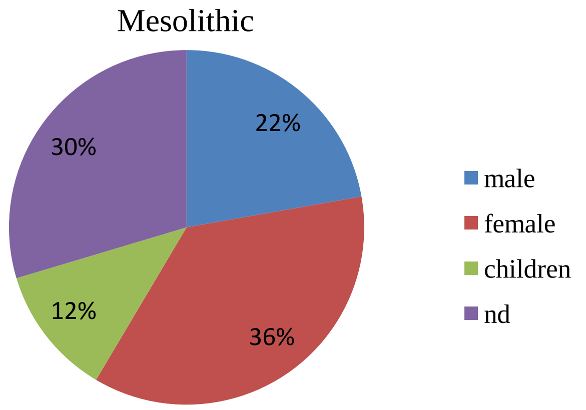

Figure 3.2. Sex and age distribution of the study sample in Mesolithic period

Table 3.3. Distribution of sex and age in relation to site in Mesolithic

Site	Female	Male	Children	Unidentified sex	Total
Padina	20	2	4	7	33
Lepenski Vir	1	5	1	3	10
Vlasac	25	18	8	25	76
Hajdučka Vodenica	3	5	3	5	16
Total	49	30	16	40	135

3.1.1.2. Neolithic, the Danube Gorges

In the Neolithic phase of the Danube Gorges, of the 90 individuals, 62 were adults and 28 belong to children (Fig 3.3; Table 3.4). Among individuals over 19 years of age for whom sex could be determined, 15 (16.66 %) are males or probable males, and 20 (22.22 %) are females or probable females. The remaining of 27 individuals were adults of indeterminate sex, or for whom sex could not be determined due to poor preservation of material.

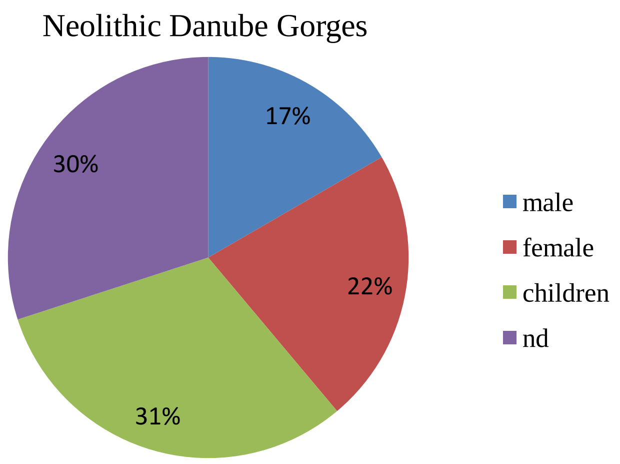

Figure 3.3. Sex and age distribution of individuals in Neolithic of the Danube Gorges

Table 3.4. Distribution of sex and age in relation to site in Neolithic Danube Gorges

Site	Female	Male	Children	Unidentified sex	Total
Lepenski Vir	16	10	16	22	64
Padina	1	1	-	1	3
Hajdučka Vodenica	-	3	2	3	8
Ajmana	3	1	10	1	15
Total	20	15	28	27	90

3.1.1.3. Neolithic outside the Danube Gorges

In the Neolithic period, in the regions studied outside the Danube Gorges, among 31 analyzed individuals, 19 belong to adults and 12 belong to children (Fig 3.4.; Table 3.5.). Of the individuals over 19 years of age for whom sex could be determined, 2 (6.45 %) are males or probable males, and 7 (22.5 %) are females or probable females. The remaining of 10 individuals were adults of indeterminate sex, or for whom sex could not be determined due to poor preservation of material.

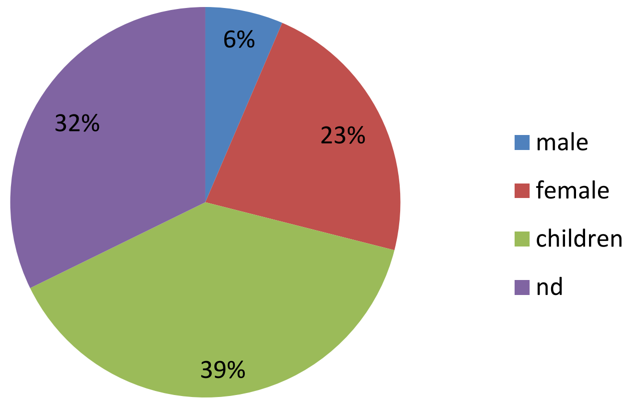

Figure 3.4. Sex and age distribution of the study sample in the regions outside the Danube Gorges

Table 3.5. Distribution of sex and age in relation to site in Neolithic outside the Danube Gorges

Site	Female	Male	Children	Unidentified sex	Total
Golokut-Vizić	2	-	5	-	7
Klisa	-	1	2	-	3
Sremski Karlovci	1	-	-	-	1
Perlez Batka	1	-	1	-	2
Obrež Baštine	-	-	1	-	1
Starčevo	1	-	1	-	2
Vinča	1	1	1	9	12
Grivac	-	-	1	1	2
Rudnik Kosovski	1	-	-	-	1
Total	7	2	12	8	31

3.2. Material composition

Study of material included standard macroscopic analysis, as well as biochemical analyses such as stable isotopes. Before performing any analysis, especially stable isotope analysis, it is important to know the structure and the rhythm of growth of the examined tissues as well as taphonomic factors that could alter the chemical structure of the sample. Thus, in the following subchapters composition of bone and tooth tissues as well as turnover velocity will be explained.

3.2.1. Bone tissue

3.2.1.1. Composition

Bone tissue is a type of dense connective tissue and it has two components: organic and mineral. The osseous tissue is very solid and it consists of 70% of minerals, 20% of collagen, 8% of water and 2% of non-collagenous proteins (Klepinger 1984). The mineral component consists mostly of a calcium phosphate (hydroxyapatite), although other minerals such as carbonate are also present (Lowenstam and Weiner 1989, Burton 2007). The organic matrix is composed of collagen and non-collagenous proteins (Lowenstam and Weiner 1989). Those non-collagenous proteins are representing 10% of organic matrix of bone and they are polypeptides, albumine, osteocalcin and alpha-2HS-glycoproteine (Williams et al. 1995).

The composition of the bone tissue can vary according to the anatomical part, age of the individual and its health status. With age, the quantity of water present in osseous matrix decreases, while mineralization is increasing. However, the variation in the quantity of organic part in bone tissues during the life is still unclear and depends on genetic factors (Williams et al. 1995). The bone is composed of compact and trabecular (spongy) tissue. The compact tissue is composed mostly of concentric collagen fibres (called “lamellae”) and vascular canals. The lamellae are arranged concentrically around a central Haversian canal which houses nerves and blood vessels.

3.2.1.2. Remodelling

During the life bone tissue undergoes constant remodelling (Robling et al. 2006). Bone remodelling is process of renewing bone in order to maintain strength and mineral homeostasis. Remodelling begins before birth and continues until death (Clarke 2008). The rate of this process is faster in trabecular bone than in compact bone (Klepinger 1984). On an annual basis, trabecular bone remodels 10 % while compact remodels 2.5% (Libby et al. 1964). In general, it is considered that bone collagen is remodelled after more 10 years in average, although that period may vary from 2-20 years (O'Connell and Hedges 1999) or even more (Ambrose 1993).

Infants and children have a high bone turnover during growth which decreases with age until it reaches adult one. During the first year of life, bone is completely remodelled three times on average, at ten years a complete turnover need ca. 3 years and from adult age more than a decade is generally necessary to renew the organic pool (Valentin 2003). During adolescence, femoral cortical bone remodels at rates of 10-30% each year, and at a much faster rate in males than females (Hedges et al. 2007).

The remodelling is influenced by many factors such as, at the first place, age, then physical activity, diet, sex, health status, growth, hormones, anatomical part of the bone, ethnicity, menopausal status (Han et al. 1997; Ambrose 2000; Valentin 2003; Seibel 2005). Bone turnover decreases with increasing age, such that the cortical bone of adults contains material previously formed many decades ago (Hedges et al. 2007).

The rates of remodelling in different bone tissues are significant when studying paleodiet using the stable isotope analysis of bone collagen. When the bone is active and remodelling is fast the diet of individual will be readily registered within the collagen in contrast to bone which has slow remodelling (Parkington 1991; Valentin 2003). The study of Tieszen and colleagues (1983) showed that individuals with bigger body mass have slower bone remodelling. It is important to keep in mind that the rates of remodelling of the protein part of bone tissue are still not well understood, especially in adults. However, scholars agree that when using bone tissue to reconstruct ancient diet it should reflect the average food consumed during the last several years of individual's life.

3.2.2. Tooth tissue

The teeth are composed of four tissues. Enamel, dentin, and cementum are the hard tissues and the pulp is the soft tissue of a tooth. Hard tissues are mostly formed of minerals, with primary mineral hydroxyapatite (a crystalline calcium phosphate). Organic part of dentine and cement is composed of collagen (in the same proportions as bone) while in enamel organic part is formed of amelogenins (Cate 1994; Hillson 1996). Organic part of enamel is too low to perform any analysis.

Opposite to the bone tissue, once formed dental tissues do not remodel. Therefore, different dental tissues can register different isotopic signals which correspond to diet (e.g. lactation) at the time of tissues' formations. As the growth calendar is rather well known (Schaefer et al. 2009), it is possible to sample specific part of the tooth dentine (root, crown) to access different periods of infancy and childhood (Beaumont et al. 2013).

3.2.3. Collagen

Proteins are macromolecules formed of one or more long chains of amino acid residues. Proteins are composed of 52 % of C and 16% of N (Philips and Koch 2002). In the body, proteins are renewed constantly through several processes: the synthesis (from free amino acids) and proteolysis (breakdown of proteins into amino acids). Renewal of the proteins depends on many factors, such as age, physiology, individual health status. The intake of proteins through food and constant renewal of the organism's cells generate ammonia (NH^{+}_{4}) excretion. Ammonia is then removed from organism's body through urea cycle. The urea cycle produces urea, which eliminate excess nitrogen from the body.

In this thesis, the focus is on one specific protein, collagen. It is a protein partially formed from protein originating from food consumed and thus it can provide information about protein part of ancient diet (Ambrose and Norr 1993). It is a main structural protein in the various connective tissues of animals and the most abundant protein in mammals as well. In form of elongated fibrils, collagen is mostly found in fibrous tissues such as skin, tendons, cartilage, blood vessels, bones and teeth.

There are 30 different types of collagen and all of them have the same basic structure: three polypeptide chains coiled together in a form of triple helix (Campbell and Smith 2002). Those chains contain ca. 1000 amino acids. More than 90% of collagen in the human body is collagen of type I. The matrix of collagen is secreted in bone tissue by osteoblasts (Campbell 1995). Bone collagen is very stable and generally insoluble in normal environments (Nielsen- Marsh et al. 2000) and plays an important role in bone solidity (Viguet-Carrin et al. 2006).

3.3. Methods

In order to assess the impact of the Neolithic transition on the Starčevo population, a number of diet and health indicators were observed on skeletal material. The demographic parameters of the population (age and sex) were determined first, as they provide the essential context for any further analysis. For each individual macroscopical observation were made for dietary and stress indicators observed on teeth (dental caries, dental calculus, dental macrowear, antemortem tooth loss, enamel hypoplasia) and bone (cribra orbitalia and porotic hyperostosis). Additionally, biochemical (stable isotope analysis) and chemical-microscopical (starch grain analysis) analysis were performed in order to access dietary patterns. As dietary choices and health status can significantly influence body proportions, analysis of metric characteristics was also done. All results on observed parameters were statistically tested and description of used tests is given at the end of this chapter.

3.3.1. Determination of age and sex [25]

Subadult age at death was determined by using primarily dental eruption (Moorrees et al. 1963a, 1963b; Ubelaker 1989), length of long bones (Stloukal and Hanakova 1978) and epiphyseal fusion (Scheuer and Black 2000, 2004).

For adult individuals the fusion of epiphyses (Buikstra and Ubelaker 1994) were first estimated to ensure age-at-death of the individual was 18 years or older. Primary age estimation was done using two probabilistic methods (Schmitt 2002, 2005), a

[25] For the Danube Gorges study sample database with age and sex estimation was provided by Camille de Becdelièvre and the detail explanation of the method is given in: de Becdelièvre, in preparation.

methodology based on characteristics of pelvic bones (auricular surface and pubic symphysis). In the absence of more accurate age estimators, cranial suture closure (Buikstra and Ubelaker 1994) was used as a secondary marker of age. The degree of suture closure was compared with sutures of individuals of known age obtained through examination of pelvic bones and only scores on suture which were associated with primary age estimation were kept and applied to the individuals of the unknown age. By using this technique, individuals without well-preserved pelvic bones could also be placed into broader age categories. Dental wear was also used to access the age (Miles 1963), but only on the sample derived outside of the Danube Gorges. Namely, teeth abrasion is very pronounced in individuals from the Danube Gorges sites, since lot of them were using teeth in non-masticatory activities (Радовић 2013).

All individuals were placed in seven age categories: subadult I (1-4), subadult II (5-9), subadult III (10-14), adolescent (15-19), young adult (20-30), middle aged adult (31-49), and old adult (50+). In the lack of evidence some individuals could not be associated to any of age categories. They were categorized as “adult” (20+ years).

Primary sex assessment was determined using morphological approach (Bruzek 1991, 2002) and probabilistic morphometric approach (Murail et al. 2005), both based on the features on the pelvic bones. Combining these two methods, observer’s errors were minimized but maximized the number of sex determinations. When it was necessary, additional criterions were used for individuals without pelvic bones: metric analysis of long bones and morphological features of skulls (Buikstra and Ubelaker 1994). Those metric and morphological data were then used to develop regression equations based on the sample of individuals for which sex was previously identified using the pelvic bone (Murail 1996). This enables to identify sex in individuals with poorly-preserved pelvic bones.

3.3.2. Dental analysis

In order to access subsistence strategies and overall health several parameters were observed on teeth: frequencies of caries, dental calculus, dental macrowear, ante mortem tooth loss, enamel hypoplasia. Teeth were identified according to the World

Dental Federation notation (developed by the Fédération Dentaire Internationale; FDI), also known as the ISO 3950 notation.

3.3.2.1. Dental caries

Dental caries is a progressive infectious process that results in decay of the enamel, dentine and cement of the tooth. It is characterized by the demineralization of dental hard tissues by organic acids produced by bacterial fermentation of dietary carbohydrates, especially sugars (Newbrun, 1982; Larsen 1982, 1987; Waldron 2009). The bacteria most commonly associated with development of caries is *Streptococcus mutans* (Caselitz 1998). Demineralization is caused by microbial activity on the tooth's surface, and when pulp chamber is exposed it raises chances of infection (Pindborg 1970; Featherstone 2004; Hillson 1996) and can result in the formation of a localized abscess and eventually in loss of the tooth (Ortner and Putschar 1981).

Although, there are multiple factors that can cause development of caries, diet, oral hygiene and dental plaque are considered to be the most important (Larsen 1997). Consumption of carbohydrates, especially sugars is one of the principal causes of caries, since its consumption considerably enhances the process of demineralization in teeth. Starches are consider less cariogenic than sugars, but may also cause caries (Hillson 2001: 260). Food containing both sugars and starches is especially very cariogenic. Proteins and fats in the diet do not seem to be involved in development of caries. On contrary, their consumption may inhibit bacterial activity (Powel 1985). There is also a study which showed that casein, a protein present in dairy products, has a protective effect (Bowen and Pearson 1993; Mundorff-Shrestha et al. 1994). On the other hand, lactic acid is found to be among main demineralising compounds in the initial development of carious lesions (Caselitz 1998).

Not only that specific type of food is important but also the way it is prepared (Prowse 2001). Sweet, sticky foods are cariogenic because sugars give support to bacterial activity and the stickiness helps the food adhere to the tooth surfaces. On contrary, coarse, and abrasive food is considered to be cariostatic because the grit removes food and bacteria from the tooth (Larsen 1995). Individuals with identified enamel hypoplasia have more chance to develop carious lesions since their teeth are more porous with lower mineral content (Duray 1990). Formation of dental plaque is also important in development of caries as it accumulates various microorganisms, food particles, salivary proteins and polysaccharides formed on teeth surfaces (Moore and Corbett 1983). The bacteria in plaque break down carbohydrates and dairy proteins producing metabolic waste and organic acids (Caselitz 1998; Hillson 1996).

However, there are also some other factors that can encourage development of caries such as elements in food and water as well as the type of teeth (Powell 1985). Considering trace elements, selenium, magnesium, lead, cadmium and silicon have cariogenic properties (Powell 1985) while zinc, copper and iron have protection role (Schneider 1986). Shape and structure of the teeth are also important since premolars and molars have usually higher incidence of caries because of numerous fissures and pits where plaque can accumulate (Hillson 1996).

In this study, caries lesions were recorded as proposed by Hillson (2001, 2005), with few modifications. It classifies the caries into several categories:

1) occlusal caries: a lesion initiated in the enamel of the crown surface (type 1).
2) contact point or interproximal smooth surface caries: lesions initiated on mesial and distal crown surfaces, just below the contact point between neighboring teeth (type 2).
3) cervical caries: originates at any cement-enamel junction (CEJ), except the interproximal regions (type 3).
4) root surface caries: caries located on the cement of the root surface, below the cemento- enamel junction (type 4).
5) large caries, also known as gross-gross caries: cavities that have destroyed the tooth so much of that they cannot be assigned a surface of origin (type 5).

All individuals with preserved teeth were examined for this analysis. Caries frequencies were calculated by a) number of individuals affected divided by the total number of observed individuals and b) by taking the total number of carious teeth and dividing by the number of observable teeth. The prevalence of caries is estimated in diversity over chronology, region and demographic category.

3.3.2.2. Dental calculus

Through the analysis of dental calculus, its presence and quantity, as well as through observations of biomolecules and microfossils trapped within its matrix, we can get valuable information about dietary habits, oral health, and lifeways of past population. These microfossils (e.g. phytoliths, diatoms, calcium phytoliths, chrysophycean, sponge spicules, calcium oxalate crystals, faunal spherulites, pollen, spores and starch grains) can derive from plant food, plants used for making non-food products, animal remains, and inform us what people were processing in their mouths (Gremillion 1997; Pearsall 2008; Weiner 2010; Blatt et.al 2011). Calculus deposits form only during life and so the microparticles that are embedded within the matrix are not diagenetically altered may survive within the dental calculus for an extensive period of time.

Therefore, analysis of dental calculus presents a unique opportunity to access direct evidence of ancient diets at an individual level and across given population.

3.3.2.2.1. Plaque formation

Dental calculus is mineralized dental plaque that adheres to tooth surfaces (Hillson 1996). Plaque formation is a continuous and dynamic process (Marsh and Bradshaw 1995). The structure of the plaque varies from tooth to tooth and from location to location within an individual (Rosan and Lamont 2000). Dental plaque exists as a biofilm containing food remains, bacteria which forms naturally on the teeth, and when it is not removed it may mineralize into calculus (Hillson 1996; Lieverse 1999). During the formation of dental plaque, food particles such as plant microremains may become trapped, and are protected from chemical dissolution by salivary amylase (Juan-Tresserras et al. 1997). Once plaque mineralizes into calculus, the microremains are protected within the robust mineral matrix, which helps in their preservation (Cummings and Magennis 1997; Hardy et al. 2009). However, the process of calculus formation is still poorly understood as many factors, including type of diet, oral hygiene, salivary flow and genetics can influence the rate of calculus deposition. Therefore is very hard to predict the time frame of accumulation on individual level

(Hillson 1996; Lieverse 1999). Generally, medium to large calculus deposits are thought to have accumulated over at least a number of years (Brothwell 1981; Li et al. 2010; Henry and Piperno 2008; Piperno and Dillehay 2008).

3.3.2.2.2. Macroscopic analysis of dental calculus

Recording of presence and amount of dental calculus is a standard part of dental analysis. By documenting presence of calculus, we can make inferences about diet and relate calculus presence to another indicator – periodontal disease. On all teeth calculus was recorded as it is recommended by Buikstra and Ubelaker (1994): extent of calculus was described using the protocol established by Brothwell:

1. absent (degree 0)
2. small amount (degree 1)
3. moderate amount (degree 2)
4. large amount (degree 3)

Regarding the aetiology of dental calculus two types were also recorded: supragingival and subgingival. Appearance of supragingival calculus is mostly connected to diet while subgingival can derive from tooth pathology. Since calculus can be easily removed in course of excavation or during conservation, in final analysis only the highest degree (3) was calculated. Calculus frequencies were calculated by a) number of individuals affected divided by the total number of observe individual and b) by taking the total number of teeth with calculus and dividing by the number of observable teeth. All individuals with preserved teeth were examined for this analysis. The prevalence of calculus is estimated in diversity over demographic category, chronology and region.

3.3.2.3. Dental macrowear analysis

Macroscopic analyses of dental wear were done following the protocol of Brothwel 1981. The degree of dental wear was observed through four stages of abrasion:

1. in enamel
2. exposed dentine
3. to the bottom of the fissure

4. pulp exposure

All individuals with preserved teeth were examined for this analysis. Dental macrowear analyses were done only on Early Neolithic sample orginated outside of the Danube Gorges in order to access age, dietary and behaviour patterns[26].

3.3.2.4. Ante mortem tooth loss

Ante mortem tooth loss can be an indicator of multiple dental diseases, but it is mostly associated with the recession of alveolar bone in periodontitis (Larsen 1997). However, it can also be caused by ablation or a big caries also known as a gross caries (Hillson 2005). All individuals with preserved teeth and alveolar sockets were examined for this analysis.The presence and absence for each tooth was scored (Buikstra and Ubelaker 1994) as follows: (0) antemortem tooth loss; (1) present and in occlusion; (2) present but lost postmortem; (3) congenital absence; and (4) unerupted. Frequencies of AMTL were determined by dividing the total occurrences of AMTL by the total alveolar positions (and on individual level). The frequencies of AMTL are estimated in diversity over chronology, region and demographic category.

3.3.2.5. Enamel hypoplasia

Dental enamel hypoplasia is an area on the crown of a tooth which has a deficient amount of enamel thickness caused by a disturbance in enamel matrix secretion (Hillson 1996). This deficiency is visible macroscopically and occurs as a pit, plane, furrow and linear (Hillson 2005). Although these lesions can appear on any tooth, incisors and canines are most commonly affected (Aufderheide and Rodríguez-Martín 1998). The most common is linear enamel hypoplasia (LEH). LEH is represented by small depressed linear bands in teeth (deciduous and permanent) which result from growth disturbances that disrupt the normal formation of dental enamel (Ortner 2003; Hillson 2005).

The prevalence of hypoplasia is frequently used in archeological studies to access health status since it might be the result of a number of different stress factors

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[26] Analysis on macrowear patterns is available in Appendix 1.

(Goodman et al. 1980; Cohen and Armelagos 1984; Larsen 1997; Hilson 2005; Papathanasiou 2005). It reflects the childhood stress and growth disturbance because it is developing while teeth are still forming. Since tooth formation occurs during the last two trimesters of pregnancy, and the first year of life, for deciduous dentition, and during the first six years of life, for permanent dentition, enamel hypoplasia shall always be an indicator of stress during early childhood (Goodman and Armelagos 1989).

Additionally, the age at which LEH was formed can be estimated based on its location on the tooth crown since enamel does not remodel (Buikstra and Ubelaker 1994; Goodman and Armelagos 1989; Auferheide and Rodriguez-Martin 1998; Goodman and Rose 1990; Larsen 1997; Waldron 2009).

Dental enamel hypoplasia typically results from systemic disruption, malnutrition, infections, hereditary conditions, or localized trauma (Goodman and Armelagos 1989; Goodman and Rose 1991; Hillson 2005). If only one tooth is affected, the defect likely results from trauma, whereas if several teeth show defects, the cause is probably systemic, caused by infectious disease or nutritional stress of long duration. Furthermore, enamel hypoplasia could be also linked to weaning stress. Namely, numerous studies shown that enamel defects occur mostly between the ages of two and four years, an age commonly associated with weaning stress (e.g. Goodman and Armelagos 1989). It is the time when children start to eat solid food for the first time which can be contaminated with various bacteria and they also lose the immunity of their mother and become susceptible to malnutrition and disease (Rodney 1983).

In this study, enamel hypoplasia was examined visually and recorded by presence or absence of hypoplastic defects on all teeth available for each individual examined. Frequencies were calculated both per individual and per tooth. Observed defects were described as pits, lines, or grooves as well as the relative location of the defects (Hillson 1996: 167). In addition, quantity per tooth was also noted in order to determine the severity of defect and to access the number of stress episodes.

Nonetheless, the position of each LEH defect was measured by digital sliding calipers. By measuring the position of LEH defects on the forming tooth crowns, the common age at which these defects began was also estimated. For the purpose of this analysis, LEH defects were observed on upper and lower incisors, canines and molars by using the macroscopic method of subdividing the tooth crown surface into zones (Reid and Dean 2006) (Fig 3.5).

All individuals with preserved teeth were examined for this analysis. Some teeth were excluded from the study due to preservation reasons (e.g. high occlusal and labial wear, fragmented crowns). In addition, some of them were not measurable due to presence of caries on cemento-enamel junction or preservation state.

The prevalence of enamel hypoplasia defects is estimated in diversity over chronology, region demographic category and sex.

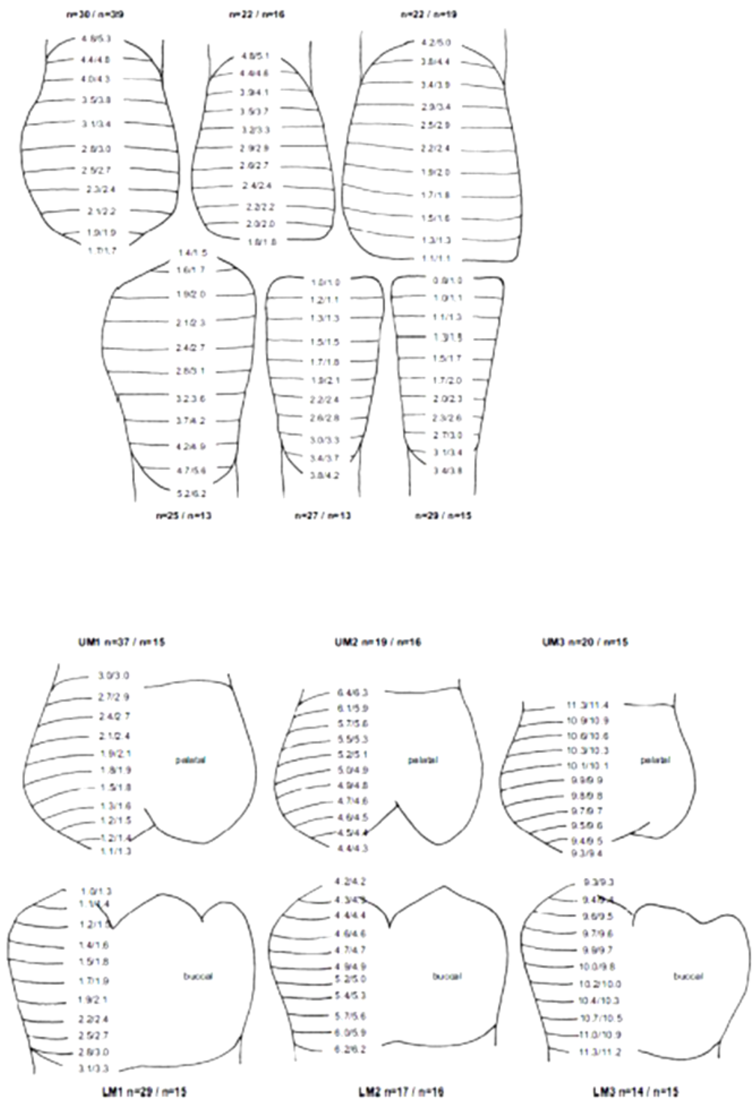

Fig. 3.5. Mean estimates for chronological ages of enamel formation for incisors, canines and molars (from Reid and Dean 2006: 343, 344)

3.3.3. The non specific stress markers

3.3.3.1. Cribra orbitalia

Cribra orbitalia is represented by porosity in the tops of the eye orbits of the frontal bone. Those porous lesions are characterized by thinning of the outer table of the crania and vary from small porosity to much larger pores (El-Najjar et al. 1976; Stuart-Macadam 1989; Walker et al. 2009:2-3).

A number of past studies interpreted cribra orbitalia as an indicator of childhood nutritional stress, more specifically iron deficiency anemia (Miles et al. 2008; Ortner, 2003; Stuart-Macadam 1989). Other possible etiologies for these cranial lesions include also other acquired anemias, dietary or hereditary (i.e. sickle cell or thalassemia) (Angel 1966; Mensforth et al. 1978; Stuart-Macadam 1989), bony inflammation, pressure induced bony atrophy, hypervascularization (Wapler et al. 2004), scurvy, vitamin C deficiency as well as localized trauma (Walker et al. 2009). Hence, these lesions probably are results of multiple conditions and causes. One can agree that some types of dietary deficiency, nutritional misbalance and overall stress is connected with the greater number of cribra orbitalia cases. This kind of dietary inadequacy could be caused by limited access to resources, or malabsorption as would occur in the case of diarrheal disease (Walker et al. 2009).

Although most of the researchers interpreting cribra orbitalia as a result of anemia, not all scholars (e.g. Waldron 2008) agree with it. The opinion is also that cribra orbitalia is more associated with vitamin C and B_{12} deficiency then anemia (Ortner 2003; Wapler et al. 2004; Walker et al. 2009).

These lesions are affecting children more often than adults and usually are in an active state of bony remodeling, while in adults lesions begin to heal over (Lallo et al. 1977; Stuart –Macadam 1985).

In this study cribra orbitalia was noted using a modified scoring method proposed in Buikstra and Ubelaker (1994), where severity and activity were scored. The material was analyzed macroscopically with a lighted magnifying glass. All individuals with preserved eye orbits (left, right or both) were examined for the purpose of this analysis.

The scoring system for cribra orbitalia used in this study:

Location:

L-left orbit

R-right orbit

Severity:

0. Not observable

1. At least one orbit present with observed small porosity

2. A cluster of mostly fine foramina covering a small area, present on at least one orbit

3. Coalescing pores with orbital roof thickening present on at least one orbit

Activity:

1. Active at the time of death

2. Healed

3. Mixed active and healed present

The frequency of cribra orbitalia is estimated in diversity over chronology, region and demographic category. For calculating frequency of cribra orbitalia both left and right orbits were taken into account and cribra was observed as present or absent, regardless if it was present on both orbits or not. Concerning frequency of degree and activity only right orbit was choose as it is represented more than left one.

3.3.3.2. Porotic hyperostosis

Porotic hyperostosis is defined as hypertrophy of the diploic skull bone, resulting in ectocranial surface porosity of the frontal and parietal bones, and less frequently in the occipital, as well (Buikstra and Ubelaker 1994; Stuart-Macadam 1987; White and Folkens 2005). Some researchers consider cribra orbitalia as similar condition to porotic hyperostosis, and, thus, having the same origin.

Like in the case of cribra orbitalia etiology, there is also a huge debate over the cause of porotic hyperostosis (Angel 1971; Wood et al. 1992; Stuart-Macadam 1992; Keenleyside et al. 2006). This non-specific stress indicator could be result of intense or prolonged anemia caused by iron deficiency, nutritional misbalance, subperiosteal hemorrhage (Aufderheide and Rodriguez-Martin 1998; Ortner 2003), or vitamin-B12 deficiency (Walker et al. 2009). There are many factors that can cause anemia such as genetic anemias, diet, bacteria and diseases (Angel 1966; Mensforth et al. 1978; Stuart-

Macadam 1989; Walker et al. 2009). In archaeological record the high frequencies of porotic hyperostosis lesions have been often interpreted as nutritional stress indicator (El-Najjar et al. 1976; Mensforth et al. 1978; Goodman et al. 1988).

Today anthropologists interpret both porotic hyperostosis and cribra orbitalia as “stress indicators” and evidence for low health and nutrition in populations, rather than reflection of a specific disease or condition. In this study a method from Buikstra and Ubelaker (1994) was used to score porotic hyperostosis because their method measures presence, severity, location and stages of expression. The material was analyzed macroscopically with a lighted magnifying glass. All individuals with preserved frontal, parietal or occipital bone were examined in purpose of this analysis.

The scoring system for porotic hyperostosis used in this study:

Degree

0 Not present

1 Barely discernible

2 Porosity only

3 Porosity with coalescence of foramina, no thickening

4 Coalescing foramina with increased thickness

Location

- frontal bone
- parietal bones
- occipital bones

Activity

1 Active at time of death

2 Healed

3 Mixed reaction: evidence of healing + active lesion

For calculating frequency of porotic hyperostosis all three bones (frontal, parietal and occipital) were taken into account and porotic hyperostosis was observed as present or absent, regardless if it was present on all three of them or only one. Concerning the frequency of degree and activity only occipital bone was chosen, as it is the most represented then the other two bones. Results were interpreted in diversity over chronology, region and demographic category.

3.3.4. Biochemical and microscopic analysis

3.3.4.1. Stable isotope analysis on bone/teeth

3.3.4.1.1. Characteristics of isotopes

Isotopes are various forms of a chemical element with the same number of protons and electrons, but different number of neutrons in the nucleus of the atom. The different number of neutrons in the nucleus induces variation in atomic weight between isotopes of the same element. Almost all of naturally occurring chemical elements have more than one isotope. Isotopes are divided into two main groups, those that are stable, which mean they do not decay into other elements and those that are radioactive or unstable (e.g. ^{14}C) (Hoefs 1997).

Isotopes are integrated into the tissues of plants through water and soils, and subsequently into animals through the food, water or breathing. An organism is taking isotopes during its life and continuously replacing those as the tissues are being replaced (like bone tissue). At death of the organism, the tissues stop incorporating isotopes and level of isotopes remains the same, as it was in the moment of organism's death, under the condition that the tissue is well preserved. Thus, isotopic values can be measured in the tissues of all plants, animals and humans and they are providing valuable information about organism's life.

3.3.4.1.2. Isotopic ratios

Carbon (C), hydrogen (H), oxygen (O) and nitrogen (N) are the four most abundant elements in the biosphere. Different isotopes of an element have identical chemical properties, hence the atomic mass difference means that they have not the same kinetic properties and thus participate in reactions at different rates. Heavy stable isotopes have stronger chemical bonds and attractive forces of atoms than lighter isotopes of an element. Thus, heavier isotopes react more slowly than the lighter isotopes which lead to the process, termed fractionation, between reactant and product in both biological and physical reactions.

The stable isotope structure of a certain sample is determined by mass spectrometry. This study focuse on carbon, nitrogen and sulphur elements. Stable isotope ratios are expressed using the δ notation in parts per thousand (‰ or permil) according to general equation:

$$\delta (‰) = [(Rsample/Rstandard) – 1)] \ x \ 1000$$

δ is the difference in isotopic composition of the sample relative to that of reference, in parts per mil (‰). R indicates the ratio of the heavy to light isotope (e.g., $^{13}C/^{12}C$; $^{15}N/^{14}N$; $^{34}S/^{32}S$), and R sample and R standard are the ratios in the sample and standard. A positive δ value means that the isotopic ratio of the sample is higher than that of the standard; a negative δ value means that the isotopic ratio of the sample is lower than that of the standard.

Carbon, nitrogen and sulphur all have stable versions of their atoms with different numbers of neutrons: carbon- 12 vs. carbon-13, nitrogen-14 vs. nitrogen-15, and sulphur-34 vs. sulphur-32. For these elements, the light isotope is far more abundant (>94%) than the heavier.

Carbon stable isotopes are expressed as the ratios between the heavy (^{13}C) and the light (^{12}C) isotope of the element carbon as $\delta^{13}C$, and are measured in ‰ units relative to the international standard Pee Dee Belemnite (PDB), a carbonate rock in South Carolina, USA (Craig 1953). For example, a $\delta^{13}C$ value of -28‰ means that the $^{13}C/^{12}C$ of the sample is 28 parts-per-thousand lower than the $^{13}C/^{12}C$ of the standard (Pee-Dee Belemnite limestone). The stable isotope ratio of nitrogen ($\delta^{15}N$) is expressed as the ratio between the heavy (^{15}N) and the light (^{14}N) isotope and is described in ‰ units in relation to the standard value of atmospheric air (AIR), which is ~0‰ (Mariotti 1983). Sulphur stable isotopes are expressed as the ratios between the heavy (^{34}S) and the light (^{32}S) isotope of the element sulphur as $\delta^{34}S$, and are measured in ‰ units relative to the international standard meteoric troilite (particularly the Canon Diablo Troilite (CDT) from Arizona, USA) (Krouse 1980).

Stable isotope analysis in reconstruction of paleodiet pathways

Isotopes can be found everywhere in the environment and thus stable isotope analysis has a widespread application in lot of scientific fields. More than 40 years of research in ecology and paleoecology (e.g. Ambrose and Norr 1993; Hobson et al. 1993, Phillips and Koch 2002) led to creating multiple databases and strong references which allow relevant application of stable isotope analysis to examine paleodietary behaviours. In archaeological studies, stable isotope analysis is representing a key method to examine human dietary habits and subsistence strategies (e.g. Richards and Schulting 2003), animal husbandry practices (e.g. Frémondeau et al. 2012), weaning patterns (e.g. Beaumont et al. 2015), migrations (e.g. Bentley 2006), individual life histories (e.g. Eriksson and Liden 2013) and to characterize artefacts (e.g. Lazzarini and Antonelli 2003).

Although there are multiple approaches to access human dietary behaviors (lipid, pollen, phytolith analysis), by performing stable isotope analysis we can get direct evidence of past human diet on individual level and by extension to a group level. The relative isotopic variability between different types of human diets for a particular environment is well described in many studies on living mammals (e.g Hobson et al. 1997; Sponheimer et al. 2003; Kempster et al. 2007) and modern human populations (e.g. Minagawa 1992; Froment and Ambrose 1995; O'Connell and Hedges 1999; Nardoto et al. 2006; Bender et al. 2014). Hence, the study of $\delta^{13}C$ and $\delta^{15}N$ in animal bone collagen is very important to define local isotopic baseline of each archaeological site and to interpret human data and palaeodietary behaviours (e.g. van Klinken 1994; Hedges et al. 2004; Goude and Fontugne 2016).

The most used isotopes for reconstruction of dietary patterns are $\delta^{13}C$, $\delta\ ^{15}N$ and $\delta\ ^{34}S$. Since the bone isotope composition is determined by the food that an individual consumes, analyses of those isotopes can provide individual dietary information on protein intake during the last ca. 15 years of an individual's life (Hedges et al. 2007). The study of $\delta^{13}C$ and $\delta^{15}N$ from human bone collagen enables us to reconstruct the type of environment from which individuals took their resources (e.g. marine versus terrestrial) and their place in the food web (e.g. herbivore and carnivore). The use of $\delta^{34}S$ analysis in archaeology increased recently; it can give information on past diets and migration patterns of humans and animals, but it is mainly used for detecting freshwater/marine fish consumption (e.g. Privat et al. 2007; Nehlich et al. 2010; Drucker et al. 2011).

3.3.4.1.3. Carbon

As carbon is found in all dietary fractions, the analysis of carbon stable isotope ratios can be performed on collagen and apatite. The carbon in collagen is predominantly routed from dietary protein, especially when there is sufficient protein in diet (Ambrose and Norr 1993; Howland et al 2003; Jim et al. 2004, 2006), in contrast to that in apatite which is more equally derived from all parts of the diet. Thus, the $\delta^{13}C$ of collagen is mostly reflecting the source of dietary protein intake, while that of apatite also reflects carbohydrate and lipid intake. The analysis of carbon in apatite is less used due to the absence of international consensus to determine the preservation state of bone and tooth carbonate.

Principally, the analysis of stable carbon isotope ratios from bone collagen allows estimating the relative parts of marine and freshwater versus terrestrial protein in the diet. It also helps to distinguish the type of plants consumed (C_3 and C_4 photosynthetic plants) (Chisholm et al. 1982; Schoeninger and DeNiro 1984; Schwarcz and Schoeninger 1991; Lillie et al. 2003; Richards 2002; Eriksson et al. 2008). The C_4 photosynthesis pathway discriminates less against ^{13}C than the more common C_3 pathway (Smith and Epstein 1971; Peterson and Fry 1987). Thus, C_3 plants (like wheat, barley, rice, fruits and tubers) have lower $\delta^{13}C$ values averaging nearly 26‰ than C_4 plants (like tropical grasses, maize and millets) which show less negative $\delta^{13}C$ values, averaging 12‰ (Ambrose et al. 2003).

The first use of carbon stable isotopes in reconstruction of palaeodietary behaviours was to track the introduction of a C_4 plant, maize, into the temperate C_3 environment of north-east America (Vogel and van der Merwe 1977). After that, Tauber (1981) used carbon stable isotopes to show the evident abandonment of diet based on marine resources after the introduction of agriculture in Denmark. The distinction between marine and terrestrial $\delta^{13}C$ lay in the fact that marine plants take their carbon from dissolved CO_2, which has a higher $\delta^{13}C$ than atmospheric CO_2. Thus, marine food resources will always have higher $\delta^{13}C$ than terrestrial C_3 food resources (Smith and Epstein 1971).

3.3.4.1.4. Nitrogen

In human diet, nitrogen is found in protein and its constituent of amino acids (Schoeller 1999). Variation in $\delta^{15}N$ in terrestrial plants is mainly due to climate, temperature, precipitation and salinity (Heaton et al. 1986; van Klinken et al. 2000), while variation in $\delta^{15}N$ of consumers is mainly influenced by the trophic level effect. $\delta^{15}N$ fractionates in the food chain within the tissue of an organism, leading to an enrichment of approximately 3-5‰ in each trophic level (DeNiro and Epstein 1981; Minagawa and Wada 1984; Bocherens and Drucker 2003). Thus, nitrogen stable isotope ratios ($\delta^{15}N$) are used to establish the trophic level of an organism in the food web (Schoeninger and DeNiro 1984). For example, if the plants have an average $\delta^{15}N$ of about 3‰, herbivores that eat those plants will have $\delta^{15}N$ values of 7‰, and carnivores who consume those herbivores will have $\delta^{15}N$ values of about 11‰. $\delta^{15}N$ values are specific to regions and ecosystems, and in very warm climates the $\delta^{15}N$ values are higher than in countries with milder climate (Schwarcz et al. 1999).

Nitrogen stable isotope ratios ($\delta^{15}N$) from bone collagen are used to access the relative consumption of animal (meat or dairy products) versus plant protein, or marine versus terrestrial origin of protein (Schoeninger and DeNiro 1984).

De Niro and Epstein (1978, 1981) were among the first who used nitrogen and carbon stable isotope ratios for dietary reconstructions. They studied nitrogen and carbon stable isotope ratios of animals that were raised on diets of known isotopic composition. They conclude that the isotopic composition of animal tissues was influenced by that of the diet. As mentioned above, quantification of marine resource consumption was first introduced by Tauber (1981) in his study on prehistoric Denmark human groups. Shortly afterwards, similar applications and results have been found by Schoeninger and DeNiro (1984).

3.3.4.1.5. Sulphur

Sulphur is an important bioelement and essential part of all living cells. In plants and animals, organically bonded sulphur is a component of all proteins, like the amino acids, cysteine and methionine. Inorganic sulphur is bound into biomolecules by plants and then is transferred up in the food chain with small fractionation (≤1‰). Sulphur isotope ratios are varying in different organisms. Marine organisms have sulphur isotopic ratios around 20‰ while terrestrial organisms have in general from -5‰ to 10‰ (Krouse 1980). To understand and interpret sulphur isotope data for animal and human collagen from a particular region it is necessary to define the sulphur isotopic compositions from the local geology and water sources as well as biologically bound sulphur of different ecosystems in the area of interest (Nehlich et al. 2010).

In general, local inorganic sulphur is a mixture of rainwater (5–10‰), groundwater (-5 to 10‰) and streamwater (-20 to 10‰) (Nriagu et al. 1991). Sulphur isotope ratios in terrestrial plant depend of different sources (groundwater, rain, atmosphere, sea spray and erosion (Krouse 1989; Nehlich 2015). Therefore, the bioavailability of sulphur is varying according to regions; the $\delta^{34}S$ in dietary resources consumed by humans depends on $\delta^{34}S$ value of the ecosystem.

Combined with other elements, sulphur stable isotope ratio analysis allows us to further document ancient diets (marine *versus* terrestrial and freshwater *versus* terrestrial) (Leach et al. 1996; Richards et al. 2001; Craig et al. 2006; Privat et al. 2007; Hu et al. 2009; Nehlich et al. 2010, 2011) as well as migration patterns of past humans and animals (Vika 2009). A small number of archaeological studies used sulphur as a paleodietary proxy but they recently increased due to technological advancements (Leach et al. 1996; Richards et al. 2001; Craig et al. 2006; Privat et al. 2007; Fornander et al. 2008; Linderholm et al. 2008; Vika 2009; Hu et al. 2009; Nehlich et al. 2010, 2011; Nehlich 2015).

In bone collagen, sulphur is found only in methionine, one of the essential amino acids, and $\delta^{34}S$ is directly linked to food consumed. As for carbon and nitrogen, some archaeological studies have demonstrated a slight increase of the $\delta^{34}S$ between consumers and food resources considered as insignificant for paleodietary interpretation (Richards et al. 2001; Nehlich 2015). While marine resources show the highest $\delta^{34}S$ (close to +20‰), terrestrial plants show lower ratios, which vary according to the potential impact of sea spray (ca.-14‰ to +14‰). The freshwater ecosystem shows a broad range of values according to the impact of different sulphur sources (-22‰ to +20‰) (Richards et al. 2001; Nehlich et al. 2011).

Privat and its colleagues in study from 2007 reconstruct ancient diet and consumption of freshwater fish by using sulphur stable isotope ratios. They analyzed Early Bronze age, Iron age and Eneolithic human and animal skeletal remains from Russia and Ukraine and showed how important is to know the geological setting in sulphur isotope studies. Those sites are located 500 km far from the sea and very close to freshwater and saline lakes. On the Eneolithic site of Bil'shivtsi sulphur isotope ratios for freshwater and terrestrial food species were indistinguishable, demonstrating that $\delta^{34}S$ values cannot always be used to identify freshwater and terrestrial consumers. Recently Hu and colleagues (2009) demonstrated the possibility to distinguish between the consumption of food from aquatic and terrestrial ecosystems in the diet of a 40 ka BP modern human from Tianyuan, China.

3.3.4.1.6. Stable isotope analysis in reconstruction of infant feeding practices

Weaning is the process which refers to the termination of lactation and gradual introduction of a mammal infant to its adult food (Humphrey 2010). World Health Organization (WHO) suggest mothers to breastfed their children for the first two years of baby s life (WHO 2015). Most of the clinical studies recommend that the introduction of solid food should occur around 6 months and termination of weaning by 2-3 years (Swellen, 2001). However, some populations continue to breastfeed children until 5 years under specific conditions and factors (e.g. environmental) (Kennedy 2005; Moffat and Finnis 2010).

The process of weaning has been examined in many studies using stable isotope analysis (Katzenberg et al. 1993; Schurr 1998; Wright and Schwarcz 1999; Mays et al. 2002; Schurr and Powell 2005; Fuller et al. 2006; Williams et al. 2006; Dupras and Tocheri 2007; Pearson et al. 2010; Nitsch et al. 2011, Waters-Rist et al. 2011; Herrscher 2013; Howcroft 2013, Kaupova et al. 2014; Beaumont 2015). The first study of children feeding practices using nitrogen stable isotope ratios was first published in 1989 by Fogel and his collaborators. This study, as well as other modern clinical ones, has highlighted a trophic level shift of between 2 and 4‰ in the nitrogen isotope ratio ($\delta^{15}N$) between the hair and fingernail keratin of infants, relative to the keratin $\delta^{15}N$ values of their mothers during breastfeeding (Fogel et al. 1989; Fuller et al. 2006). Since maternal milk is enriched in ^{15}N compared to the maternal diet the ^{15}N of new infant tissues formed just after the beginning of breastfeeding will be slightly higher than that from the mother's tissues (Fogel et al. 1989; Fuller et al. 2006a; de Becdelièvre et al. 2015b; Herrscher et al. accepted). When additional food is introduced to the infant's diet, the ^{15}N of infant tissues will begin to fall, until mothers completely stop to breastfeed their children (Fogel et al. 1989; Fuller et al. 2006; Jay et al. 2008; Millard 2000). Similar pattern is also documented for carbon stable isotope ratios but with a small trophic level increases between infants and mothers (Fuller et al. 2006). By analyzing carbon isotopic ratios one can also identify some specific weaning food which are not originating from maternal milk (Wright and Schwarcz 1999; Williams et al. 2005; Clayton et al. 2006; Keenleyside et al. 2009; Choy et al. 2010).

3.3.4.2. Sampling strategy and extraction of collagen

3.3.4.2.1. The sampling strategy

The stable isotope analysis of bone/tooth collagen was conducted on 40 human and animal samples coming from the sites outside the Danube Gorges. Cortical parts of long bones (or cranium bones) of 19 humans (Table 3.6.) were sampled for carbon, nitrogen and sulphur isotope analysis. In order to define local isotopic baseline and food resources available 11 animal remains were also sampled (cattle, sheep/goat, pig, roe deer, dog/wolf).

Concerning young children, an intra-individual strategy was developed to assess the weaning patterns of three children, aged from 3 to 9 years (Table 3.7). This multi-sampling strategy is based on the schedule of dental development and growth rates of tissues.

Carbon and nitrogen isotopic signals were then compared between different tissues formed in different time (according to Ubelaker 1989) (Fig:3.6):

a) dentine collagen extracted from the upper part of crown of the first deciduous molar (recording dietary signal ca. from birth to 6 months),

Table 3.6. The basic information on human and animals samples, the sites, burial number, material sampled, sex, age and dating information.

Site	Environment	Altitude	Sample	Individual/Context	Lab Code	Age	Sex	Species	Period	Abs. dating (cal. BC)
Klisa	Plains/Vojvodina	76m	Humerus	grave 6	Kl.6.1.	4-5	ND	Human	EN	
Klisa	Plains/Vojvodina	76m	Phalanx	grave 8	Kl.8.1.	15-18	F	Human	EN	
Klisa	Plains/Vojvodina	76m	Radius	grave 10a	Kl.10a.1.	>40	M	Human	EN	
Klisa	Plains/Vojvodina	76m	Molar	grave 8	Kl.8.2.			Pig/Wild boar	EN	
Klisa	Plains/Vojvodina	76m	Tibia	grave 6	Kl.6.2.			Dog/Wolf	EN	
Klisa	Plains/Vojvodina	76m	Maxillar	grave 6	Kl.6.3.			Cattle	EN	
Klisa	Plains/Vojvodina	76m	Humerus	grave 10	Kl.10a.4			Sheep	EN	
Klisa	Plains/Vojvodina	76m	Mandible	grave 10	Kl.10a.3			Sheep/goat	EN	
Perlez- Batka "B"	Plains/Vojvodina	72m	Humerus	grave ?	Pb.XI.1	14	ND	Human	EN	
Perlez- Batka "C"	Plains/Vojvodina	72m	Ulna	grave 1	Pb.C.1	>30	F	Human	EN	6090-5880 (Borić 2011)
Perlez- Batka "B"	Plains/Vojvodina	72m	Pelvis	grave ?	Pb.XI.3			Cattle	EN	
Perlez- Batka "C"	Plains/Vojvodina	72m	Cranium	grave 1	Pb.C.3			Cattle/Auroch	EN	
Perlez- Batka "C"	Plains/Vojvodina	72m	Long Bone	grave 1	Pb.C.4			Sheep/goat	EN	
Perlez- Batka "C"	Plains/Vojvodina	72m	Long Bone	grave 1	Pb.C.2	Fœtus		Pig	EN	
Perlez- Batka "B"	Plains/Vojvodina	72m	Long Bone	grave ?	Pb.XI.2			Roe deer	EN	

Sremski Karlovci	Plains/Vojvodina	175m	Phalanx	grave1	Sk.1	35-50	F	Human	EN	
Sremski Karlovci	Plains/Vojvodina	175m	Metatarsus	grave1	Sk.2			Sheep/goat	EN	
Golokut-Vizić	Plains/Vojvodina	207m	Rib	grave 2/1984	GV.2.(1984).b	40-50	F	Human	EN	5560-5360 (Whittle et al. 2002)
Golokut-Vizić	Plains/Vojvodina	207m	Long Bone	grave 1/2003	GV.1.b	7-9	ND	Human	EN	
Golokut-Vizić	Plains/Vojvodina	207m	Long Bone	grave 2/2003	GV.2.b	16-17	ND	Human	EN	
Golokut-Vizić	Plains/Vojvodina	207m	Rib	grave 3/2003	GV.3.b	15-18	ND	Human	EN	
Golokut-Vizić	Plains/Vojvodina	207m	Cranium	grave 4/2003	GV.4.b	12-15	ND	Human	EN	
Golokut-Vizić	Plains/Vojvodina	207m	Long Bone	grave ?/2003	GV.X.b	1-3	ND	Human	EN	
Obrež-Baštine	Plains/Vojvodina	68m	Cranium	grave 1	BO.1.b.	4-6	ND	Human	EN	
Vinča-Belo Brdo	Plains/Šumadija	79m	Cranium	Skull III	Vin.III	30-40	ND	Human	EN	5570–5475 (Tasić et al. 2015)
Vinča-Belo Brdo	Plains/Šumadija	79m	Cranium	Skull IV	Vin.IV	20-30	ND	Human	EN	5620–5485 (Tasić et al. 2015)
Vinča-Belo Brdo	Plains/Šumadija	79m	Cranium	Skull IX	Vin.IX	25-30	F	Human	EN	5660–5555 (Tasić et al. 2015)
Vinča-Belo Brdo	Plains/Šumadija	79m	Cranium	Skull M	Vin.M	>30	ND	Human	EN	
Grivac	Hills/Šumadija	410m	Cranium	grave 1	GRI	30-35	ND	Human	EN	
Rudnik Kosovski	Hills/Kosovo	678m	Cranium	grave 1	RK	>50	F	Human	EN	

Table 3.7. The basic information for children on which multisampling strategy was applied (the sites, burial number, teeth sampled, sex, and age).

Site	Environment	Altitude	Sample	Individual/Context	Lab Code	Age	Sex	Species	Period
Klisa	Plains/Vojvodina	76m	m1 (54) crown	grave 6	Kl.6.m1.c	4-5	ND	Human	EN
Klisa	Plains/Vojvodina	76m	m1 (54) root	grave 6	Kl.6.m1.r	4-5	ND	Human	EN
Klisa	Plains/Vojvodina	76m	M1 (36) crown	grave 6	Kl.6.M1.c	4-5	ND	Human	EN
Golokut-Vizić	Plains/Vojvodina	207m	m1 (84) crown	grave 1/2003	GV.1.m1.c	7-9	ND	Human	EN
Golokut-Vizić	Plains/Vojvodina	207m	M1 (46) crown	grave 1/2003	GV.1.M1.c	7-9	ND	Human	EN
Golokut-Vizić	Plains/Vojvodina	207m	M2 (47) root	grave 1/2003	GV.1.M2.r	7-9	ND	Human	EN
Obrež-Baštine	Plains/Vojvodina	68m	m1 (64) crown	grave 1	BO.1.m1.c	4-6	ND	Human	EN
Obrež-Baštine	Plains/Vojvodina	68m	M1 (46) crown	grave 1	BO.1.M1.c	4-6	ND	Human	EN
Obrež-Baštine	Plains/Vojvodina	68m	M1 (46) root	grave 1	BO.1.M1.r	4-6	ND	Human	EN

b) dentine collagen extracted from the upper part of the crown of the first permanent molar (recorded signal reflecting an average of the diet from 6 months to 2-3 years old),

c) bone collagen - cortical part of the bone (recording events few months/years prior death according to the age of the child and depending on turnover velocity) and

d) dentine collagen from the growing root of a tooth; the recorded isotopic signal reflects the diet just before death of a child (records a more recent events before death).

This analysis provides a continuous picture of the diet from the birth of a child to the time of its death. It provides information on the protein part of diet of each individual at different times of their life and it also offers the possibility to discuss patterns of change, including the timing of the weaning process.

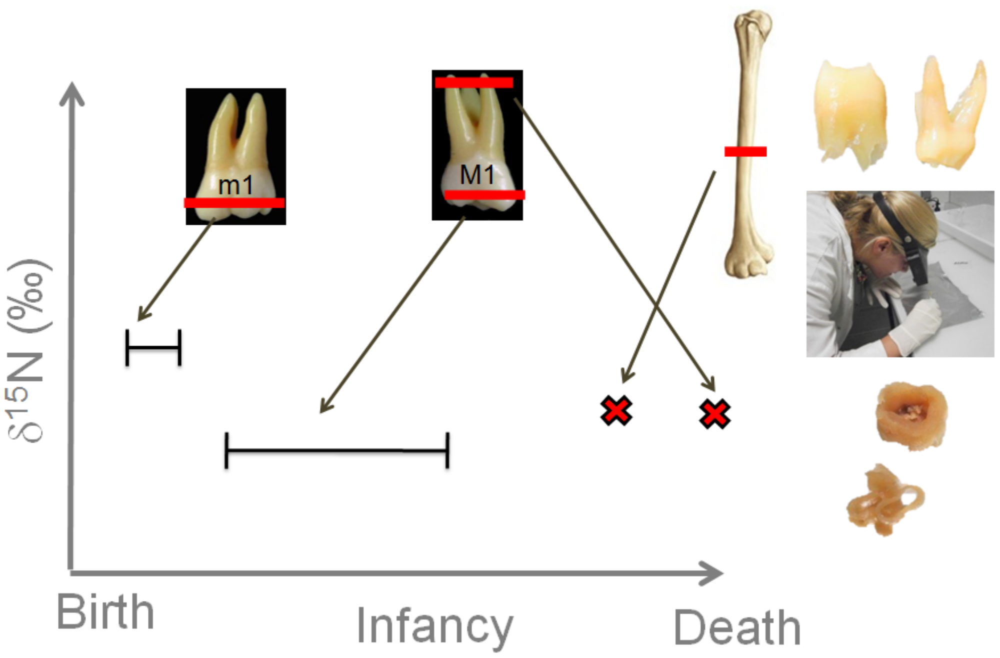

Fig. 3.6. A specific multisampling strategy applied to access patterns of weaning (adapted from Jovanović et al. 2015a)

3.3.4.2.2. Extraction of collagen

Bone and tooth samples are firstly cleaned by Al_2O_3 abrasion. Collagen was extracted from bone following Longin and Bocherens' methods (Longin 1971) (Bocherens 1992) (LAMPEA laboratory, Aix en Provence, France). Bone was crushed (0.710 mm) and powder was demineralized during 20 min with an HCl solution (1M) and then rinsed and filtered. The remaining filtrate was soaked into a NaOH solution (0.125M) for 20h, rinsed and filtered. The filtrate is dissolved into a weak acid solution (HCl, pH2) at 100°C during 17h and filtered with an Ezee Filter®. The solution is then frozen and freeze dried during 48h.

Teeth were soaked entirely into an HCl solution (0.5M) in the fridge (5°C). Once completely demineralized (including enamel part), teeth were rinsed and cut at strategic points as presented in Figure 3.7. The selected piece of teeth collagen were then prepared as for bone. Extraction yield is calculated on freeze dried samples, and only samples over 1% of collagen are analyzed. Elemental composition and stable isotope ratios are analyzed by EA-IRMS (Europa Scientific elemental analyser coupled to Europa Scientific 20-20 IRMS; Iso-Analytical Ltd, UK). The reference material used for analysis was laboratory standards calibrated against and traceable to comparison international standards (IAEA); the measurement error is 0.05 for $\delta^{13}C$, 0.2 for $\delta^{15}N$ and 0.3 for $\delta^{34}S$.

3.3.4.2. Starch grain analysis

In this thesis analysis of plant microfossils trapped in dental calculus was conducted, more precisely starch grains in order to better explore Mesolithic-Neolithic use of plant foods. Starch grains are storage units which are mostly found in high concentrations in parts of the plant that are used as food, such as seeds, fruits and tubers. They can be identified by both size and the position of the hilum (the area where the grain started its growth) that can be seen with an overlaying "X" or Maltese cross (Figure 3.7) under cross-polarized light (Horrocks and Wozniak 2008). Examination of starch grains provides a good source of information which can help in understanding the use and domestication of plants and crop cultivation in the past. Nonetheless, investigation of starch grains provides not only information about diet, but also on culinary practices in the past, because cooking can influence the shape, size and other features of starch grains that are visible with light microscopy (e.g. Lamb and Loy, 2005; Samuel 2000; del Pilar Babot 2003; Henry et al. 2009).

Consumption of starch-rich food does not guarantee that the starch granules will be trapped and preserved in the dental calculus of the consumer. In addition, not all edible plants and plant organs produce starch, thus it is unreliable to make any predictions about the frequency/degree of consumption of starch-containing food based on the number of starch grains recovered from the calculus (Mickleburgh and Pagan-Jimenez 2012). Most of the starch grains range from 1 μm to around 100 μm in size. Their size, shape and morphological characteristics tend to vary and can be used as a basis for botanical identification. However, not all starch grains have diagnostic features based on which they can be identified to plant species (Mickleburgh and Pagan-Jimenez 2012). This further complicates the attempt at estimating the degree of consumption of starch-producing plants/plant parts. However, it is plausible that greater consumption of starch-rich food raises the chances of starch grains becoming trapped in the calculus.

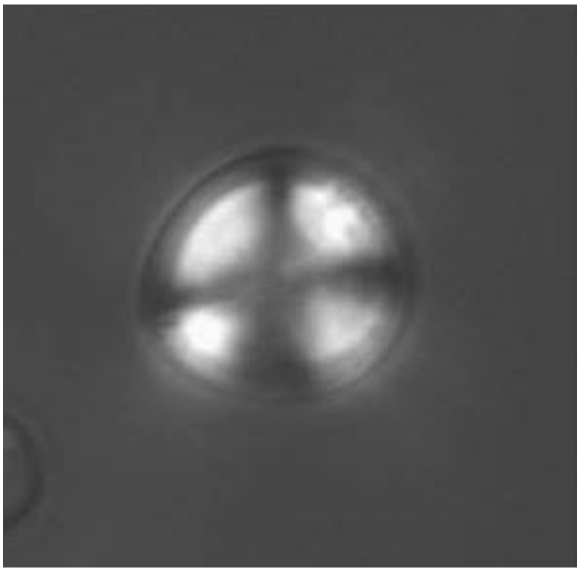

Fig. 3.7. Example of wheat starch grain with visible Maltese cross in the middle under polarized microscope (from Henry et al. 2009).

Therefore, the aim of this study was to detect presence/absence of starch grains in the dental calculus and, where possible, identify the grains only to the family level. The data on starch are then combined with the available stable isotope data and together used to assess possible dietary trend towards higher intake of carbohydrates in the Neolithic. Only samples with macroscopically evident calculus were chosen to perform microfossil extraction and analysis.

3.3.4.3.1.Calculus demineralization and starch grain extraction

All calculus removal, demineralization and microfossil extraction was performed in the Histology laboratory at the Crop science Department, Faculty of Agriculture University of Belgrade. The calculus was carefully removed with a sterilized dental tool in sterile and starch-free conditions. It was gently scraped into 1 cm2 aluminium foil pans and weighed to 0.001 mg on a microbalance, with extracted weights ranging from 0.024 to 18.248 mg. Recovered calculus fragments were placed in sterile 1.5 ml Eppendorf tubes for the demineralization step. For extracting starch grains from calculus Tromp methodology (Tromp 2012) was used, which actually uses protocol of Hardy and colleagues (2009) as a base version of protocol. Here is the detail description of the protocol used for starch grain extraction from calculus.

3.3.4.3.2. Starch grain extraction protocol (Tromp 2012:105):

1. Add 500 μl of 0.6 M HCl to calculus for 2 – 5 minutes to remove any adhering sediment (will fizz if sediment is present)
2. Vortex and centrifuge sample, discarding supernatant
3. Add 1 ml of 0.6 M HCl to calculus for decalcification
4. Place tube on nutator tray in 4°C refrigerator for 24 hours
5. After 24 hours, use a sterile micropestle to gently break apart softened calculus
6. Centrifuge sample (10,000 rpm) for 2 minutes
7. Pipette off most of supernatant, leaving sample pelleted at the bottom of the tube
8. Use 1 ml of fresh, chilled 0.6 M HCl to wash off any material that might be adhering to the pestle back into the 1.5 ml tube.

9. Place tube back on nutator tray for an additional 1 – 3 days (visually inspect every 12 – 24 hours, there should be no large chunks left when decalcification is complete)

10. When decalcification is complete, centrifuge sample (10,000 rpm) for 2 minutes

11. Rinse sample three times (twice with 18 MΩ water and once with isopropyl) using the following steps:

a. Centrifuge sample (10,000 rpm) for 2 minutes

b. Pipette off most of supernatant leaving sample pelleted at the bottom of the tube

12. Store in < 200 μl of isopropyl alcohol

Afterwards, all the samples were observed with a Olympus BX51 housed in the Laboratory for Optical Microscopy at Faculty of Agriculture, University of Belgrade. For each sample a drop of 30 μl was placed on a standard 25 x 75 mm glass slide, mounted in one or two drops of paraffin oil and covered with an 18 x 18 mm glass cover slip secured with clear nail polish at two corners. The total surface of the slide was examined in its entirety in horizontal transects using cross-polarized light to identify and photograph all starches and also under light microscopy. Every starch grain was counted, photographed and compared to a reference collection starch grain databases in order to detect family and number of starches. For comparison, images and descriptions from published papers were used to identify starch grains found in the samples. Once analyses were finished all slides were sealed with two coats of clear nail polish and placed in a slide holder for storage. The obtained results were interpreted together with stable isotope data in relation to demographic category, chronology and region.

3.3.5. Metric characteristics

Cranial and postcranial measurements have been an important part in studying skeletal biology since they can be used to describe differences and variations on individual and population level. Groups that share more metric features in common are considered to be more closely related than groups not sharing these same features (Larsen 1997). Factors that are mostly influencing on variations in skeletal morphology are genetic, environment, age, sex, behaviour, and nutrition (Hauspie 2002; Hindmarsh 2002). By examining dimensions of long bones we can get valuable data to estimate stature, body mass, age, sex and activity patterns (Ruff et al. 1984; Trotter and Gleser

1958). Estimation of adult stature and body mass is important because it can be indicator of physiological stress, malnutrition, or disease (Goodman et al. 1984; Kemkes-Grottenthaler 2005).

Metrical analyses of cranial and postcranial skeleton were done by using standard anthropological measurements as defined by Martin (1924). Additional measurements were taken from Buikstra and Ubelaker (1994). Furthermore, standard indices derived from these measurements were calculated. All the measurements and calculated indices are represented in Tables 1-7, in the Appendix 1. The measurements for the Danube Gorges skeletons were taken from de Becdelièvre (in prep.) and Jovanović and colleagues (2016).

Adult stature was estimated using any available long bone measurement with preference to the femur when present by applying the equation as suggested by Trotter and Gleser (1958). Body mass was calculated using equation based on maximum diameter of femoral head (Ruff et al. 1991; Auerbach and Ruff 2004).

3.3.5.1. The Body mass index

The body mass index (BMI) is a value obtained from the body mass (weight) and height of an individual. It measures amount of fat in an individual and categorize it into four categories:

I Underweight (under 18,5)
II Normal weight (18, 5-25)
III Overweight (25-30)
IV Obese (over 30)

BMI is calculated by dividing weight (kg) by height squared in meters (Quetelet 1832; Keys 1972).

3.3.6. Statistical analysis

All statistical analyses were performed in SPSS 15.0® using mainly non parametric tests. Statistical significance was calculated at a threshold of $p>0.05$. A chi-square and Fisher's exact test were used to access the frequencies of different pathological conditions over chronology, region and demographic category based on their presence and absence, and in some cases for activity and degree patterns of pathological condition (cribra orbitalia and porotic hyperostosis). Considering the sample size, Fisher's exact test was used whenever 2 x 2 contingency tables were present, while chi-square test was done in cases of analyzing activity and degree, which included more than two modes. For calculating the effect size, Cramer's V was used. Tests were done separately on population level, for adult males, females, and for children. In order to access differences in body mass index (BMI) in Mesolithic and Neolithic, the t-test for testing whether the means of BMI between two periods are significantly different, was performed. Whenever the sample size was less than 10, test was not performed.

4. RESULTS

In this chapter all results will be presented as well as results of statistical tests whenever sample size permitted to perform statistical analysis. First, results on dietary indicators (stable isotope analysis, starch grain analysis) will be presented, and after results on dental caries, calculus, and AMTL frequencies. At the end, the results on markers of physiological stress (cribra orbitalia, porotic hyperostosis, enamel hypoplasia) will be showed, as well as results on body proportions.

4.1. Results of stable isotope analysis

The results from the analysis of carbon ($\delta^{13}C$), nitrogen ($\delta^{15}N$) and sulphur ($\delta^{34}S$) isotopes in human and animal samples are presented here. To test the quality of the collagen used to measure carbon, nitrogen and sulphur isotopes, two different variables were observed: carbon, nitrogen and sulphur content (weight %) and the atomic C/N, C/S and N/S ratio. Carbon, nitrogen and sulphur content (% C, % N and %S) is a measurement of the two elements in collagen sample by weight using an elemental analyzer. It is known from previous studies that modern mammalian bone collagen has carbon ratios ranging from 15.3% to 47% and nitrogen ratios ranging from 5.5% to 17.3% (Ambrose 1990) while for sulphur is between 0.15-0.35 % (Nehlich and Richards 2009). Samples that exhibit % C, % N and % S ratios outside of these ranges were not used. The atomic C/N ratio of modern humans and animals collagen usually ranges from 2.9 to 3.6 (DeNiro 1985) or 3.1 to 3.5 (van Klinken 1999). The N/S ratio of mammals ranges from 100-300, while for fish is 40-80. The C/S ratio of mammals ranges from 300-900, while for fish is 175±50 (Nehlich and Richards 2009).

The elemental and isotopic data for all human and animal bone samples used in this study are presented in Table 4.1. C/N ratios for the human and faunal samples ranged from 3.1 to 3.3. N/S ratios range from 91.4 to 149.3, while C/S range from 306.9 to 475.6. All these fall within the range for well-preserved collagen. The percent nitrogen values ranged from 10.1% to 15.0%; the percent carbon values ranged from 29.2% to 42.7% and percent sulphur values ranged from 0.1% to 0.3%.

Table 4.1. The basic information and elemental and isotopic data for all human and animal bone samples used in this study

* Samples which very slightly exceed some of the collagen quality criteria (%C, %N, C/N, %S, C/S, N/S), but which originate from individuals discovered on sites for which this study is the first work dedicated on stable isotopes, and which are therefore presented here.

Site	Environment	Altitude	Sample	Context	Lab Code	Age	Sex	Species	A. dating (cal BC)	$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)	%C	%N	C/N	$\delta^{34}S$ (‰)	%S	C/S	N/S	Note
Klisa	Plains/Vojvodina	76m	Humerus	grave 6	Kl.6.1.	4-5	ND	Human		-19.9	12.4	36.8	13.4	3.2	3.7	0.3	353.4	110.3	
Klisa	Plains/Vojvodina	76m	m1 (54) crown	grave 6	Kl.6.m1.c	4-5	ND	Human		-19.6	14.3	40.6	14.5	3.2	3.4	0.2	539.6	165.4	
Klisa	Plains/Vojvodina	76m	m1 (54) root	grave 6	Kl.6.m1.r	4-5	ND	Human		-19.4	14.3	39.2	13.8	3.3	4.3	0.3	347.9	104.8	
Klisa	Plains/Vojvodina	76m	M1 (36) crown	grave 6	Kl.6.M1.c	4-5	ND	Human		-19.4	14.2	41.5	15.0	3.2	4.2	0.2	552.2	171.1	
Klisa	Plains/Vojvodina	76m	Phalanx	grave 8	Kl.8.1.	15-18	F	Human		-21.0	10.1	35.8	13.1	3.2	4.8	0.2	475.6	149.3	
Klisa*	Plains/Vojvodina	76m	Radius	grave 10a	Kl.10a.1.	>40	M	Human		-20.6	10.4	39.9	14.6	3.2	5.1	0.3	402.7	126.2	
Klisa	Plains/Vojvodina	76m	Molar	grave 8	Kl.8.2.			Pig/Wild boar		-20.1	8.3	36.2	13.1	3.2					
Klisa*	Plains/Vojvodina	76m	Tibia	grave 6	Kl.6.2.			Dog/Wolf		-18.8	10.3	40.9	15.0	3.2	6.5	0.3	426.2	133.7	
Klisa	Plains/Vojvodina	76m	Maxillar	grave 6	Kl.6.3.			Cattle		-20.8	6.0	30.6	11.2	3.2	2.7	0.2	410.1	128.6	
Klisa*	Plains/Vojvodina	76m	Humerus	grave 10	Kl.10a.4			Sheep		-20.4	6.0	36.7	13.5	3.2	3.6	0.3	389.8	122.6	
Klisa	Plains/Vojvodina	76m	Mandible	grave 10	Kl.10a.3			Sheep/goat		-20.3	5.3	36.6	13.6	3.1	4.2	0.2	424.2	134.9	
Perlez-Batka "B"	Plains/Vojvodina	72m	Humerus	grave ?	Pb.XI.1	14	ND	Human		-19.7	12.1	37.5	13.8	3.1					
Perlez-Batka "C"	Plains/Vojvodina	72m	Ulna	grave 1	Pb.C.1	>30	F	Human	6090-5880 (Borić 2011)	-20.4	10.0	40.3	14.8	3.2					

Perlez-Batka "B"	Plains/Vojvodina	72m	Pelvis	grave ?	Pb.XI.3			Cattle		-18.9	8.5	38.9	14.3	3.2					
Perlez-Batka "C"	Plains/Vojvodina	72m	Skull	grave 1	Pb.C.3			Cattle/Auroch		-21.1	7.4	40.3	14.7	3.1					
Perlez-Batka "C"	Plains/Vojvodina	72m	Long Bone	grave 1	Pb.C.4			Sheep/goat		-20.0	7.6	42.4	15.0	3.3					
Perlez-Batka "C"	Plains/Vojvodina	72m	Long Bone	grave 1	Pb.C.2	Fœtus		Pig		-20.8	3.8	42.7	14.3	3.1					
Perlez-Batka "B"	Plains/Vojvodina	72m	Long Bone	grave ?	Pb.XI.2			Roe deer		-20.0	7.7	40.6	15.0	3.1					
Sremski Karlovci	Plains/Vojvodina	175m	Phalanx	grave1	Sk.1	35-50	F	Human		-20.7	10.6	38.3	14.0	3.2					
Sremski Karlovci	Plains/Vojvodina	175m	Metatarsus	grave1	Sk.2			Sheep/goat		-20.5	9.4	38.7	14.1	3.2					
Golokut-Vizić	Plains/Vojvodina	207m	Rib	grave 2/1984	GV.2.(1984).b	40-50	F	Human	5560-5360 (Whittle et al. 2002)	-20.3	10.2	35.2	13.0	3.1					
Golokut-Vizić	Plains/Vojvodina	207m	Long Bone	grave 1/2003	GV.1.b	7-9	ND	Human		-20.1	6.4	39.1	14.4	3.2					
Golokut-Vizić	Plains/Vojvodina	207m	m1 (84) crown	grave 1/2003	GV.1.m1.c	7-9	ND	Human											no collagen
Golokut-Vizić	Plains/Vojvodina	207m	M1 (46) crown	grave 1/2003	GV.1.M1.c	7-9	ND	Human		-20.6	11.1	3.8	1.1	4.2					bad C/N ratio
Golokut-Vizić	Plains/Vojvodina	207m	M2 (47) root	grave 1/2003	GV.1.M2.r	7-9	ND	Human		-20.9	11.9	25.7	7.8	3.8					bad C/N ratio
Golokut-Vizić*	Plains/Vojvodina	207m	Long Bone	grave 2/2003	GV.2.b	16-17	ND	Human		-20.4	6.4	29.4	10.6	3.2					
Golokut-Vizić*	Plains/Vojvodina	207m	Rib	grave 3/2003	GV.3.b	15-18	ND	Human		-19.9	11.8	162.1		3.1	2.2	0.2	514.3		
Golokut-Vizić	Plains/Vojvodina	207m	Skull	grave 4/2003	GV.4.b	12-15	ND	Human		-20.6	10.4	34.9	13.0	3.1	4.1	0.2	580.0	185.5	
Golokut-Vizić	Plains/Vojvodina	207m	Long Bone	grave ?/2003	GV.X.b	1-3	ND	Human		-21.1	10.2	35.6	13.1	3.2					

Obrež-Baštine	Plains/Vojvodina	68m	Skull	grave 1	BO.1.b.	4-6	ND	Human		-20.4	11.0	32.4	12.0	3.1	4.7	0.2	431.3	137.0	
Obrež-Baštine	Plains/Vojvodina	68m	m1 (64) crown	grave 1	BO.1.m1.c	4-6	ND	Human		-19.7	15.5	37.1	13.3	3.2					
Obrež-Baštine	Plains/Vojvodina	68m	M1 (46) crown	grave 1	BO.1.M1.c	4-6	ND	Human											no collagen
Obrež-Baštine	Plains/Vojvodina	68m	M1 (46) root	grave 1	BO.1.M1.r	4-6	ND	Human		-20.7	12.0	28.4	10.2	3.3					
Vinča-Belo Brdo*	Plains/Šumadija	79m	Skull	Skull III	Vin.III	30-40	ND	Human	5570–5475 Tasić et al. 2015	-20.8	11.6	29.2	10.1	3.3	4.6	0.3	306.9	91.4	
Vinča-Belo Brdo	Plains/Šumadija	79m	Skull	Skull IV	Vin.IV	20-30	ND	Human	5620–5485 Tasić et al. 2015	-20.7	13.3	29.5	10.5	3.2	5.6	0.2	359.7	110.0	
Vinča-Belo Brdo	Plains/Šumadija	79m	Skull	Skull IX	Vin.IX	25-30	F	Human	5660–5555 Tasić et al. 2015	-20.6	12.0	38.9	14.2	3.2	4.3	0.2	430.0	134.6	
Vinča-Belo Brdo*	Plains/Šumadija	79m	Skull	Skull M	Vin.M	>30	ND	Human		-20.5	11.9	36.6	13.3	3.2	7.4	0.3	329.1	102.2	
Grivac	Hills/Šumadija	410m	Skull	grave 1	GRI	30-35	ND	Human		-19.9	12.0	35.2	12.4	3.3					
Rudnik Kosovski	Hills/Kosovo	678m	Skull	grave 1	RK	>50	F	Human		-20.6	8.9	39.2	13.9	3.3					

4.1.1. Animal stable isotope values

Eleven animal bone samples were analyzed for their carbon, nitrogen and sulphur isotope composition. Animal values range from -21.1‰ to -18.8‰ for carbon (Δ=2.3‰; n=11) (Fig.4.1), from 5.3‰[27] to 10.3‰ for nitrogen (Δ=5‰; n=11) and from 2.7‰ to 6.5‰ (Δ=3.8‰; n=4) for sulphur (Fig.4.2). Terrestrial herbivore and omnivore animal values range within the expected range for terrestrial C_3 plant ecosystem (Bocherens 1997). Dog/ Wolf value from Klisa show the highest carbon and sulphur stable isotope ratios compared to the other animal species and similar $\delta^{15}N$ compared to the contemporaneous humans from this site. The observed difference between values of herbivores/pigs (n=10) and dog/wolf (n=1) is in agreement with the isotopic fractionation in the food chain. It indicates that the dog/wolf had an important amount of animal proteins in the diet. There were also no significant differences of animal stable isotope values between sites.

4.1.2. Human stable isotope values

Nineteen human bone samples were analyzed for their carbon, nitrogen and sulphur isotopes. Human stable isotope ratios values range from -21.0‰ to -19.7‰ for carbon (Δ=1.3‰; n=19), from 6.4‰ to 13.3‰ for nitrogen (Δ=6.9‰; n=19) (Fig.4.1) and from 2.2‰ to 7.4‰ for sulphur (Δ=5.2‰; n=10) (Fig.4.2). These isotopic data are consistent with the published data (Whittle et al. 2002; Nehlich et al. 2010) for regions of the Central Balkans which are studied here. Among adults in this study, stable isotope ratios of nitrogen and sulphur are the highest in Vinča humans, ranging from 11.6‰ to 13.3‰ (Δ=1.7‰; n=4) for $\delta^{15}N$ and $\delta^{34}S$ range from 4.3 to 7.4 (Δ=3.1‰), while their $\delta^{13}C$ values range from -20.8‰ to -20.5‰ (Δ=0.3‰). Adult individual from Rudnik Kosovski has the lowest $\delta^{15}N$ (8.9‰) while its $\delta^{13}C$ is -20.9‰. Children from Klisa (grave 6) Perlez Batka "B" and Golokut-Vizić (grave 3/2003) show the highest nitrogen values, while the lowest $\delta^{15}N$ values are recorded for Golokut-Vizić (1/2003 and 2/2003). The highest sulphur values show children from Klisa (8) and Obrež-Baštine.

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[27] The pig foetus values were not taken into consideration.

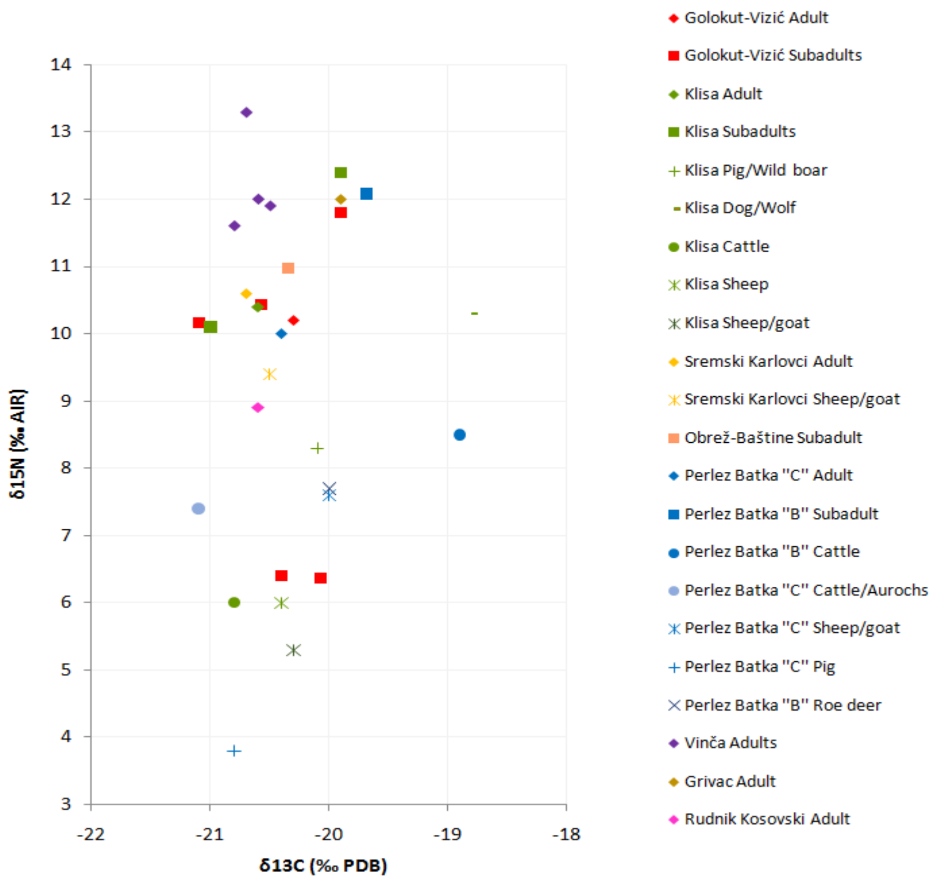

Fig. 4.1. δ^{13}C and δ^{15}N values of humans and animals used in this study

4.1.3. Results for weaning patterns

The multisampling strategy was successful in only two children: Klisa (grave 6) and Obrež Baštine (grave 1). The tooth samples of the child from the site of Golokut Vizić (grave 1/2003) exhibited bad C/N ratios and thus were excluded from the further study. One value for the root of permanent M1 (site Obrež Baštine) was also excluded due to bad C/N ratio.

The 4-5 year-old child from Klisa exhibited high nitrogen values of tooth crowns (both deciduous and permanent first molars), which reflects diet between 0-6 month, and around 1.75 year. High δ^{15}N value was also observed for the root of deciduous first molar. On the other hand, the bone signal shows decreasing in nitrogen value.

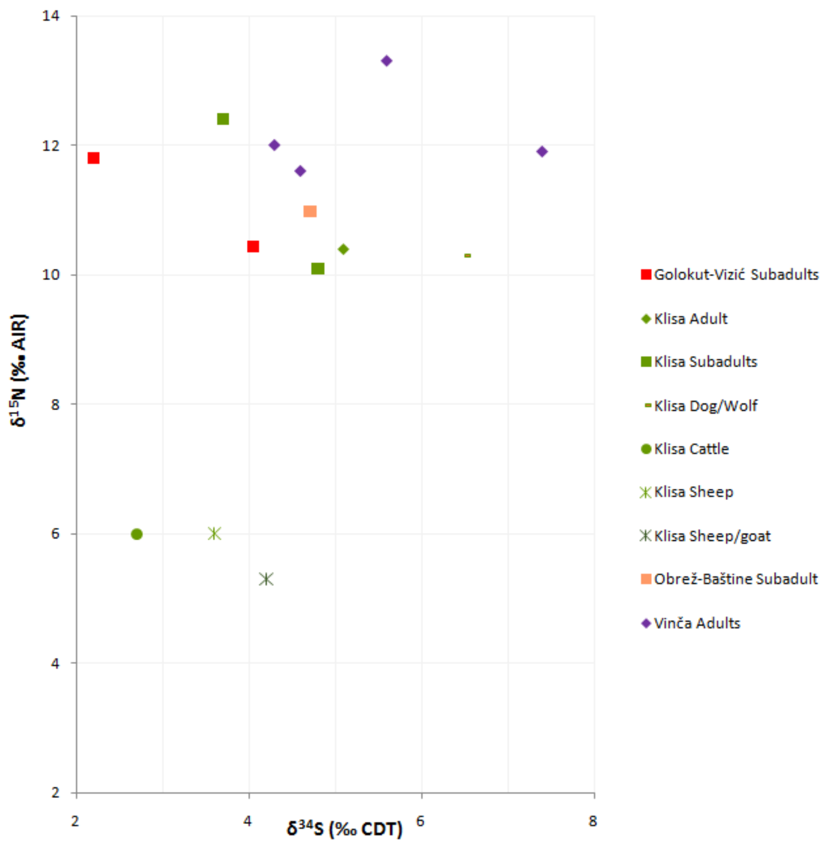

Fig. 4.2. δ^{34} S and δ^{15} N values of humans and animals used in this study

For the second child (4-6 years old) from the site of Obrež-Baštine only two values were obtained. The first value (crown of deciduous first molar), which reflects diet from approximately 0-6 month showed high nitrogen value, while the second value (bone) exhibited lower nitrogen.

4.2. Results of starch grain analysis

Results of starch grains analysis are presented in Table 4.2. The total number of starch grains found in Mesolithic is 5 while in Neolithic in the Danube Gorges is 30 and in Neolithic outside of the Danube Gorges is 131. Starch grains are mostly originated from Poaceae family. In Mesolithic 33% (4/12) of analyzed individuals had starch grains inside dental calculus, while in the Neolithic period of the Danube

Table 2.Total number of starch grains and basic information on sampled individuals

Site	Burial	Period	Sex	Age category	Absolute dating (cal BC)	Tooth number	Lab Code	Total number of starch grains
Ajmana	3	N	ND	10-14		11	AJ-3-11	0
Ajmana	6	N	M?	Young adult	6030-5824(Borić 2011)	23	AJ-6-23	0
Ajmana	7	N	ND	Middle aged adult	6214-6008 (Borić 2011)	16	AJ-7-16	1
Ajmana	9	N	F	Old adult		34	AJ-9-34	5
Ajmana	11	N	F	Middle aged adult		44	AJ-11-44	1
Ajmana	12	N	ND	1-4		85	AJ-12-85	8
Ajmana	13	N	ND	10-14		22	AJ-13-22	2
Ajmana	14	N	ND	5-9		42	AJ-14-42	1
Ajmana	15	N	ND	5-9		41	AJ-15-41	0
Golokut-Vizić	2/1984	N	F	Middle aged adult	5560-5360 (Whittle et al. 2002)	47	GV-2-47	0
Golokut-Vizić	3/1984	N	F	Middle aged adult	5620-5460 (Whittle et al. 2002)	42	GV-3-42	2
Hajdučka Vodenica	14	M	ND	5-9		32	HV-14-32	1
Hajdučka Vodenica	18	M	ND	10-14		16	HV-18-16	0
Lepenski Vir	6	N	F?	15-19		45	LV-6-45	0
Lepenski Vir	7/I	N	M	Old adult	5230-5985 (Bonsall et al. 2015)	27	LV-7/I-27	1
Lepenski Vir	9	N	ND	Adult size	5980-5740 (Bonsall et al. 2015)	26	LV-9-26	0
Lepenski Vir	11	N	ND	10-14		42	LV-11-42	1
Lepenski Vir	13	N	F?	Adult size		27	LV-13-27	0
Lepenski Vir	14	N	F	Adult size	5235-5990 (Bonsall et al. 2015)	33	LV-14-33	1
Lepenski Vir	16	N	F?	Adult size		41	LV-16-41	0
Lepenski Vir	17	N	ND	Young adult	5776-5575 (Borić 2011)	32	LV-17-32	1
Lepenski Vir	19	N	F	Middle aged adult	5984-5752(Borić 2011)	31	LV-19-31	0
Lepenski Vir	20	N	F	Adult size		17	LV-20-17	0
Lepenski Vir	21	M	ND	Adult size		46	LV-21-46	0
Lepenski Vir	22	M	M?	Adult size	7580–7190 (Borić 2011)	16	LV-22-16	0
Lepenski Vir	26	N	M	Young adult	6025-5890 (Bonsall et al. 2015)	47	LV-26-47	0
Lepenski Vir	27a	N	F?	Middle aged adult		16	LV-27a-16	0
Lepenski Vir	28	N	M	Adult size		48	LV-28-48	1
Lepenski Vir	32a	N	F	Old adult	6076-5731 (Borić 2011)	33	LV-32a-33	1
Lepenski Vir	32b	N	F?	Middle aged adult	6080-5720 (Borić 2011)	46	LV-32b-46	0
Lepenski Vir	37	N	ND	15-19		41	LV-37-41	1
Lepenski Vir	47	N	F	Adult size		38	LV-47-38	0
Lepenski Vir	48	N	ND	Young adult		41	LV-48-41	0
Lepenski Vir	50	M	M	Middle aged adult	8310-7970 (Borić and Price)	47	LV-50-47	0
Lepenski Vir	54e	N	F	Young adult	6210-5930 (Bonsall et al. 2015)	47	LV-54e-47	0

Lepenski Vir	56	N	ND	5-9		17	LV-56-75	1
Lepenski Vir	57	N	ND	15-19		16	LV-57-16	0
Lepenski Vir	57(1)	N	ND	Adult size		47	LV-57(1)-47	2
Lepenski Vir	60	M	M	Middle aged adult	9175-8635 (Bonsall et al. 2015)	46	LV-60-46	1
Lepenski Vir	61	N	ND	5-9	6225-5915 (Bonsall et al. 2015)	11	LV-61-11	1
Lepenski Vir	64	M	M	Middle aged adult		18	LV-64-18	1
Lepenski Vir	69	M	M	Middle aged adult	7940-7590 (Bonsall et al. 2015)	48	LV-69-48	0
Lepenski Vir	73	N	M	Middle aged adult	6005-5845 (Borić 2011)	26	LV-73-26	0
Lepenski Vir	74	N	M?	Adult size		23	LV-74-23	0
Lepenski Vir	79a	N	M?	Old adult	6020-5890 (Bonsall et al. 2015)	37	LV-79a-37	0
Lepenski Vir	82	N	ND	Adult size		17	LV-82-17	0
Lepenski Vir	83a	N	ND	Adult size		31	LV-83a-31	0
Lepenski Vir	88	N	F	Middle aged adult	5984-5644 (Borić 2011)	45	LV-88-45	0
Lepenski Vir	89a	N	ND	Adult size	6060-5780 (Bonsall et al. 2015)	37	LV-89a-37	0
Lepenski Vir	91	N	ND	Adult size		27	LV-91-27	1
Lepenski Vir	105	M	ND	Adult size		36	LV-105-36	2
Lepenski Vir	122	N	ND	15-19	6208-5987 (Borić 2011)	16	LV-122-16	0
Padina	11	M	ND	5-9	8616-8296 (Borić 2011)	46	PA-11-46	0
Vinča	II	N	ND	Middle aged adult	5515–5380 (Tasić et al. 2015)	43	VIN-II-43	6
Vinča	V	N	ND	Young adult	5565–5470 (Tasić et al. 2015)	44	VIN-V-44	5
Vinča	VI?	N	ND	Young adult		36	VIN-VI?-36	0
Vinča	VII	N	F	15-19	5565–5470 (Tasić et al. 2015)	35	VIN-VII-35	23
Vinča	IX	N	F	Young adult	5660–5555 (Tasić et al. 2015)	37	VIN-IX-37	93
Vinča	VIII	N	M	Middle aged adult		38	VIN-VIII-38	1
Vinča	X	N	ND	Middle aged adult	5535–5385 (Tasić et al. 2015)	22	VIN-X-22	1
Vlasac	18c(2)	M	ND	5-9		I(incisor)	VL-18c(2)-I	0
Vlasac	64b	M	ND	5-9		32	VL-64(2)-32	0

Gorges 41.46% (17/41) of analyzed individuals showed presence of starch grains (Fig. 4.3; 4.4). In the regions outside the Danube Gorges starch grains were detected in 77.77 % (7/9) of analyzed individuals.

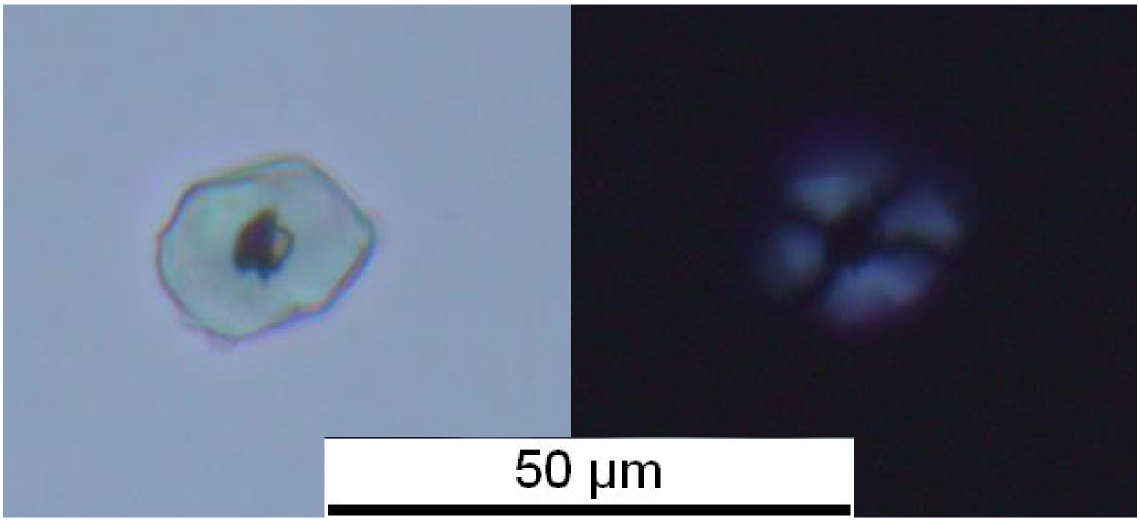

Fig. 4.3. Starch grains recovered from the dental calculus, Ajmana, grave 9 (left image shows the starch under brightfield light and right shows it under cross-polarized light)

When Mesolithic and both Neolithic periods are crossed together results are as follows: in Mesolithic 33 % (4/12) of individuals showed presence of starch grains while in Neolithic starch grains were found in 48 % (24/50) (Table 4.3). Fisher's test showed no statistically significant correlation between period and presence of starch grains (Fisher's exact $p = 0.279$), and has low effect (Cramer's V = 0.116). However, when Mesolithic and only Neolithic outside the Danube Gorges are compared results approached statistical significance (Fisher's exact $p = 0.056$), with medium effect (Cramer's V = 0.440) (Table. 4.4). The similar situation was observed when two Neolithic regions are compared since Fisher's exact p ($p = 0.053$) also approached statistical significance with low effect (Cramer's V = 0.279) (Table 4.5).

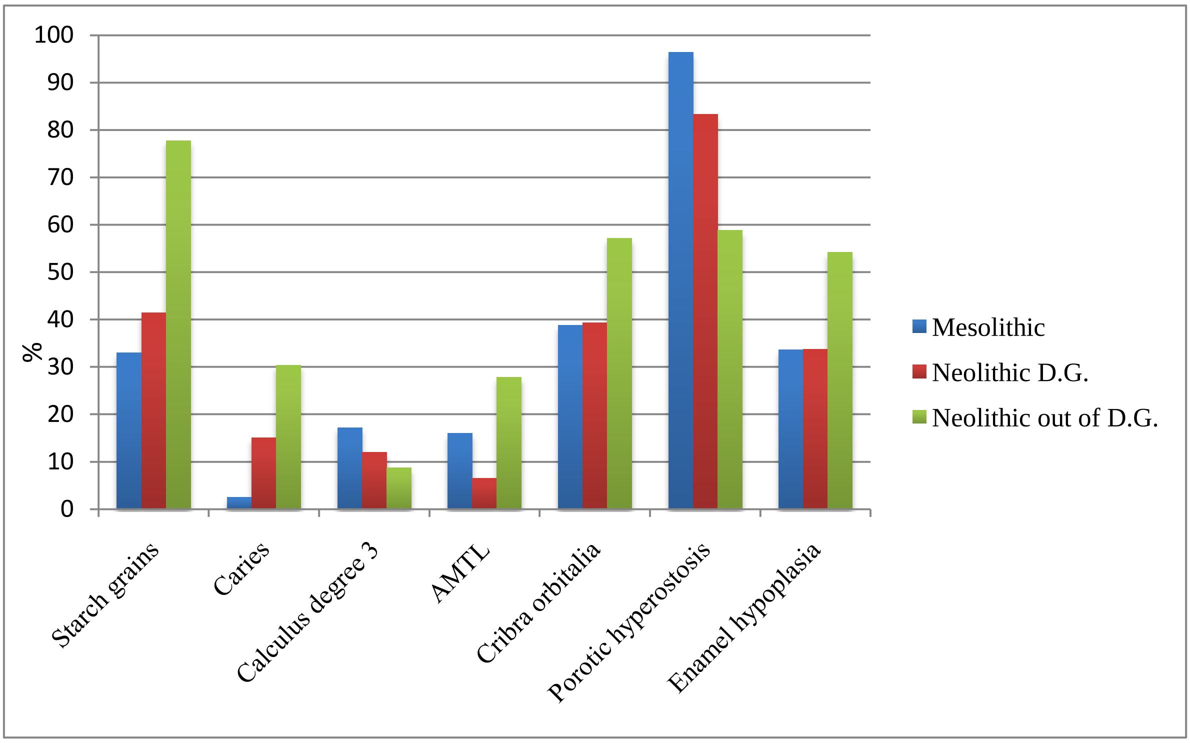

Fig. 4.4. The frequency of diet and health indicators among Mesolithic and Neolithic studied groups

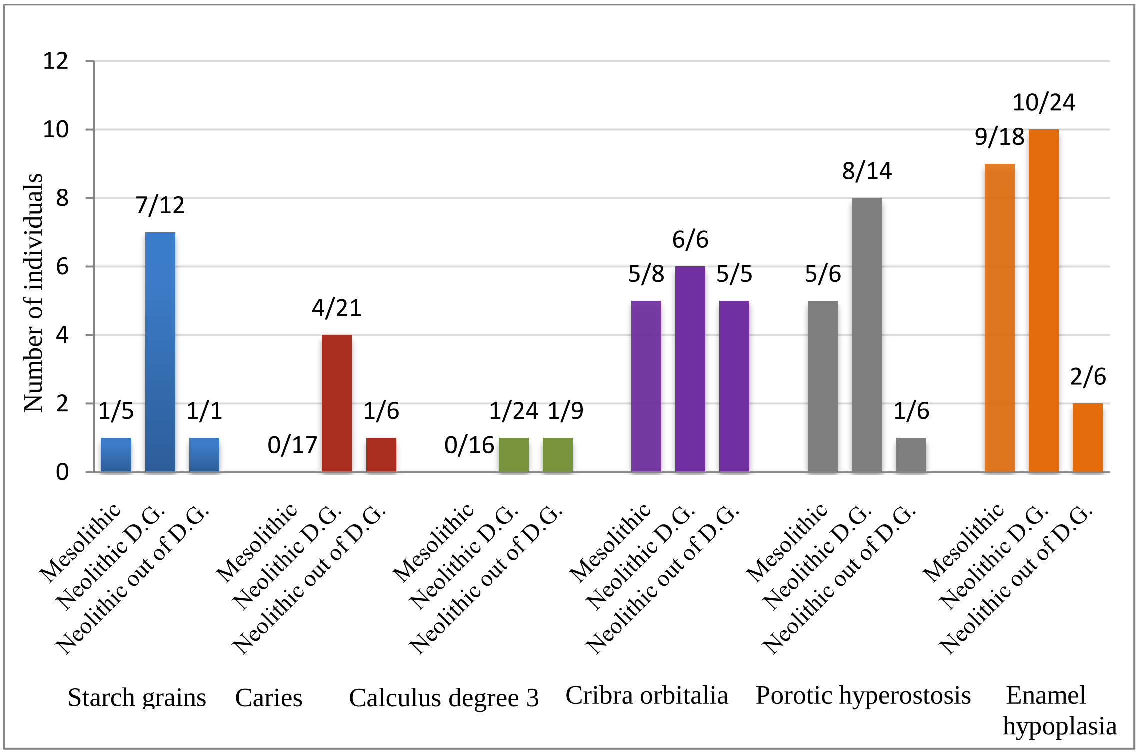

Fig. 4.6. The distribution of diet and health indicators among Mesolithic and Neolithic children

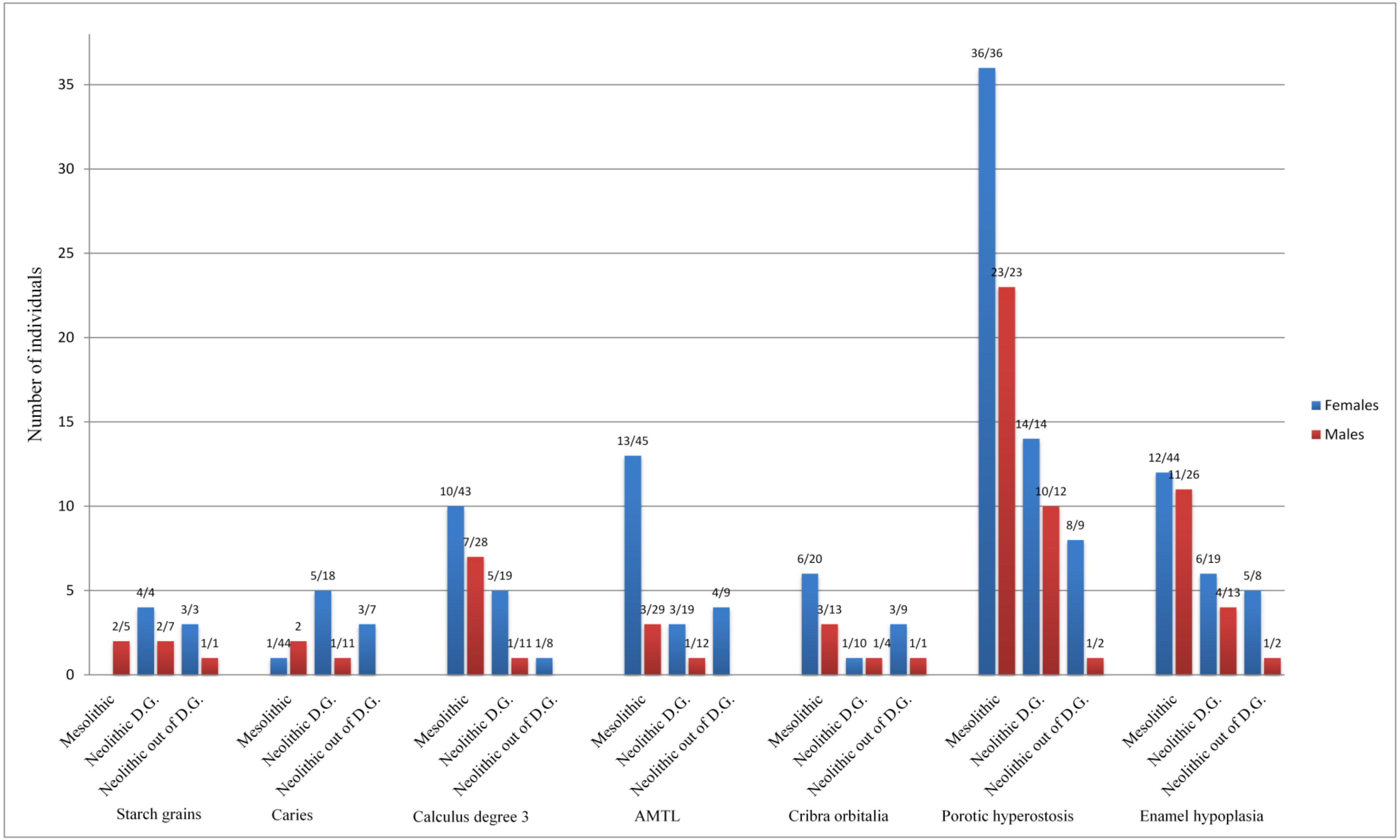

Fig. 4.5.The distribution of diet and health indicators among females and males in Mesolithic and Neolithic studied regions

Table. 4.3. Crosstabulation of period and presence of starch grains in Mesolithic and both Neolithic studied regions

		PRESENCE		TOTAL
		Absent	Present	
MESOLITHIC	**COUNT**	8	4	12
EXPECTED	**COUNT**	6.6	5.4	12.0
NEOLITHIC	**COUNT**	26	24	50
EXPECTED	**COUNT**	27.4	22.6	50.0
TOTAL	**COUNT**	34	28	62

Table 4.4. Crosstabulation of period and presence of starch grains in Mesolithic and Neolithic outside the Danube Gorges

		PRESENCE		TOTAL
		Absent	Present	
MESOLITHIC	**COUNT**	8	4	12
EXPECTED	**COUNT**	5.7	6.3	12.0
NEOLITHIC	**COUNT**	2	7	9
EXPECTED	**COUNT**	4.3	4.7	9.0
TOTAL	**COUNT**	10	11	21

Table 4.5. Crosstabulation of period and presence of starch grains in inhabitants of both Neolithic studied regions

	PRESENCE		TOTAL
	Absent	Present	
NEOLITHIC OUTSIDE D.G.			
COUNT	2	7	9
EXPECTED COUNT	4.7	4.3	9.0
NEOLITHIC D.G.			
COUNT	24	17	41
EXPECTED COUNT	21.3	19.7	41.0
TOTAL **COUNT**	26	24	50

4.2.1. Age and sex distribution

In the Mesolithic 2 out of 5 analyzed males showed presence of starch grains. (Fig. 4.5). In the Neolithic phase of the Danube Gorges 4 out of 14 analyzed females have starch grains inside dental calculus, while 2 out of 7 males showed presence of starch grains (Fig. 4.5). In the Neolithic outside the Danube Gorges 3 out of 4 analyzed females had starch grains (Fig. 4.5). The only male which was analyzed out of the Danube Gorges showed the presence of starch grains.

When both of Neolithic periods were considered together, one can observe that 38.9 % (7/18) of females had starches trapped inside the calculus and 37.5 % (3/8) of males (Table. 4.6). No statistically significant correlation between sex and presence was found (Fisher's exact $p = 0.648$), with low effect (Cramer's V = 0.013).

Considering children, the results are as follows: in Mesolithic only 1 out of 5 (20 %) of analyzed individuals showed presence of starch grains; in the Danube Gorges Neolithic 7 out of 12 (58.33 %), while in Neolithic outside the Danube Gorges, it was possible to analyze only one child who showed the presence of starch grains inside its dental calculus. When Mesolithic and both Neolithic periods are crossed together results are as follows: in Mesolithic 20 % (1/5) of children showed presence of starch grains while in Neolithic starch grains were found in 61.5 % (8/13) (Table.4.7). Fisher's test showed no statistically significant correlation between period and presence of starch grains (Fisher's exact $p = 0.147$), and has low effect (Cramer's V = 0.372).

Table.4.6. Crosstabulation of period and presence of starch grains in Mesolithic and Neolithic females and males

		PRESENCE		TOTAL
		Absent	Present	
FEMALES	**COUNT**	11	7	18
EXPECTED	**COUNT**	11.1	6.9	18.0
MALES	**COUNT**	5	3	8
EXPECTED	**COUNT**	4.9	3.1	8.0
TOTAL	**COUNT**	16	10	26

Table.4.7. Crosstabulation of period and presence of starch grains in Mesolithic and Neolithic children

		PRESENCE		TOTAL
		Absent	Present	
MESOLITHIC	**COUNT**	4	1	5
EXPECTED	**COUNT**	2.5	2.5	5.0
NEOLITHIC	**COUNT**	5	8	13
EXPECTED	**COUNT**	6.5	6.5	13.0
TOTAL	**COUNT**	9	9	18

4.3. Dental caries

4.3.1. The Danube Gorges

In Mesolithic, the presence of dental caries was detected in 2.5% (3/119) individuals while in Neolithic 15.1 % (11/73) had caries (Fig. 4.4; Table 4.8). Statistical analysis has shown statistically significant correlation between the period and presence of caries (Fisher's exact p = 0.002), with low effect (Cramer's V = 0.234). Concerning the number of teeth affected, in Mesolithic 0.2 % is affected (3/1404), while in Neolithic 2.1 % (19/902).

Table 4.8. Crosstabulation of period and presence of dental caries in Mesolithic and Neolithic inhabitants of the Danube Gorges

		PRESENCE		TOTAL
		Absent	Present	
MESOLITHIC	**COUNT**	116	3	119
EXPECTED	**COUNT**	110.3	8.7	119.0
NEOLITHIC	**COUNT**	62	11	73
EXPECTED	**COUNT**	67.7	5.3	73.0
TOTAL	**COUNT**	178	14	192

Among adult females from Mesolithic, 2.3% (1/44) of them have caries, and in Neolithic – 27.8% (5/18) (Fig. 4.5; Table 4.9). The correlation between period and the presence is statistically significant (Fisher's exact p = 0.006), with medium effect (Cramer's V = 0.392). Concerning the number of teeth affected, in Mesolithic 0.2 % is affected (1/546), while in Neolithic 3.8 % (11/287).

Among adult males from Mesolithic, 7.1 % (2/28) of them have caries, and in Neolithic – only one male out of 11 had caries which is 9.1 % (Fig. 4.5; Table 4.10). Correlation between period and presence is not statistically significant (Fisher's exact p = 0.642), with low effect (Cramer's V = 0.033). Concerning the number of teeth affected, in Mesolithic 0.5 % is affected (2/406), while in Neolithic 0.7 % (1/138).

Table 4.9. Crosstabulation of period and presence of dental caries in Mesolithic and Neolithic females in the Danube Gorges

		PRESENCE		TOTAL
		Absent	Present	
MESOLITHIC	**COUNT**	26	2	28
EXPECTED	**COUNT**	25.1	2.9	28.0
NEOLITHIC	**COUNT**	9	2	11
EXPECTED	**COUNT**	9.9	1.1	11.0
TOTAL	**COUNT**	35	4	39

Table 4.10. Crosstabulation of period and presence of dental caries in Mesolithic and Neolithic males in the Danube Gorges

		PRESENCE		TOTAL
		Absent	Present	
MESOLITHIC	**COUNT**	43	1	44
EXPECTED	**COUNT**	39.7	4.3	44.0
NEOLITHIC	**COUNT**	13	5	18
EXPECTED	**COUNT**	16.3	1.7	18.0
TOTAL	**COUNT**	56	6	62

Statistical analysis conducted between females and males in Neolithic also shows not statistically significant correlation between sex and presence of caries (Fisher's exact p = 0.237), with low effect (Cramer's V = 0.224) (Fig. 4.5; Table 4.11). Concerning the number of teeth affected 4.2 % of female teeth showed presence of caries, while 0.6 % male's teeth had caries.

None of Mesolithic children had traces of caries (0/17), while in Neolithic 19 % (4/21) of them had caries (Fig.4.6; Table 4.12). Statistical test has shown marginally significant correlation between period and presence of caries (Fisher's exact p = 0.081), with medium effect (Cramer's V = 0.309). Concerning the number of teeth affected, in Mesolithic 0 % is affected (0/248), while in Neolithic 2.1 % (5/278).

Table 4.11. Crosstabulation of period and presence of dental caries in Neolithic females and males in the Danube Gorges

	PRESENCE		TOTAL
	Absent	Present	
NEOLITHIC FEMALES			
COUNT	13	5	18
EXPECTED COUNT	14.3	3.7	18.0
NEOLITHIC MALES			
COUNT	10	1	11
EXPECTED COUNT	8.7	2.3	11.0
TOTAL **COUNT**	23	6	29

4.3.2. Outside the Danube Gorges

On the population level, in the Danube Gorges Mesolithic presence of dental caries was detected on 2.5% (3/119) individuals, while in Neolithic 30.4 % (7/23) had caries (Figure 4.4; Table 4.13). Statistical analysis showed statistically significant correlation between the period and the presence of caries (Fisher's exact $p < 0.001$), with medium effect (Cramer's V = 0.402). When number of affected teeth is considered, in Mesolithic 0.2 % (3/1404) of teeth are affected, while in Neolithic 4.5 % (15/330) showed presence of dental caries.

Table 4.12. Crosstabulation of period and presence of dental caries in Neolithic children in the Danube Gorges

		PRESENCE		TOTAL
		Absent	Present	
MESOLITHIC	**COUNT**	17	0	17
EXPECTED	**COUNT**	15.2	1.8	17.0
NEOLITHIC	**COUNT**	17	4	21
EXPECTED	**COUNT**	18.8	2.2	21.0
TOTAL	**COUNT**	34	4	38

Table 4.13. Crosstabulation of period and presence of dental caries in Mesolithic of the Danube Gorges and Neolithic outside the Gorges

		PRESENCE		TOTAL
		Absent	Present	
MESOLITHIC	**COUNT**	116	3	119
EXPECTED	**COUNT**	110.6	8.4	119.0
NEOLITHIC	**COUNT**	16	7	23
EXPECTED	**COUNT**	21.4	1.6	23.0
TOTAL	**COUNT**	132	10	142

Among adult females from Mesolithic, 2.3% (1/44) of them have caries, and in Neolithic – 42.9% (3/7) (Figure 4.5; Table 4.14). The correlation between period and presence is statistically significant (Fisher's exact p = 0.006), with medium effect (Cramer's V = 0.519). When number of affected teeth is considered, in Mesolithic 0.2 % (1/546) of teeth are affected, while in Neolithic 6.7 % (10/150) showed presence of dental caries.

Table 4.14. Crosstabulation of period and presence of dental caries among females in the Mesolithic of the Danube Gorges and Neolithic outside the Gorges

		PRESENCE		TOTAL
		Absent	Present	
MESOLITHIC	**COUNT**	43	1	44
EXPECTED	**COUNT**	40.5	3.5	44.0
NEOLITHIC	**COUNT**	4	3	7
EXPECTED	**COUNT**	6.5	0.5	7.0
TOTAL	**COUNT**	47	4	51

Among adult males from Mesolithic, 7.1% (2/28) of them have caries, and in Neolithic – none of the adult males (0/2) have caries (Figure 4.5; Table 4.15). The correlation between period and the presence is not statistically significant (Fisher's exact $p = 0.869$), with low effect (Cramer's V = 0.071). When the number of affected teeth is considered, in Mesolithic 0.5 % (2/406) of teeth are affected, while in Neolithic 0 % (0/20) show presence of dental caries.

Table 4.15. Crosstabulation of period and presence of dental caries among males in the Mesolithic of the Danube Gorges and Neolithic outside the Gorges

		PRESENCE		TOTAL
		Absent	Present	
MESOLITHIC	**COUNT**	26	2	28
EXPECTED	**COUNT**	26.1	1.9	28.0
NEOLITHIC	**COUNT**	2	0	2
EXPECTED	**COUNT**	1.9	0.1	2.0
TOTAL	**COUNT**	28	2	30

None of Mesolithic children have traces of caries (0/17), while in Neolithic 16.7% (1/6) of them have caries (Figure 4.6; Table 4.16). No statistically significant correlation was found between period and presence (Fisher's exact $p = 0.261$), with medium effect (Cramer's V = 0.359). When the number of affected teeth is considered, in Mesolithic 0 % (0/248) of teeth are affected, while in Neolithic 1.8 % (1/55) show presence of dental caries.

Table 4.16. Crosstabulation of period and presence of dental caries among children in the Mesolithic of the Danube Gorges and Neolithic outside the Gorges

		PRESENCE		TOTAL
		Absent	Present	
MESOLITHIC	**COUNT**	17	0	17
EXPECTED	**COUNT**	16.3	0.7	17.0
NEOLITHIC	**COUNT**	5	1	6
EXPECTED	**COUNT**	5.7	0.3	6.0
TOTAL	**COUNT**	22	1	23

4.4. Dental calculus

4.4.1. The Danube Gorges

During the Mesolithic 17.2 % of individuals showed the presence of degree 3 of dental calculus (20/116) while in the Neolithic, 12 % (9/75) (Figure 4.4; Table 4.17). Statistical analysis showed no significant correlation between the period and the presence of dental calculus (Fisher's exact $p = 0.219$), with very low effect (Cramer's V = 0.071). When the number of affected teeth is considered, in Mesolithic 3.5 % (48/1381) of teeth were affected, while in Neolithic 1.9 % (17/886) showed the presence of dental calculus.

As concerning the presence of subgingival calculus on the population level – in Mesolithic it was present in 15.5% (18/116) of individuals, regardless of calculus degree. In Neolithic, 16.1% (10/62) of individuals had subgingival calculus (Figure 4.7; Table 4.18). There was no statistically significant correlation between the period and the presence of subgingival calculus (Fisher's exact $p = 0.537$), with low effect (Cramer's V = 0.008). When the number of affected teeth is considered, in Mesolithic

Table 4.17. Crosstabulation of period and presence of degree 3 of dental calculus among Mesolithic and Neolithic inhabitants of the Danube Gorges

		PRESENCE		TOTAL
		Absent	Present	
MESOLITHIC	**COUNT**	96	20	116
EXPECTED	**COUNT**	98.4	17.6	116.0
NEOLITHIC	**COUNT**	66	9	75
EXPECTED	**COUNT**	63.6	11.4	75.0
TOTAL	**COUNT**	162	29	191

19.4 % (198/1023) of teeth were affected, while in Neolithic 15.5 % (71/459) showed the presence of subgingival calculus.

The situation was quite different when supragingival calculus was observed. In Mesolithic, 84.5% (98/116) of individuals had supragingival calculus of various degrees, and in Neolithic – 83.9% (52/62) (Figure 4.7; Table 4.19). Fisher's test showed no statistically significant correlation between the period and the presence of supragingival calculus (Fisher's exact $p = 0.537$), with low effect (Cramer's V = 0.008). When the number of affected teeth is considered, in Mesolithic 80.6 % (825/1023) of teeth were affected, while in Neolithic 84.5 % (388/459) showed the presence of dental calculus.

Table 4.18. Crosstabulation of period and presence of subgingival calculus among Mesolithic and Neolithic inhabitants of the Danube Gorges

		PRESENCE		TOTAL
		Absent	Present	
MESOLITHIC	**COUNT**	98	18	116
EXPECTED	**COUNT**	97.8	18.2	116.0
NEOLITHIC	**COUNT**	52	10	62
EXPECTED	**COUNT**	52.2	9.8	62.0
TOTAL	**COUNT**	150	28	178

Table 4.19. Crosstabulation of period and presence of supragingival calculus among Mesolithic and Neolithic inhabitants of the Danube Gorges

		PRESENCE		TOTAL
		Absent	Present	
MESOLITHIC	COUNT	18	98	116
EXPECTED	**COUNT**	18.2	97.8	116.0
NEOLITHIC	COUNT	10	52	62
EXPECTED	**COUNT**	9.8	52.2	62.0
TOTAL	COUNT	28	150	178

Among Mesolithic adult females, 23.3% (10/43) had the calculus of degree 3, and in Neolithic 26.3% (5/19) (Figure 4.5; Table 4.20). There was no statistically significant correlation between the period and presence (Fisher's exact $p = 0.516$), with low effect (Cramer's V = 0.033). When the number of affected teeth is considered, in Mesolithic 4.5% (23/538) of teeth were affected, while in Neolithic 4.0 % (10/249).

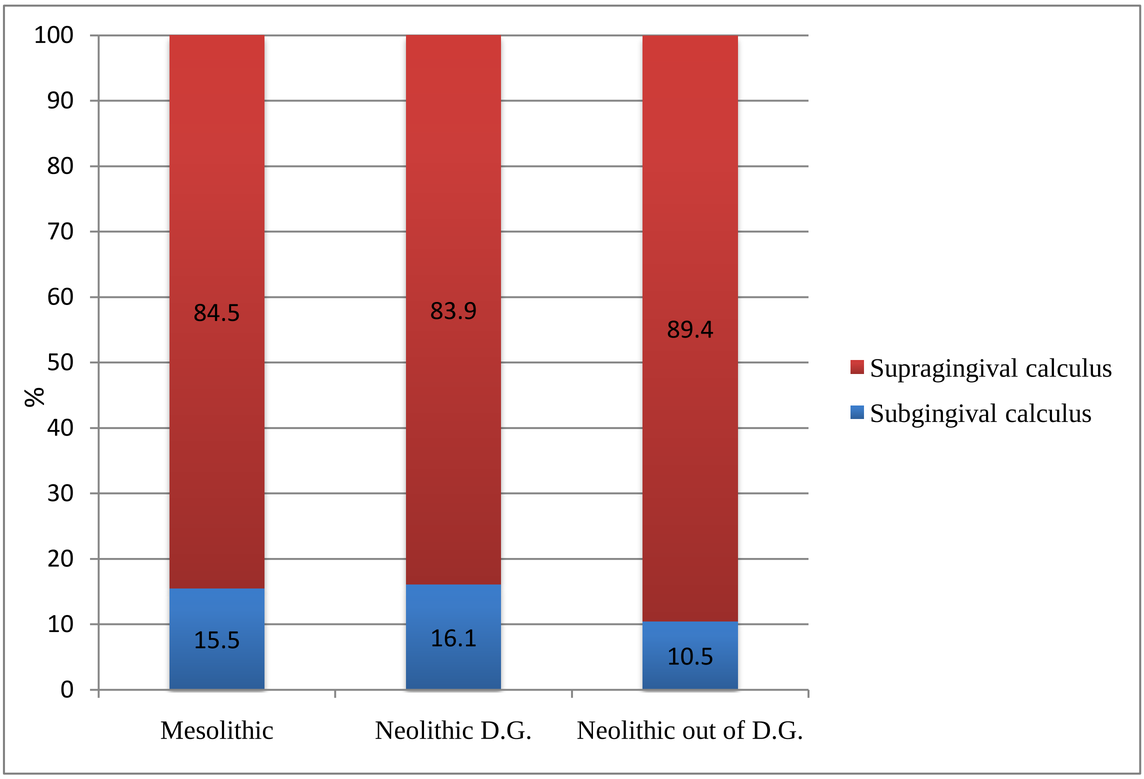

Fig. 4.7. The frequency of supragingival and subgingival calculus among Mesolithic and Neolithic inhabitants of the studied regions

Table 4.20. Crosstabulation of period and presence of dental calculus of degree 3 among Mesolithic and Neolithic females in the Danube Gorges

		PRESENCE		TOTAL
		Absent	Present	
MESOLITHIC	**COUNT**	33	10	43
EXPECTED	**COUNT**	32.6	10.4	43.0
NEOLITHIC	**COUNT**	14	5	19
EXPECTED	**COUNT**	14.4	4.6	19.0
TOTAL	**COUNT**	47	15	62

When considering adult males from Mesolithic, the situation was quite similar as with adult females – in Mesolithic 25.0 % (7/28) of the males had the calculus of degree 3, while in Neolithic only one male out of 11 had the calculus of degree 3 (9.09%) (Figure 4.5; Table 4.21). No statistically significant correlation between period and presence of calculus was found (Fisher's exact $p = 0.262$), with low effect (Cramer's V = 0.177). The number of affected teeth in Mesolithic was 4.4% (17/389) and in Neolithic 0.58 % (1/172).

Table 4.21. Crosstabulation of period and presence of dental calculus of degree 3 among Mesolithic and Neolithic males in the Danube Gorges

		PRESENCE		TOTAL
		Absent	Present	
MESOLITHIC	**COUNT**	21	7	28
EXPECTED	**COUNT**	22.3	5.7	28.0
NEOLITHIC	**COUNT**	10	1	11
EXPECTED	**COUNT**	8.7	2.3	11.0
TOTAL	**COUNT**	31	8	39

Statistical analysis between females and males within the Neolithic period showed no statistically significant correlation between sex and the presence of dental calculus (Fisher's exact $p = 0.261$), with low effect (Cramer's V = 0.208) (Fig. 4.5; Table 4.22).

Mesolithic children showed no traces of the calculus of degree 3 (0/16), while in Neolithic only one child exhibited the calculus of degree 3 (1/24 or 4.16 %).

Table 4.22. Crosstabulation of period and presence of dental calculus of degree 3 among Neolithic females and males in the Danube Gorges

	PRESENCE		TOTAL
	Absent	Present	
NEOLITHIC FEMALES			
COUNT	14	5	19
EXPECTED COUNT	15.2	3.8	19.0
NEOLITHIC MALES			
COUNT	10	1	11
EXPECTED COUNT	8.8	2.2	11.0
TOTAL **COUNT**	24	6	30

4.4.2. Outside the Danube Gorges

On the population level, in the Danube Gorges Mesolithic 17.2% (20/116) of individuals had traces of calculus of degree 3. In Neolithic, the frequency was lower – 8.7% (2/23) of individuals had the calculus of degree 3 (Figure 4.4; Table 4.23). Statistical analysis showed no statistically significant correlation between the period and the presence of dental calculus (Fisher's exact p = 0.247), with very low effect (Cramer's V = 0.087). When the number of affected teeth was considered, in Mesolithic 3.5 % (48/1381) of teeth were affected, while in Neolithic 0.6 % (2/315) showed the presence of dental calculus.

Regarding the presence of subgingival calculus on the population level – in Mesolithic it was present in 15.5% (18/116) of individuals, regardless of calculus degree. In Neolithic, 10.5 % (2/19) of individuals had subgingival calculus regardless of calculus degree (Figure 4.7; Table 4.24). There was no statistically significant correlation between the period and the presence of subgingival calculus (Fisher's exact p = 0.437),

Table 4.23. Crosstabulation of period and presence of dental calculus of degree 3 among inhabitants of Mesolithic Danube Gorges and Neolithic outside the Gorges

		PRESENCE		TOTAL
		Absent	Present	
MESOLITHIC	**COUNT**	96	20	116
EXPECTED	**COUNT**	97.6	18.4	116.0
NEOLITHIC	**COUNT**	21	2	23
EXPECTED	**COUNT**	19.4	3.6	23.0
TOTAL	**COUNT**	117	22	139

with low effect (Cramer's V = 0.049). When the number of affected teeth was considered, in Mesolithic 19.4 % (198/1023) of teeth had subgingival calculus, while in Neolithic 1.3 % (2/154) showed the presence of subgingival calculus.

Table 4.24. Crosstabulation of period and presence of subgingival calculus among Mesolithic Danube Gorges and Neolithic inhabitants outside the Danube Gorges

		PRESENCE		TOTAL
		Absent	Present	
MESOLITHIC	**COUNT**	98	18	116
EXPECTED	**COUNT**	98.8	17.2	116.0
NEOLITHIC	**COUNT**	17	2	19
EXPECTED	**COUNT**	16.2	2.8	19.0
TOTAL	**COUNT**	115	20	135

The situation is quite different when observing supragingival calculus. In Mesolithic, 84.5% (98/116) of individuals had supragingival calculus of various degrees, and in Neolithic – 89.4% (17/19) (Figure 4.7; Table 4.25). No statistically significant correlation between the period and the presence of supragingival calculus was found (Fisher's exact $p = 0.437$), with low effect (Cramer's V = 0.049). When the number of affected teeth was considered, in Mesolithic 80.6 % (825/1023) of teeth had supragingival calculus, while in Neolithic 98.7 % (152/154) showed the presence of supragingival calculus.

Table 4.25. Crosstabulation of period and presence of supragingival calculus among inhabitants of Mesolithic Danube Gorges and Neolithic outside the Danube Gorges

		PRESENCE		TOTAL
		Absent	Present	
MESOLITHIC	**COUNT**	18	98	116
EXPECTED	**COUNT**	17.2	98.8	116.0
NEOLITHIC	**COUNT**	2	17	19
EXPECTED	**COUNT**	2.8	16.2	19.0
TOTAL	**COUNT**	20	115	135

Among Mesolithic adult females, 23.3% (10/43) had the calculus of degree 3, and in Neolithic one woman out of 8 had calculus of degree 3 which is 12.5 % (Figure 4.5; Table 4.26). There was no statistically significant correlation between the period and the presence (Fisher's exact p = 0.443), with low effect (Cramer's V = 0.095). When the number of affected teeth was considered, in Mesolithic 4.5 % (23/538) of teeth was affected, while in Neolithic 1.0 % (1/102) showed the presence of dental calculus.

Table 4.26. Crosstabulation of period and presence of dental calculus of degree 3 among Mesolithic (Danube Gorges) and Neolithic females outside the Danube Gorges

		PRESENCE		TOTAL
		Absent	Present	
MESOLITHIC	**COUNT**	33	10	43
EXPECTED	**COUNT**	33.7	9.3	43.0
NEOLITHIC	**COUNT**	7	1	8
EXPECTED	**COUNT**	6.3	1.7	8.0
TOTAL	**COUNT**	40	11	51

Regarding adult males from Mesolithic, one could observe that 25% of them (7/28) had the calculus of degree 3, while in Neolithic neither of the two males had the calculus of degree 3 (Figure 4.5; Table 4.27). No statistically significant correlation between the period and the presence of supragingival calculus was found (Fisher's exact p = 0.582), with low effect (Cramer's V = 0.147). When the number of affected teeth is considered, in Mesolithic 4.4% (17/389) of teeth were affected and in Neolithic 0 % (0/10).

Comparison between males and females was not possible due to small sample size (one female out of 8 had calculus, while none of the two analyzed males had it.

In Mesolithic none of the children showed the highest degree of dental calculus (0/16) while in Neolithic only one child exhibited degree 3 (1/9) or 11.1 %.

Table 4.27. Crosstabulation of period and presence of dental calculus of degree 3 among Mesolithic (Danube Gorges) and Neolithic males outside the Danube Gorges

		PRESENCE		TOTAL
		Absent	Present	
MESOLITHIC	**COUNT**	21	7	28
EXPECTED	**COUNT**	21.5	6.5	28.0
NEOLITHIC	**COUNT**	2	0	2
EXPECTED	**COUNT**	1.5	0.5	2.0
TOTAL	**COUNT**	23	7	30

4.5. Ante mortem tooth loss

4.5.1. The Danube Gorges

Among Mesolithic population, 16% (19/119) of individuals experienced ante mortem loss of teeth, while in Neolithic 6.5% (5/77) (Figure 4.4; Table 4.28). The test showed statistically significant correlation between period and ante mortem loss of teeth (Fisher's exact p = 0.037), with low effect (Cramer's V = 0.141). When the number of teeth was considered, in Mesolithic 3.1 % (65/2107) of teeth were lost prior to death, while in Neolithic 0.7 % (8/1222) were lost.

Table 4.28. Crosstabulation of period and presence of AMTL among Mesolithic and Neolithic inhabitants of the Danube Gorges

		PRESENCE		TOTAL
		Absent	Present	
MESOLITHIC	**COUNT**	100	19	119
EXPECTED	**COUNT**	104.4	14.6	119.0
NEOLITHIC	**COUNT**	72	5	77
EXPECTED	**COUNT**	67.6	9.4	77.0
TOTAL	**COUNT**	172	24	196

In Mesolithic, 28.9% (13/45) of adult females showed ante mortem loss of teeth, while in Neolithic there were 15.8% (3/19) (Figure 4.5; Table 4.29a). No statistically significant correlation between the period and the presence was found (Fisher's exact $p = 0.218$), with low effect (Cramer's V = 0.138). When the number of teeth was considered, in Mesolithic 3.4 % (30/890) of teeth were lost prior to death, while in Neolithic 0.5 % (2/403) were lost.

Table 4.29a. Crosstabulation of period and presence of AMTL among Mesolithic and Neolithic females in the Danube Gorges

		PRESENCE		TOTAL
		Absent	Present	
MESOLITHIC	**COUNT**	32	13	45
EXPECTED	**COUNT**	33.8	11.3	45.0
NEOLITHIC	**COUNT**	16	3	19
EXPECTED	**COUNT**	14.3	4.8	19.0
TOTAL	**COUNT**	48	16	64

Mesolithic adult males showed low frequency of ante mortem loss of teeth – 10.3 % (3/29), and only one male out of 12 from the Neolithic that could have been observed, showed ante mortem loss of teeth, which is 8.3 % (Figure 4.5; Table 4.29b). No statistically significant correlation between the period and the presence was found (Fisher's exact p = 0.668), with low effect (Cramer's V = 0.031).When the number of teeth is considered, in Mesolithic 6.4 % (30/890) of teeth were lost prior to death, while in Neolithic 1.3 % (2/403) was lost.

Table 4.29b. Crosstabulation of period and presence of AMTL among Mesolithic and Neolithic males in the Danube Gorges

		PRESENCE		TOTAL
		Absent	Present	
MESOLITHIC	**COUNT**	26	3	29
EXPECTED	**COUNT**	26.2	2.8	29.0
NEOLITHIC	**COUNT**	11	1	12
EXPECTED	**COUNT**	10.8	1.2	12.0
TOTAL	**COUNT**	37	4	41

4.5.2. Outside the Danube Gorges

Among Mesolithic population in the Danube Gorges, 16% (19/119) of individuals showed ante mortem loss of teeth, while in Neolithic the percentage was a bit higher – 27.8% (6/18) (Figure 4.4; Table 4.30). Statistical test showed a marginally significant correlation between the period and ante mortem loss of teeth (Fisher's exact p = 0.070), with low effect (Cramer's V = 0.152). When the number of teeth is considered, in Mesolithic 3.1 % (65/2107) of teeth were lost prior to death, while in Neolithic 7.3 % (31/422) were lost.

In Mesolithic, 28.9% (13/45) of adult females showed ante mortem loss of teeth, while in Neolithic 44.4% (4/9) (Figure 4.5; Table 4.31). No statistically significant correlation between the period and the presence was found (Fisher's exact p = 0.293),

Table 4.30. Crosstabulation of period and presence of AMTL among Mesolithic (D.G.) and Neolithic inhabitants outside the Danube Gorges

		PRESENCE		TOTAL
		Absent	Present	
MESOLITHIC	**COUNT**	100	19	119
EXPECTED	**COUNT**	97.3	21.7	119.0
NEOLITHIC	**COUNT**	12	6	18
EXPECTED	**COUNT**	14.7	3.3	18.0
TOTAL	**COUNT**	122	25	137

with low effect (Cramer's V = 0.125). When the number of teeth is considered, in Mesolithic 3.4 % (30/890) of teeth were lost prior to death, while in Neolithic 5.6 % (10/178) were lost.

Table 4.31. Crosstabulation of period and presence of AMTL among Mesolithic (D.G.) and Neolithic females outside the Danube Gorges

		PRESENCE		TOTAL
		Absent	Present	
MESOLITHIC	**COUNT**	32	13	45
EXPECTED	**COUNT**	30.8	14.2	45.0
NEOLITHIC	**COUNT**	5	4	9
EXPECTED	**COUNT**	6.2	2.8	9.0
TOTAL	**COUNT**	37	17	54

Mesolithic adult males showed low frequency of ante mortem loss of teeth – 10.3 % (3/29), and in the Neolithic the only two adult male that could have been observed, showed no ante mortem loss of teeth (Figure 4.5). Since the Neolithic sample size was too small, no statistical test was carried out.

4.6. Cribra orbitalia

4.6.1. The Danube Gorges

Presence

When traces of cribra orbitalia were considered within the entire population in Mesolithic and in Neolithic, the 2x2 contingency table showed that, in Mesolithic, 38.8% (19/49) of individuals had cribra orbitalia, while in Neolithic in the Danube Gorges the results were similar – 39.3% (11/28) (Figure 4.4, Table 4.32.). Statistical analysis showed that there was no statistically significant correlation between the period and the presence of cribra orbitalia (Fisher's exact p = 0.577), and that the effect was low (Cramer's V = 0.005).

Table 4.32. Crosstabulation of period and presence of cribra orbitalia among Mesolithic and Neolithic inhabitants of the Danube Gorges

		PRESENCE		TOTAL
		Absent	Present	
MESOLITHIC	**COUNT**	30	19	49
EXPECTED	**COUNT**	29.9	19.1	49.0
NEOLITHIC	**COUNT**	17	11	28
EXPECTED	**COUNT**	17.1	10.9	28.0
TOTAL	**COUNT**	47	30	7

Among women from the Mesolithic, 30% (6/20) of them had traces of cribra orbitalia. The distribution of cribra orbitalia in Neolithic was lower, considering that only 10 % (1/10) of the women had traces of cribra orbitalia (Figure 4.5; Table 4.33). No statistically significant correlation between the period and the presence of cribra orbitalia was found (Fisher's exact p = 0.228), with low effect (Cramer's V = 0.223).

Among Mesolithic males, 23.1% (3/13) of them had cribra orbitalia. In Neolithic 25 % (1/4) with preserved eye orbits showed traces of cribra orbitalia (Figure 4.5; Table 4.34). No statistically significant correlation between the period and the presence of cribra orbitalia was found (Fisher's exact p = 0.700), with very low effect (Cramer's V = 0.019).

Table 4.33. Crosstabulation of period and presence of cribra orbitalia among Mesolithic and Neolithic females in the Danube Gorges

		PRESENCE		TOTAL
		Absent	Present	
MESOLITHIC	**COUNT**	14	6	20
EXPECTED	**COUNT**	15.3	4.7	20.0
NEOLITHIC	**COUNT**	9	1	10
EXPECTED	**COUNT**	7.7	2.3	10.0
TOTAL	**COUNT**	23	7	30

Table 4.34. Crosstabulation of period and presence of cribra orbitalia among Mesolithic and Neolithic males in the Danube Gorges

		PRESENCE		TOTAL
		Absent	Present	
MESOLITHIC	**COUNT**	10	3	13
EXPECTED	**COUNT**	9.9	3.1	13.0
NEOLITHIC	**COUNT**	3	1	4
EXPECTED	**COUNT**	3.1	0.9	4.0
TOTAL	**COUNT**	13	4	17

Concerning children, 62.5% (5/8) in Mesolithic had cribra orbitalia, while 100% (6/6) of Neolithic children showed the presence of cribra orbitalia (Figure 4.6; Table 4.35). No statistically significant correlation was found (Fisher's exact $p = 0.154$), with medium effect (Cramer's V = 0.452).

Degree

Considering the degree of cribra orbitalia on the population level, in Mesolithic degree 1 was present in 63.2% of individuals (12/19); degree 2 – 26.3% (5/19); and degree 3 – 10.5% (2/19). In Neolithic, the frequency of degree 1 was 63.6% (7/11), degree 2 – 18.2 % (2/11), and degree 3 – 18.2% (2/11) (Fig. 4.8; Table 4.36). Chi-square test results showed no statistically significant correlation (X^2 =0.504, df = 2, p = 0.777) with low effect (Cramer's V = 0.130).

Table 4.35. Crosstabulation of period and presence of cribra orbitalia among Mesolithic and Neolithic children in the Danube Gorges

		PRESENCE		TOTAL
		Absent	Present	
MESOLITHIC	**COUNT**	3	5	8
EXPECTED	**COUNT**	1.7	6.3	8.0
NEOLITHIC	**COUNT**	0	6	6
EXPECTED	**COUNT**	1.3	4.7	6.0
TOTAL	**COUNT**	3	11	1

Table 4.36. Crosstabulation of period and degree of cribra orbitalia among Mesolithic and Neolithic inhabitants of the Danube Gorges

		DEGREE			TOTAL
		1	**2**	**3**	
MESOLITHIC	**COUNT**	12	5	2	19
EXPECTED	**COUNT**	12.0	4.4	2.5	19.0
NEOLITHIC	**COUNT**	7	2	2	11
EXPECTED	**COUNT**	7.0	2.6	1.5	11.0
TOTAL	**COUNT**	19	7	4	30

Among females in Mesolithic, 50% (3/6) had degree 1 and 50% had degree 2 (3/6), while degree 3 was not present at all. In Neolithic, the only woman with cribra orbitalia had degree 3.

Among males in Mesolithic, degree 1 was present in two out of three males, while degree 2 was present in one male. In Neolithic, the only male with cribra orbitalia had degree 1.

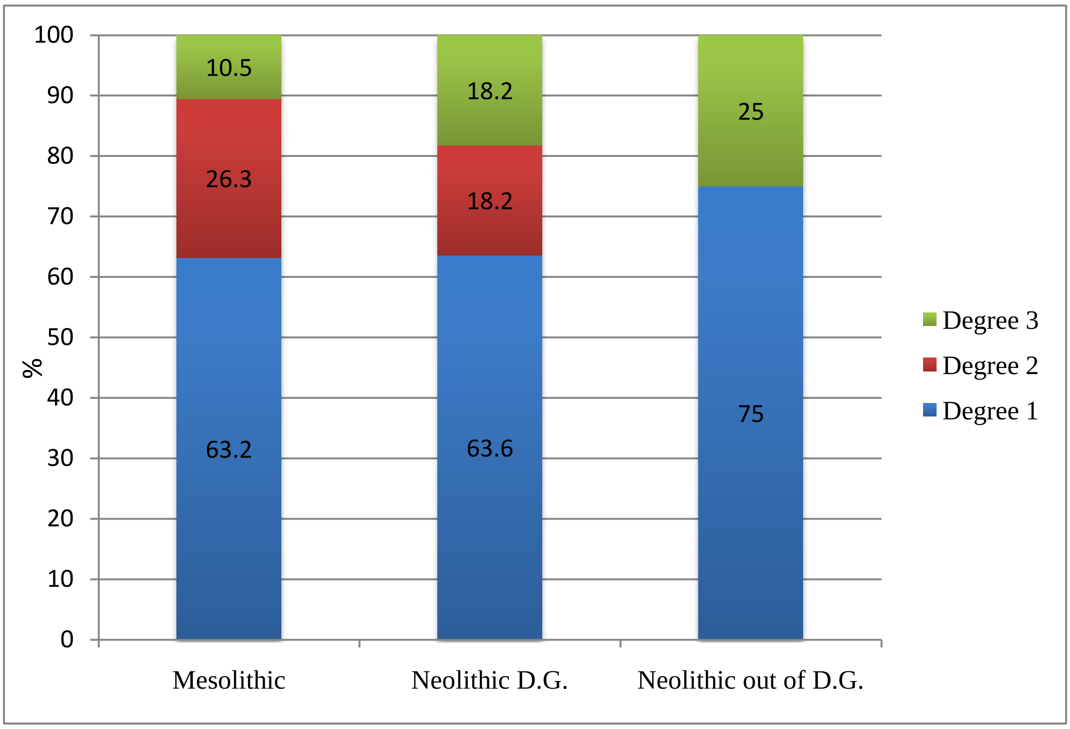

Fig. 4.8. The frequency of different degrees of cribra orbitalia among population of Mesolithic and Neolithic in the Danube Gorges and Neolithic outside the Gorges

In Mesolithic 60% of children (3/5) had degree 1, while 40% (2/5) had degree 2. In Neolithic, 66.7 % (4/6) individuals had degree 1. Degrees 2 and 3 were equally represented, with 16.7 % of each (1/6) (Table 4.37). Chi-square test results indicated no statistically significant correlation between the period and the activity of cribra orbitalia (X^2 =1.397, df = 2, p = 0.497), and the effect was of the medium strength (Cramer's V = 0.356).

Activity

When considering the activity of cribra orbitalia, on the population level in Mesolithic, the most common activity type was 2 (healed lesions) – 78.9% (15/19), followed by 1(active lesions at the time of death) – 15.8% (3/19) and 3 (mixed lesions) – 5.3% (1/19). In Neolithic, type 1 was present in 36.4 % (4/11) of individuals, type 2 in 45.5 % (5/11) and type 3 in 18.2 % (2/11) (Figure 4.9; Table 4.38). Chi-square test results indicated no statistically significant correlation between the period and the activity of cribra orbitalia (X^2 =3.599, df = 2, p = 0.165), and the effect was of medium strength (Cramer's V = 0.346).

Table 4.37. Crosstabulation of period and degree of cribra orbitalia among Mesolithic and Neolithic children in the Danube Gorges

		DEGREE			TOTAL
		1	**2**	**3**	
MESOLITHIC	**COUNT**	3	2	0	5
EXPECTED	**COUNT**	3.2	1.4	0.5	5.0
NEOLITHIC	**COUNT**	4	1	1	6
EXPECTED	**COUNT**	3.8	1.6	0.5	6.0
TOTAL	**COUNT**	7	3	1	11

Table 4.38. Crosstabulation of period and activity type of cribra orbitalia among Mesolithic and Neolithic inhabitants of the Danube Gorges

		ACTIVITY			TOTAL
		1	**2**	**3**	
MESOLITHIC	**COUNT**	3	15	1	19
EXPECTED	**COUNT**	4.4	12.7	1.9	19.0
NEOLITHIC	**COUNT**	4	5	2	11
EXPECTED	**COUNT**	2.6	7.3	1.1	11.0
TOTAL	**COUNT**	7	20	3	30

Among Mesolithic women, 66.7% (4/6) had activity type 2, and types 1 and 3 were evenly distributed – 16.7% (1/6) of each. In Neolithic the only woman with cribra orbitalia showed activity type 3.

In Mesolithic 3 males had cribra orbitalia, and all were of activity type 2, while only one Neolithic male had cribra orbitalia, and it was of activity type 2.

Statistical analysis of activity type of cribra orbitalia for children from Mesolithic and Neolithic showed the following results: the most common activity type among Mesolithic children was 2 - 60 % (3/5), followed by type 1, which was represented by 40 % (2/5), while activity type 3 was not observed among Mesolithic children with cribra orbitalia. Within the group of Neolithic children, type 1 was represented by 66.7 % (4/6), while type 2 appeared in 33.3 % (2/6) of individuals (Table 4.39). Type 3 was not present. Chi-square test results showed no statistically significant correlation (X^2= 0.782, df = 1; p = 0.376), with low effect (Cramer's V = 0.267).

Table 4.39. Crosstabulation of period and activity type of cribra orbitalia among Mesolithic and Neolithic children in the Danube Gorges

		ACTIVITY		TOTAL
		1	**2**	
MESOLITHIC	**COUNT**	2	3	5
EXPECTED	**COUNT**	2.7	2.3	5.0
NEOLITHIC	**COUNT**	4	2	6
EXPECTED	**COUNT**	3.3	2.7	6.0
TOTAL	**COUNT**	6	5	11

4.6.2. Outside the Danube Gorges

<u>*Presence*</u>

Regarding the traces of cribra orbitalia on the population level in the Danube Gorges Mesolithic and Neolithic outside the Gorges, the 2x2 contingency table showed that, in Mesolithic, 38.8% (19/49) of individuals had cribra orbitalia, while in Neolithic this number was higher – 57.1% (8/14) (Figure 4.4; Table 4.40). There was no statistically significant correlation between the period and the presence of cribra orbitalia (Fisher's exact p = 0.179) and the effect was of low strength (Cramer's V = 0.154).

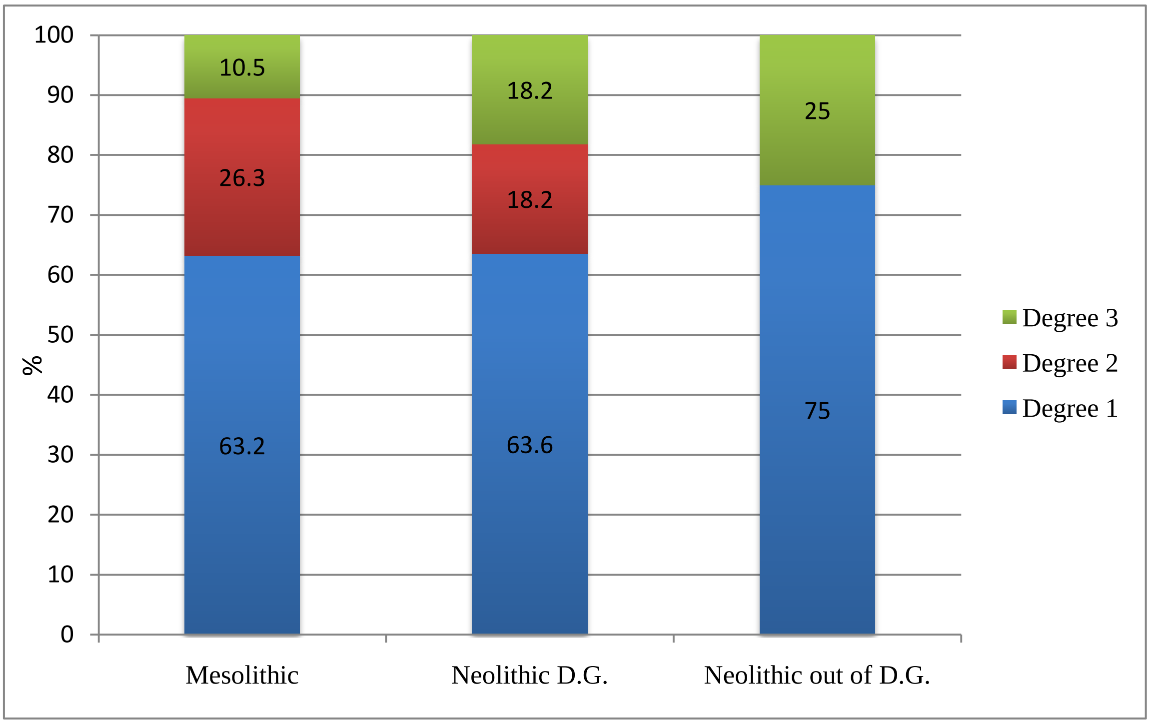

Fig. 4.9. The frequency of different activity types of cribra orbitalia among population of Mesolithic and Neolithic in the Danube Gorges and Neolithic outside the Gorges

Table 4.40. Crosstabulation of period and presence of cribra orbitalia among Mesolithic (D.G.) and Neolithic inhabitants outside the Danube Gorges

		PRESENCE		TOTAL
		Absent	Present	
MESOLITHIC	COUNT	30	19	49
EXPECTED	**COUNT**	28.0	21.0	49.0
NEOLITHIC	COUNT	6	8	14
EXPECTED	**COUNT**	8.0	6.0	14.0
TOTAL	COUNT	36	27	63

Among women from the Mesolithic, 30% (6/20) had traces of cribra orbitalia. The distribution of cribra orbitalia was similar within the observed group of Neolithic women, where 33.3% (3/9) had this condition (Figure 4.5, Table 4.41). No statistically significant correlation between the period and the presence of cribra orbitalia was found (Fisher's exact p = 0.591), with low effect (Cramer's V = 0.033).

Table 4.41. Crosstabulation of period and presence of cribra orbitalia among Mesolithic (D.G.) and Neolithic females outside the Danube Gorges

	PRESENCE		TOTAL
	Absent	Present	
MESOLITHIC **COUNT**	14	6	20
EXPECTED COUNT	13.8	6.2	20.0
NEOLITHIC **COUNT**	6	3	9
EXPECTED COUNT	6.2	2.8	9.0
TOTAL **COUNT**	20	9	29

Among Mesolithic males, 23.1% (3/13) had cribra orbitalia. In Neolithic, only one male had preserved eye orbits and showed traces of cribra orbitalia (Figure 4.6).

As concerning children, 62.5% (5/8) from Mesolithic had cribra orbitalia, while 100% (5/5) of Neolithic children showed the presence of cribra orbitalia (Figure 4.6, Table 4.42). No statistically significant correlation was found (Fisher's exact $p = 0.196$), with medium effect (Cramer's V = 0.433).

Table 4.42. Crosstabulation of period and presence of cribra orbitalia among Mesolithic (D.G.) and Neolithic children outside the Danube Gorges

	PRESENCE		TOTAL
	Absent	Present	
MESOLITHIC **COUNT**	3	5	8
EXPECTED COUNT	1.8	6.2	8.0
NEOLITHIC **COUNT**	0	5	5
EXPECTED COUNT	1.2	3.8	5.0
TOTAL **COUNT**	3	10	13

<u>Degree</u>

Concerning the degree of cribra orbitalia on the population level in Mesolithic, degree 1 was present in 63.2% of individuals (12/19); degree 2 in 26.3% (5/19); degree

3 in 10.5% (2/19). In Neolithic, the frequency of degree 1 was 75% (6/8), degree 2 was not present, and degree 3 in 25% (2/8) (Figure 4.8, Table 4.43). Chi-square test results showed no statistically significant correlation (X^2 = 3.020, df = 2, p = 0.221), with medium effect (Cramer's V = 0.334).

Table 4.43. Crosstabulation of period and degrees of cribra orbitalia among Mesolithic (D.G.) and Neolithic inhabitants outside the Danube Gorges

		DEGREE			TOTAL
		1	**2**	**3**	
MESOLITHIC	**COUNT**	12	5	2	19
EXPECTED	**COUNT**	12.7	3.5	2.8	19.0
NEOLITHIC	**COUNT**	6	0	2	8
EXPECTED	**COUNT**	5.3	1.5	1.2	8.0
TOTAL	**COUNT**	18	5	4	27

Among females in Mesolithic, degrees 1 and 2 were evenly distributed – 50% (3/6) of each, while degree 3 was not present. In Neolithic, the frequency of degree 1 was 66.7% (2/3), degree 2 was not present, and degree 3 – 33.3% (1/3).

Table 4.44. Crosstabulation of period and degree of Cribra orbitalia among Mesolithic (D.G.) and Neolithic children outside the Danube Gorges

		DEGREE			TOTAL
		1	**3**	**4**	
MESOLITHIC	**COUNT**	5	0	0	5
EXPECTED	**COUNT**	4.0	0.5	0.5	5.0
NEOLITHIC	**COUNT**	3	1	1	5
EXPECTED	**COUNT**	4.0	0.5	0.5	5.0
TOTAL	**COUNT**	8	1	1	10

Among males in Mesolithic, degree 1 was present in 66.7% (2/3) while degree 2 was present in 33.3% (1/3) of individuals. In Neolithic, only one male had cribra orbitalia, and it was of degree 1.

Among Mesolithic children, all five of them with cribra orbitalia, exhibited traces of degree 1. In Neolithic, 60% (3/5) of children had degree 1, while degrees 3 and 4 were evenly distributed – there were 20% (1/5) of each (Table 4.44). There was no statistically significant correlation between the period and the degree of cribra orbitalia (X^2 = 2.500, df = 2, p = 0.287), with large effect (Cramer's V = 0.500).

Activity

When considering the activity of cribra orbitalia, on the population level in Mesolithic, the most common activity type was 2 (healed lesions) – 78.9% (15/19), followed by 1 (active lesions at the time of death) – 15.8% (3/19) and type 3 (mixed lesions) – 5.3% (1/19). In Neolithic, type 1 was not present, and types 2 and 3 were distributed equally – 4/8 (Figure 4.9; Table 4.45). Chi-square test results indicated a statistically significant correlation between the period and activity of cribra (X^2 = 8.018, df = 2, p = 0.018), and the effect was of medium strength (Cramer's V = 0.545).

Table 4.45. Crosstabulation of period and activity types of Cribra orbitalia among Mesolithic (D.G.) and Neolithic inhabitants outside the Danube Gorges

		ACTIVITY			TOTAL
		1	**2**	**3**	
MESOLITHIC	**COUNT**	3	15	1	19
EXPECTED	**COUNT**	2.1	13.4	3.5	19.0
NEOLITHIC	**COUNT**	0	4	4	8
EXPECTED	**COUNT**	0.9	5.6	1.5	8.0
TOTAL	**COUNT**	3	19	5	27

Among Mesolithic women, 66.7% (4/6) had activity type 2, and types 1 and 3 were distributed evenly – 16.7% (1/6) of each. The results for Neolithic females showed the highest frequency of activity type 3 – 66.7 % (2/3), while activity type 2 made 33.3 % (1/3) of the total, and activity type 1 was not present at all.

Only 3 males in Mesolithic showed presence of cribra orbitalia, and all of them were of activity type 2, while only one Neolithic male had cribra orbitalia, and it was of activity type 3.

Statistical analysis of activity type of cribra orbitalia for children from Mesolithic and Neolithic showed the following results: the most common activity type among Mesolithic children was 2 - 60 % (3/5), followed by type 1, which was represented by 40 % (2/5), while activity type 3 was not observed in Mesolithic children with cribra orbitalia. Within Neolithic children, type 2 was also the most common – 60% (3/5), while types 1 and 3 were evenly distributed – 20% (1/5) of each (Table 4.46). Chi-square test results showed no statistically significant correlation (X^2= 1.333, df = 2, p = 0.513), with medium effect (Cramer's V = 0.365).

Table 4.46 Crosstabulation of period and activity types of cribra orbitalia among Mesolithic (D.G.) and Neolithic children outside the Danube Gorges

		ACTIVITY			TOTAL
		1	**2**	**3**	
MESOLITHIC	**COUNT**	2	3	0	5
EXPECTED	**COUNT**	1.5	3.0	0.5	5.0
NEOLITHIC	**COUNT**	1	3	1	5
EXPECTED	**COUNT**	1.5	3.0	0.5	5.0
TOTAL	**COUNT**	3	6	1	10

4.7. Porotic hyperostosis

4.7.1. The Danube Gorges

Presence

In Mesolithic 96.4 % (80/83) of individuals showed the presence of porotic hyperostosis, while in Neolithic 83.3% (45/54) of individuals had porotic hyperostosis (Figure 4.4; Table 4.47). The result of chi-square test showed that the observed difference between periods was statistically significant (Fisher's exact $p = 0.010$), with low effect (Cramer's V = 0.226).

Table 4.47. Crosstabulation of period and presence of porotic hyperostosis among Mesolithic and Neolithic inhabitants of the Danube Gorges

		PRESENCE		TOTAL
		Absent	Present	
MESOLITHIC	**COUNT**	3	80	83
EXPECTED	**COUNT**	7.3	75.7	83.0
NEOLITHIC	**COUNT**	9	45	54
EXPECTED	**COUNT**	4.7	49.3	54.0
TOTAL	**COUNT**	12	125	137

In Mesolithic all females (36/36) had traces of porotic hyperostosis as well as in the Neolithic (14/14).

Among males from Mesolithic, 100% (23/23) of them had porotic hyperostosis, and in Neolithic 83.3 % (10/12) of individuals (Figure 4.5; Table 4.48). No statistically significant correlation between the period and the presence was found (Fisher's exact $p = 0.111$), with medium effect (Cramer's V = 0.341).

Table 4.48. Crosstabulation of period and presence of porotic hyperostosis among Mesolithic and Neolithic males in the Danube Gorges

		PRESENCE		TOTAL
		Absent	Present	
MESOLITHIC	**COUNT**	0	23	23
EXPECTED	**COUNT**	1.3	21.7	23.0
NEOLITHIC	**COUNT**	2	10	12
EXPECTED	**COUNT**	0.7	11.3	12.0
TOTAL	**COUNT**	2	33	35

Among Mesolithic children, 83.3% (5/6) had porotic hyperostosis, and in Neolithic 57.1% (8/14) (Figure 4.6; Table 4.49). No statistically significant correlation between the period and the presence of porotic hyperostosis was found (Fisher's exact p = 0.277), with low effect (Cramer's V = 0.252).

Table 4.49. Crosstabulation of period and presence of porotic hyperostosis among Mesolithic and Neolithic children in the Danube Gorges

		PRESENCE		TOTAL
		Absent	Present	
MESOLITHIC	**COUNT**	1	5	6
EXPECTED	**COUNT**	2.1	3.9	6.0
NEOLITHIC	**COUNT**	6	8	14
EXPECTED	**COUNT**	4.9	9.1	14.0
TOTAL	**COUNT**	7	13	20

Degree

In Mesolithic period, the occurrence of different degrees of porotic hyperostosis on the population level was as follows: degree 1 – 17.5% (14/80); degree 2 – 41.3% (33/80); degree 3 – 27.5% (22/80); degree 4 – 13.8% (11/80). In Neolithic, degree 1 was represented in 13.3% (6/45); degree 2 – 51.1 (23/45); degree 3 – 24.4% (11/45); degree 4 – 11.1% (5/45) (Figure 4.10; Table 4.50). Chi-square test results showed no statistically significant correlation between the period and the degree of porotic hyperostosis (X^2 =1.196, df =3, p = 0.754), with low effect (Cramer's V = 0.098).

In Mesolithic period, the occurrence of different degrees of porotic hyperostosis among adult females was as follows: degree 1- 16.7% (6/36); degree 2 – 52.8% (19/36); degree 3 – 25.0% (9/36); degree 4 – 5.6% (2/36). In Neolithic, the situation was: degree 1 – 7.1% (1/14); degree 2 – 64.3% (9/14), degree 3 – 21.4% (3/14) and degree 4 – 7.1% (1/14) (Table 4.51). Chi-square test results showed no statistically significant correlation (X^2 = 0.987, df =3, p = 0.804) with low effect (Cramer's V = 0.141).

Table 4.50. Crosstabulation of period and degree of porotic hyperostosis among Mesolithic and Neolithic inhabitants of the Danube Gorges

		DEGREE				TOTAL
		1	**2**	**3**	**4**	
MESOLITHIC	**COUNT**	14	33	22	11	80
EXPECTED	**COUNT**	12.8	35.8	21.1	10.2	80.0
NEOLITHIC	**COUNT**	6	23	11	5	45
EXPECTED	**COUNT**	7.2	20.2	11.9	5.8	45.0
TOTAL	**COUNT**	20	56	33	16	125

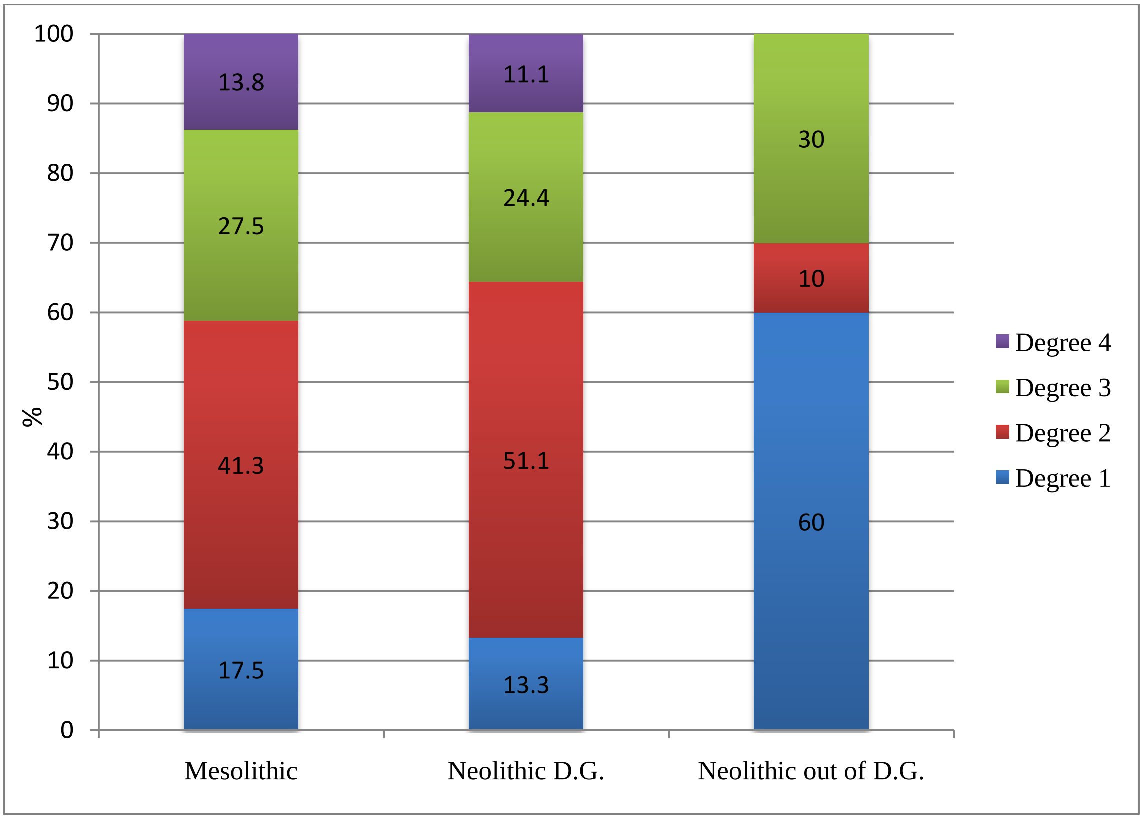

Figure 4.10. The frequency of different degrees of porotic hyperostosis among Mesolithic-Neolithic population in the Danube Gorges and Neolithic communities outside the Gorges

In Mesolithic period, the occurrence of different degrees of porotic hyperostosis among adult males was as follows: degree 1 – 17.4% (4/23); degree 2 – 34.8% (8/23); degree 3 – 21.7% (5/23); degree 4 – 26.1% (6/23). In Neolithic, degree 1 was not present; degree 2 – 30.0% (3/10); degree 3 – 40% (4/10) and degree 4 – 30.0% (3/10) (Table 4.52). Chi-square test results showed statistically no significant correlation (X^2 =2.678, df = 3, p = 0.444) with low effect (Cramer's V = 0.285).

Table 4.51. Crosstabulation of period and degree of porotic hyperostosis among Mesolithic and Neolithic females in the Danube Gorges

		DEGREE				TOTAL
		1	**2**	**3**	**4**	
MESOLITHIC	**COUNT**	6	19	9	2	36
EXPECTED	**COUNT**	5.0	20.2	8.6	2.2	36.0
NEOLITHIC	**COUNT**	1	9	3	1	14
EXPECTED	**COUNT**	2.0	7.8	3.4	0.8	14.0
TOTAL	**COUNT**	7	28	12	3	50

Table 4.52. Crosstabulation of period and degree of porotic hyperostosis among Mesolithic and Neolithic males in the Danube Gorges

		DEGREE				TOTAL
		1	**2**	**3**	**4**	
MESOLITHIC	**COUNT**	4	8	5	6	23
EXPECTED	**COUNT**	2.8	7.7	6.3	6.3	23.0
NEOLITHIC	**COUNT**	0	3	4	3	10
EXPECTED	**COUNT**	1.2	3.3	2.7	2.7	10.0
TOTAL	**COUNT**	4	11	9	9	33

Among children from Mesolithic period, the occurrence of different degrees of porotic hyperostosis was as follows: degree 1 – 60.0% (3/5); degree 2 was not present; degree 3 – 20.0 % (1/5); degree 4 – 20.0% (1/5). In Neolithic degree 1 was present in

37.5 % (3/8) of the children, while 62.5 % (5/8) had degree 2. Degree 3 and 4 were not present (Table 4.53). Chi-square test results showed a marginally significant correlation between periods and degrees (X^2 =6.663, df = 3, p = 0.083) with strong effect (Cramer's V = 0.716).

Table 4.53. Crosstabulation of period and degree of porotic hyperostosis among Mesolithic and Neolithic children in the Danube Gorges

		DEGREE				TOTAL
		1	**2**	**3**	**4**	
MESOLITHIC	**COUNT**	3	0	1	1	5
EXPECTED	**COUNT**	2.3	1.9	0.4	0.4	5.0
NEOLITHIC	**COUNT**	3	5	0	0	8
EXPECTED	**COUNT**	3.7	3.1	0.6	0.6	8.0
TOTAL	**COUNT**	6	5	1	1	13

Activity

In Mesolithic, among 80 individuals with porotic hyperostosis, 18.8 % (15/80) had active lesions at the time of death; 50.0 % (40/80) had healed lesions while 31.3 % (25/80) had mixed active and healed lesions. In Neolithic, out of 45 individuals with porotic hyperostosis, 40.0 % (18/45) had active lesions at the time of death, 40.0 % (18/45) had healed lesions while 20.0 % (9/45) had mixed active and healed lesions (Figure 4.11,Table 4.54). The result of chi-square test showed that the observed difference between periods was statistically significant (X^2 =6.887, df = 2; p = 0.032) with low effect (Cramer's V = 0.235).

Statistical analysis of activity type of porotic hyperostosis for female individuals from Mesolithic and Neolithic showed the following results: the most common type among Mesolithic females was type 2 – 55.6 % (20/36), followed by type 3 – 25.0% (9/36) and type 1 – 19.4 % (7/36). The results for Neolithic women showed the highest frequency of activity type 1 – 42.9 % (6/14), than type 2 – 28.6 % (4/14) and type 3– 28.6 % (4/14) (Table 4.55). Chi-square test results showed no statistically significant correlation (X^2 =3.704; df =2, p = 0.157), with low effect (Cramer's V = 0.272).

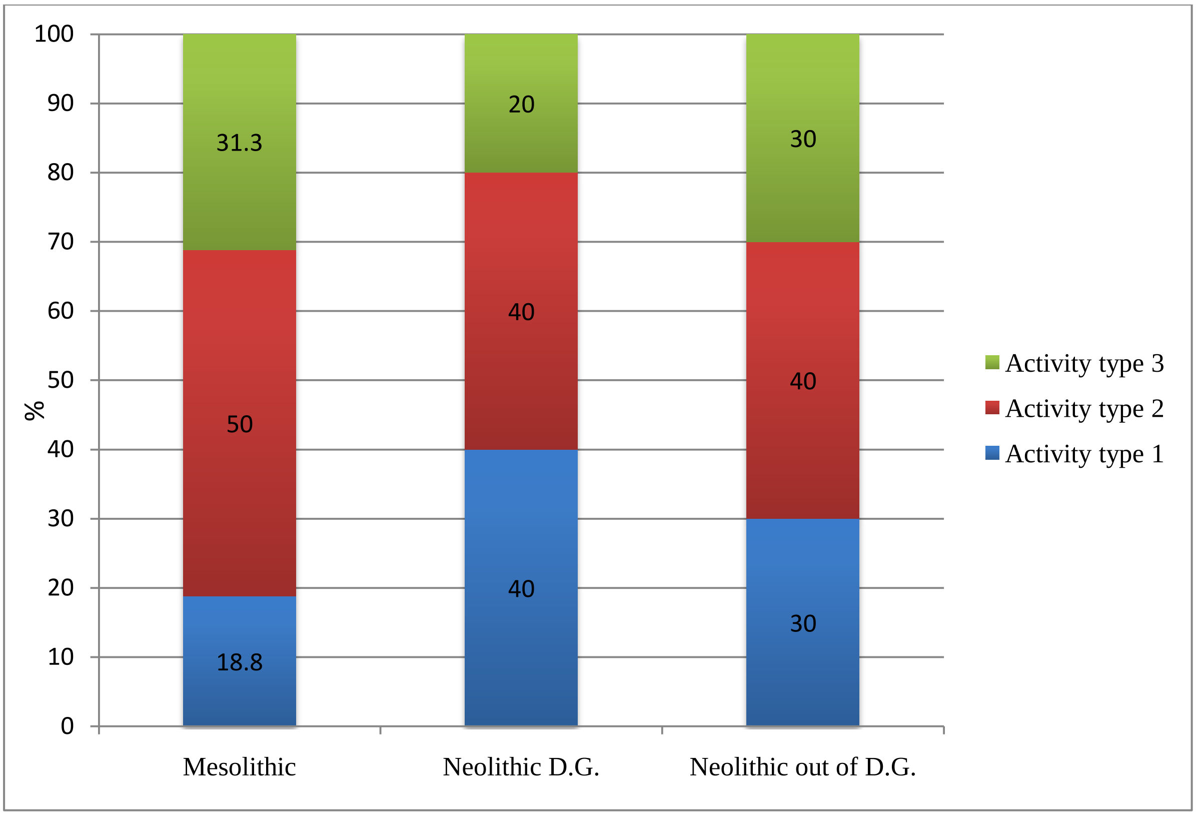

Figure 4.11. The frequency of different activity types of porotic hyperostosis among Mesolithic-Neolithic population in the Danube Gorges and Neolithic communities outside the Gorges

Table 4.54. Crosstabulation of period and activity types of porotic hyperostosis among Mesolithic and Neolithic inhabitants of the Danube Gorges

		ACTIVITY			TOTAL
		1	**2**	**3**	
MESOLITHIC	**COUNT**	15	40	25	80
EXPECTED	**COUNT**	21.1	37.1	21.8	80.0
NEOLITHIC	**COUNT**	18	18	9	45
EXPECTED	**COUNT**	11.9	20.9	12.2	45.0
TOTAL	**COUNT**	33	58	34	125

Table 4.55. Crosstabulation of period and activity types of porotic hyperostosis among Mesolithic and Neolithic females in the Danube Gorges

		ACTIVITY			TOTAL
		1	**2**	**3**	
MESOLITHIC	**COUNT**	7	20	9	36
EXPECTED	**COUNT**	9.4	17.3	9.4	36.0
NEOLITHIC	**COUNT**	6	4	4	14
EXPECTED	**COUNT**	3.6	6.7	3.6	14.0
TOTAL	**COUNT**	13	24	13	50

Statistical analysis of activity type of porotic hyperostosis for male individuals from Mesolithic and Neolithic showed the following results: the most common type among Mesolithic males was type 2 – 56.5 % (13/23), followed by type 3 – 30.4% (7/23) and type 1 – 13.0 % (3/23). In Neolithic 40.0 % (4/10) of males had activity type 1; 50.0 % (5/10) had degree 2, while 10 % (1/10) had degree 3. (Table 4.56). Chi-square test results showed no statistically significant correlation (X^2 = 3.642; df = 2; p = 0.162), with medium effect (Cramer's V = 0.332).

Table 4.56. Crosstabulation of period and activity types of porotic hyperostosis among Mesolithic and Neolithic males in the Danube Gorges

		ACTIVITY			TOTAL
		1	**2**	**3**	
MESOLITHIC	**COUNT**	3	13	7	23
EXPECTED	**COUNT**	4.9	12.5	5.6	23.0
NEOLITHIC	**COUNT**	4	5	1	10
EXPECTED	**COUNT**	2.1	5.5	2.4	10.0
TOTAL	**COUNT**	7	18	8	33

Statistical analysis of activity type of porotic hyperostosis for Mesolithic-Neolithic children showed the following results: the most common types among

Mesolithic children were types 2 – 40% (2/5) and 3 – 40% (2/5), while activity type 1 was represented in 20% (1/5). As concerning Neolithic children the most common activity type was 1 - 50% (4/8), followed by activity type 2 – 37.5 % (3/8) and activity type 3 was found in only one child, which is 12.5 % (1/8) (Table 4.57). Chi-square test results showed no statistically significant difference (X^2 = 1.733, df = 2, p = 0.420), with medium effect (Cramer's V = 0.365).

Table 4.57. Crosstabulation of period and activity types of porotic hyperostosis among Mesolithic and Neolithic children in the Danube Gorges

		ACTIVITY			TOTAL
		1	**2**	**3**	
MESOLITHIC	**COUNT**	1	2	2	5
EXPECTED	**COUNT**	1.9	1.9	1.2	5.0
NEOLITHIC	**COUNT**	4	3	1	8
EXPECTED	**COUNT**	3.1	3.1	1.8	8.0
TOTAL	**COUNT**	5	5	3	13

4.7.2. Outside the Danube Gorges

Presence

Porotic hyperostosis was quite frequent pathology among Mesolithic population from the Danube Gorges – 96.4% (80/83), while in Neolithic outside the Danube Gorges the frequency was lower – 58.8% (10/17) (Figure 4.4, Table 4.58). A statistically significant correlation between the period and the presence of porotic hyperostosis was found (Fisher's exact p = 0.000), with strong effect (Cramer's V = 0.481).

When considering females from Mesolithic period, all of them had traces of porotic hyperostosis (36/36), while in Neolithic 88.88 % (8/9) of women had porotic hyperostosis (Figure 4.5).

All males in Mesolithic (23/23) had porotic hyperostosis, while in Neolithic only one male out of two (50%) with preserved occipital bone had porotic hyperostosis (Figure 4.5).

Table 4.58. Crosstabulation of period and presence of porotic hyperostosis among Mesolithic (D.G.) and Neolithic inhabitants outside the Danube Gorges

		PRESENCE		TOTAL
		Absent	Present	
MESOLITHIC	**COUNT**	75	8	83
EXPECTED	**COUNT**	68.1	14.9	83.0
NEOLITHIC	**COUNT**	7	10	17
EXPECTED	**COUNT**	13.9	3.1	17.0
TOTAL	**COUNT**	82	18	100

Among Mesolithic children, 83.3% (5/6) had porotic hyperostosis, and in Neolithic 16.7% (1/6) (Figure 4.6; Table 4.59). A statistically significant correlation between the period and the presence of porotic hyperostosis was found (Fisher's exact $p = 0.040$), with strong effect (Cramer's V = 0.667).

Table 4.59. Crosstabulation of period and presence of porotic hyperostosis among Mesolithic (D.G.) and Neolithic children outside the Danube Gorges

		PRESENCE		TOTAL
		Absent	Present	
MESOLITHIC	**COUNT**	1	5	6
EXPECTED	**COUNT**	3.0	3.0	6.0
NEOLITHIC	**COUNT**	5	1	6
EXPECTED	**COUNT**	3.0	3.0	6.0
TOTAL	**COUNT**	6	6	12

Degree

In Mesolithic period, the occurrence of different degrees of porotic hyperostosis on the population level was as follows: degree 1 – 17.5% (14/80); degree 2 – 41.3% (33/80); degree 3 – 27.5% (22/80); degree 4 – 13.8% (11/80). In Neolithic, degree 1 was present in – 60.0% (6/10); degree 2 – 10.0 % (1/10); degree 3 – 30.0% (3/10); while degree 4 was not present (Figure 4.10; Table 4.60). Chi-square test results showed a statistically significant correlation between the period and the degree of porotic hyperostosis (X^2 = 10.918, df =3, p = 0.012), with medium effect (Cramer's V = 0.348).

In Mesolithic period, the occurrence of different degrees of porotic hyperostosis among adult females was as follows: degree 1- 16.7% (6/36); degree 2 – 52.8% (19/36); degree 3 – 25.0% (9/36); degree 4 – 5.6% (2/36). In Neolithic, the situation was the following: degrees 1 – 62.5% (5/8) and degree 2 – 12.5% (1/8), degree 3 – 25.0% (2/8) while degree 4 was not present (Table 4.61). Chi-square test results showed a statistically significant correlation (X^2 =8.281, df =3, p = 0.041) with strong effect (Cramer's V = 0.434).

Table 4.60. Crosstabulation of period and degree of porotic hyperostosis among Mesolithic (D.G.) and Neolithic inhabitants outside the Danube Gorges

		DEGREE				TOTAL
		1	**2**	**3**	**4**	
MESOLITHIC	**COUNT**	14	33	22	11	80
EXPECTED	**COUNT**	17.8	30.2	22.2	9.8	80.0
NEOLITHIC	**COUNT**	6	1	3	0	10
EXPECTED	**COUNT**	2.2	3.8	2.8	1.2	10.0
TOTAL	**COUNT**	20	34	25	11	90

Table 4.61. Crosstabulation of period and presence of porotic hyperostosis among Mesolithic (D.G.) and Neolithic females outside the Danube Gorges

		DEGREE				TOTAL
		1	**2**	**3**	**4**	
MESOLITHIC	**COUNT**	6	19	9	2	36
EXPECTED	**COUNT**	9.0	16.4	9.0	1.6	36.0
NEOLITHIC	**COUNT**	5	1	2	0	8
EXPECTED	**COUNT**	2.0	3.6	2.0	0.4	8.0
TOTAL	**COUNT**	11	20	11	2	44

In Mesolithic period, the occurrence of different degrees of porotic hyperostosis among males was as follows: degree 1 – 17.4% (4/23); degree 2 – 34.8% (8/23); degree 3 – 21.7% (5/23); degree 4 – 26.1% (6/23). In Neolithic the only male with porotic hyperostosis had degree 3.

Among children from Mesolithic period, the occurrence of different degrees of porotic hyperostosis was as follows: degree 1 – 60.0% (3/5); degree 2 was not present; degree 3 – 20.0 % (1/5); degree 4 – 20.0% (1/5). In Neolithic one child with porotic hyperostosis had degree 1.

Activity

In Mesolithic, out of the 80 individuals with porotic hyperostosis, 18.8 % (15/80) had active lesions (activity type 1) at the time of death; 50.0 % (40/80) had healed lesions (activity type 2) while 31.3 % (25/80) had mixed active and healed lesions (activity type 3). The results for Neolithic population also showed highest frequency of activity type 2 – 40.0 % (4/10), then type 1 – 30.0 % (3/10) and type 3 – 30.0 % (3/10) (Figure 4.11, Table 4.62). Chi-square test results showed no statistically significant correlation between the period and activity type of porotic hyperostosis (X^2 =0.749; df =2; p = 0.688), with low effect (Cramer's V = 0.091).

Table 4.62. Crosstabulation of period and activity type of porotic hyperostosis among Mesolithic (D.G.) and Neolithic inhabitants outside the Danube Gorges

		ACTIVITY			TOTAL
		1	**2**	**3**	
MESOLITHIC	**COUNT**	15	40	25	80
EXPECTED	**COUNT**	16.0	39.1	24.9	80.0
NEOLITHIC	**COUNT**	3	4	3	10
EXPECTED	**COUNT**	2.0	4.9	3.1	10.0
TOTAL	**COUNT**	18	44	28	90

Statistical analysis of activity type of porotic hyperostosis for female individuals from Mesolithic and Neolithic showed the following results: the most common type among Mesolithic females was type 2 – 55.6 % (20/36), followed by type 3 – 25.0% (9/36) and type 1 – 19.4 % (7/36). The results for Neolithic women also showed highest frequency of activity type 2 – 50.0 % (4/8), then type 1 – 25 % (2/8); type 3 – 25 % (2/8) (Table 4.63). Chi-square test results showed no statistically significant correlation (X^2 =0.136, df = 2, p = 0.934), with low effect (Cramer's V = 0.056).

Table 4.63. Crosstabulation of period and presence of porotic hyperostosis among Mesolithic (D.G.) and Neolithic females outside the Danube Gorges

		ACTIVITY			TOTAL
		1	**2**	**3**	
MESOLITHIC	**COUNT**	7	20	9	36
EXPECTED	**COUNT**	7.4	19.6	9.0	36.0
NEOLITHIC	**COUNT**	2	4	2	8
EXPECTED	**COUNT**	1.6	4.4	2.0	8.0
TOTAL	**COUNT**	9	24	11	44

The presence of different activity types of porotic hyperostosis for male individuals from Mesolithic and Neolithic is as follows: the most common type among Mesolithic males is type 2 – 56.5 % (13/23), followed by type 3 – 30.4% (7/23) and type 1 – 13.0 % (3/23). The only Neolithic male has type 3.

The presence of different activity types of porotic hyperostosis for children from Mesolithic and Neolithic was as follows: the most common types among Mesolithic children were types 2 – 40% (2/5) and 3 – 40% (2/5), while activity type 1 was present in 20% (1/5). The child from Neolithic with porotic hyperostosys, had activity type 1.

4.8. Enamel hypoplasia

4.8.1. The Presence, age and sex related differences

4.8.1.1. The Danube Gorges

The analysis of dental enamel hypoplasia (EH) on the population level showed the following results: in Mesolithic, 33.6 % (41/122) of individuals had hypoplasia, while in Neolithic 33.7% (29/77) of individuals had this physiological stress indicator (Figure 4.4; Table 4.64). The correlation between the period and the presence of enamel hypoplasia was not statistically significant (Fisher's exact p = 0.332), with low effect (Cramer's V = 0.041). Similar results were obtained when the number of affected teeth was observed. In Mesolithic 5.8 % (82/1404) of teeth had at least one hypoplastic defect, while in Neolithic 6.5 % (59/902).

Table 4.64. Crosstabulation of period and presence of enamel hypoplasia among Mesolithic and Neolithic inhabitants of the Danube Gorges

		PRESENCE		TOTAL
		Absent	Present	
MESOLITHIC	**COUNT**	81	41	122
EXPECTED	**COUNT**	79.1	42.9	122.0
NEOLITHIC	**COUNT**	48	29	77
EXPECTED	**COUNT**	49.9	27.1	77.0
TOTAL	**COUNT**	129	70	199

Among Mesolithic adult females, 27.3% (12/44) had hypoplasia, and in Neolithic – 31.6 % (6/19) (Figure 4.5, Table 4.65). Statistical analysis showed no statistically significant correlation between the period and the presence (Fisher's exact p = 0.476), with low effect (Cramer's V = 0.044). Similar results were obtained when the number of affected teeth was observed. In Mesolithic 4.4 % (24/546) of teeth had at least one hypoplastic defect, while in Neolithic 5.6 % (16/287).

Among adult males from Mesolithic 42.3% (11/26) had EH. In Neolithic, 30.8% (4/13) of males had hypoplasia (Figure 4.5, Table 4.66). There was no statistically significant correlation between the period and the presence of enamel hypoplasia (Fisher's exact p = 0.367), with low effect (Cramer's V = 0.112). Similar results were obtained when the number of affected teeth was observed. In Mesolithic 7.6 % (31/406) of teeth had at least one hypoplastic defect, while in Neolithic 5.1 % (7/138).

Table 4.65. Crosstabulation of period and presence of enamel hypoplasia among Mesolithic and Neolithic females in the Danube Gorges

		PRESENCE		TOTAL
		Absent	Present	
MESOLITHIC	**COUNT**	32	12	44
EXPECTED	**COUNT**	31.4	12.6	44.0
NEOLITHIC	**COUNT**	13	6	19
EXPECTED	**COUNT**	13.6	5.4	19.0
TOTAL	**COUNT**	45	18	63

Table 4.66. Crosstabulation of period and presence of enamel hypoplasia among Mesolithic and Neolithic males in the Danube Gorges

		PRESENCE		TOTAL
		Absent	Present	
MESOLITHIC	**COUNT**	15	11	26
EXPECTED	**COUNT**	16.0	10.0	26.0
NEOLITHIC	**COUNT**	9	4	13
EXPECTED	**COUNT**	8.0	5.0	13.0
TOTAL	**COUNT**	24	15	39

In addition, statistical analysis conducted between males and females within the Neolithic period showed no statistically significant correlation between sex and the presence of hypoplasia (Fisher's exact $p = 0.636$), with very low effect (Cramer's V = 0.009) (Table 4.67).

Among children in Mesolithic, 50% (9/18) of them have hypoplasia, while in Neolithic, 41.7% (10/24) of them (Figure 4.6, Table 4.68). Statistical analysis has shown no statistically significant correlation between the period and presence (Fisher's exact $p = 0.411$), with very low effect (Cramer's V = 0.083).

Table 4.67. Crosstabulation of period and presence of enamel hypoplasia among Mesolithic and Neolithic females and males in the Danube Gorges

	PRESENCE		TOTAL
	Absent	Present	
NEOLITHIC FEMALES			
COUNT	13	6	19
EXPECTED COUNT	13.1	5.9	19.0
NEOLITHIC MALES			
COUNT	9	4	13
EXPECTED COUNT	8.9	4.1	13.0
TOTAL **COUNT**	22	10	32

Table 4.68. Crosstabulation of period and presence of enamel hypoplasia among Mesolithic and Neolithic children in the Danube Gorges

	PRESENCE		TOTAL
	Absent	Present	
MESOLITHIC **COUNT**	9	9	18
EXPECTED COUNT	9.9	8.1	18.0
NEOLITHIC **COUNT**	14	10	24
EXPECTED COUNT	13.1	10.9	24.0
TOTAL **COUNT**	23	19	42

4.8.1.2. Outside the Danube Gorges

The analysis of tooth enamel hypoplasia on the population level showed the following results: in the Danube Gorges Mesolithic, 33.6 % (41/122) of individuals had hypoplasia, while in Neolithic 54.2% (13/24) of individuals had this stress indicator (Figure 4.4, Table 4.69). The correlation between the period and the presence of enamel hypoplasia was statistically significant (Fisher’s exact p = 0.048), but with the low effect (Cramer’s V = 0.158). Similar results were obtained when the number of affected teeth was observed. In Mesolithic 5.8 % (82/1404) of teeth had at least one hypoplastic defect, while in Neolithic the number was higher, 12.1 % (40/330).

Table 4.69. Crosstabulation of period and presence of enamel hypoplasia among Mesolithic (D.G.) and Neolithic inhabitants outside the Danube Gorges

		PRESENCE		TOTAL
		Absent	Present	
MESOLITHIC	**COUNT**	81	41	122
EXPECTED	**COUNT**	76.9	45.1	122.0
NEOLITHIC	**COUNT**	11	13	24
EXPECTED	**COUNT**	15.1	8.9	24.0
TOTAL	**COUNT**	92	54	146

Among Mesolithic adult females, 27.3% (12/44) had hypoplasia, and in Neolithic – 62.5% (5/8) (Figure 4.5, Table 4.70). Statistical analysis showed a marginally significant correlation between the period and the presence (Fisher's exact $p = 0.076$), with low effect (Cramer's V = 0.263). However, when the number of affected teeth was observed the situation was different. In Mesolithic 4.4 % (24/546) of teeth had at least one hypoplastic defect, while in Neolithic 14.0 % (21/150).

Table 4.70. Crosstabulation of period and presence of enamel hypoplasia among Mesolithic (D.G.) and Neolithic females outside the Danube Gorges

		PRESENCE		TOTAL
		Absent	Present	
MESOLITHIC	**COUNT**	30	12	42
EXPECTED	**COUNT**	27.7	14.3	42.0
NEOLITHIC	**COUNT**	3	5	8
EXPECTED	**COUNT**	5.3	2.7	8.0
TOTAL	**COUNT**	33	17	50

Among adult males from Mesolithic 42.3% (11/26) had enamel hypoplasia. In Neolithic, 50% (1/2) of males had hypoplasia (Figure 4.5). Similar results were obtained when the number of affected teeth was observed. In Mesolithic 7.6 % (31/406) of teeth had at least one hypoplastic defect, while in Neolithic 5.0 % (1/20).

Among children in Mesolithic, 50% (9/18) had hypoplasia. In Neolithic, 33.3% (2/6) of children had hypoplasia (Figure 4.6, Table 4.71). Statistical analysis showed no statistically significant correlation between the period and the presence (Fisher's exact p = 0.410), with low effect (Cramer's V = 0.145).

Table 4.71. Crosstabulation of period and presence of enamel hypoplasia among Mesolithic (D.G.) and Neolithic children outside the Danube Gorges

		PRESENCE		TOTAL
		Absent	Present	
MESOLITHIC	**COUNT**	9	9	18
EXPECTED	**COUNT**	9.8	8.3	18.0
NEOLITHIC	**COUNT**	4	2	6
EXPECTED	**COUNT**	3.3	2.8	6.0
TOTAL	**COUNT**	13	11	24

4.8.2. Timing of linear enamel hypoplasia (LEH)

When both periods (Mesolithic and both Neolithic) were observed together, it was found that the average age at which most LEH defects had appeared was between 2 and 4 years (Figure 4.12).

In Mesolithic, the average individual age at which most LEH defects appeared was between 3.5 and 3.9 (26.31%), while in the Neolithic (both in the Danube Gorges and outside the Danube Gorges) it was between 3.0 and 3.4 years (23.08%). The results for Neolithic in the Danube Gorges and regions outside were similar, there being no significant differences, since in Neolithic outside the Danube Gorges 24 % of individuals exhibited LEH defects at the average age between 3.0 and 3.4 (Figure 4.13).

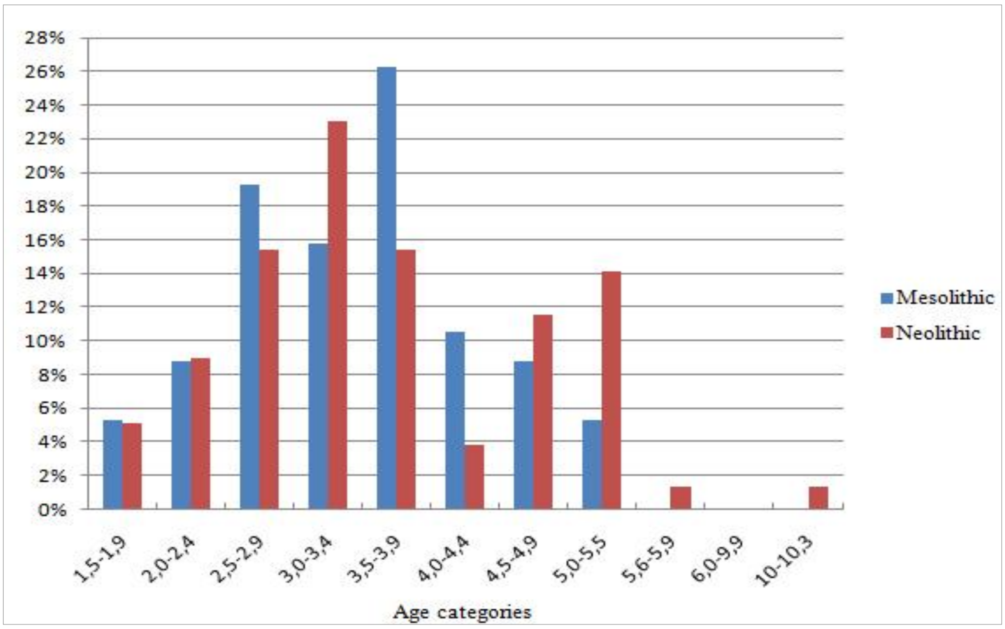

Fig.4.12.The percentages of LEH defects in relation to individuals age when defects appeared in the Mesolithic (D.G.) and both Neolithic studied population

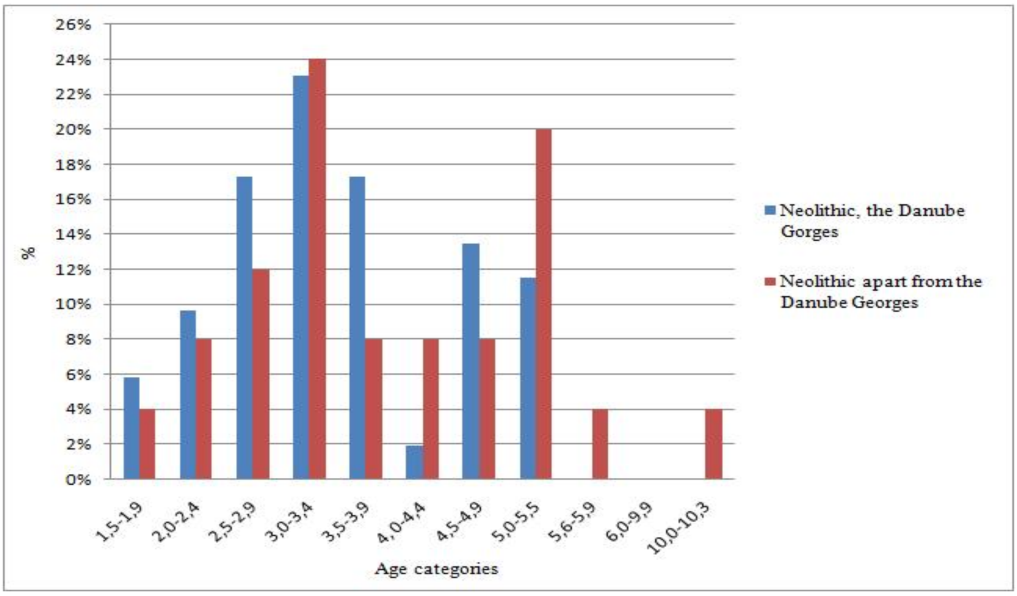

Fig. 4.13. The percentages of LEH defects in relation to individuals age when defects appeared in the Neolithic in the Danube Gorges and Neolithic population outside the Gorges

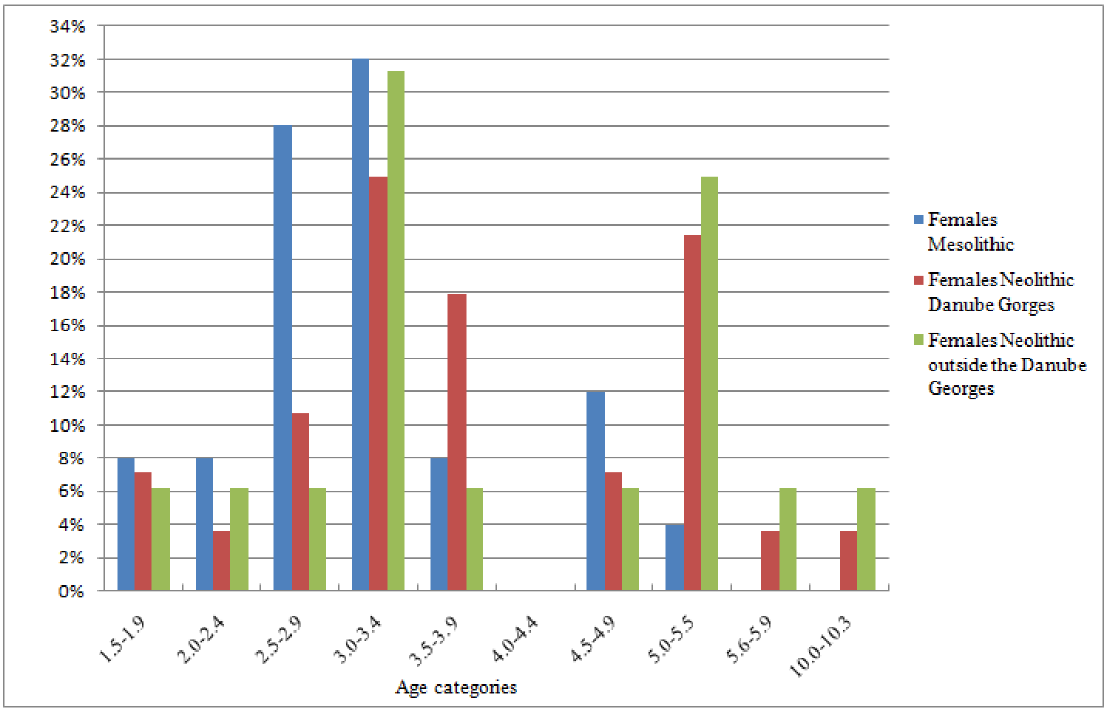

Fig. 14a. The percentages of LEH defects in relation to females age when defects appeared in the Mesolithic and both Neolithic studied population

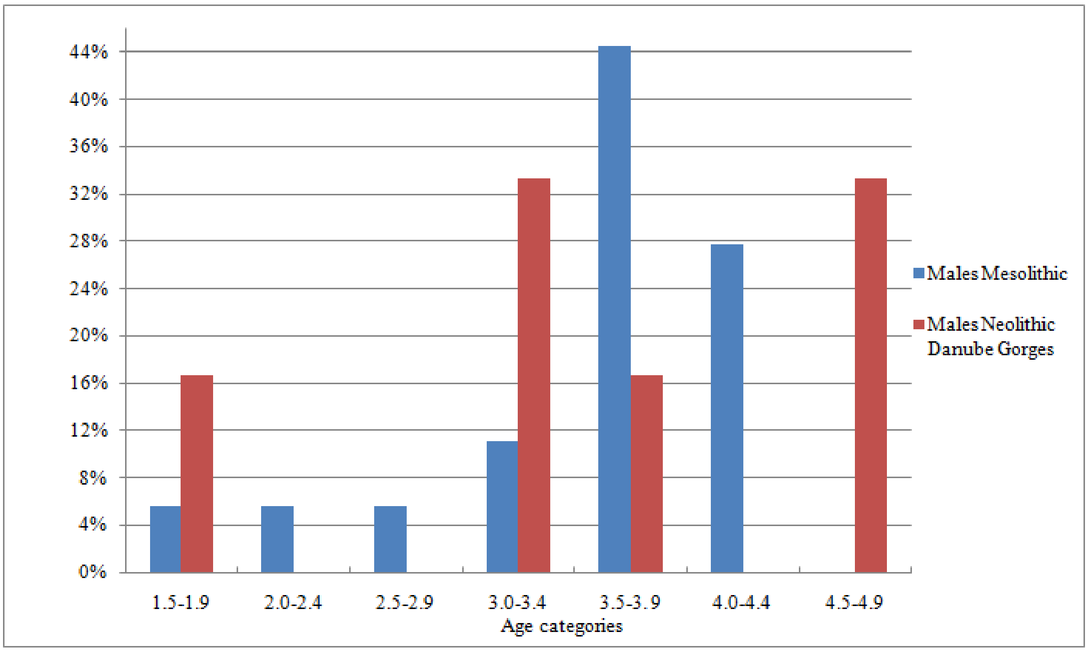

Fig. 14b. The percentages of LEH defects in relation to males age when defects appeared in the Mesolithic and both Neolithic studied population

Concerning sex, there were differences in average age between males and females (Figure 4.14a, 4.14b). In Mesolithic, females exhibited hypoplastic defect at an average age between 3.0 and 3.4, while males showed the most defects at the age of 3.5-3.9. In the Danube Gorges Neolithic, females showed the most hypoplastic defects between the age of 3.5 and 3.9, while outside the Gorges between 3.0 and 3.4. Males[28] in Neolithic of the Danube Gorges showed most of the defects between the age of 3.0 and 3.4 and 4.5 and 4.9 years.

4.8.3. The number of stress episodes

The distribution of stress events per period, individual, age and sex is shown in Table 4.74. In Mesolithic, 43% of individuals had only one stress event, while 56.56% had more than one stress episode during childhood. In the Neolithic (D.G.), 36.36% had one stress event, while 63.63% had more than one (Table 4.72). No statistically significant correlation was found between Mesolithic and Neolithic period concerning more than one stress event (Fisher's exact $p = 0.414$), with low effect (Cramer's V = 0.070).

Table 4.72. Crosstabulation of period and number of stress episodes among Mesolithic and Neolithic population in the Danube Gorges

		PRESENCE		TOTAL
		One stress episode	More than one episode	
MESOLITHIC	**COUNT**	13	17	30
EXPECTED	**COUNT**	12.1	17.9	30.0
NEOLITHIC	**COUNT**	8	14	22
EXPECTED	**COUNT**	8.9	13.1	22.0
TOTAL	**COUNT**	21	31	52

[28] Only one male out of two outside the Danube Gorges showed the presence of hypoplasia, so any further discussion would be limited.

In Neolithic outside the Danube Gorges, 27.27% had one stress event, while 72.72% had more than one (Table 4.73). No statistically significant correlation was found between Mesolithic and Neolithic period concerning more than one stress event (Fisher's exact *p* = 0.287), with low effect (Cramer's V = 0.146).

Table 4.73. Crosstabulation of period and presence of stress episodes among Mesolithic (D.G.) and Neolithic population outside the Danube Gorges

		PRESENCE		TOTAL
		One stress episode	More than one episode	
MESOLITHIC	**COUNT**	13	17	30
EXPECTED	**COUNT**	11.7	18.3	30.0
NEOLITHIC	**COUNT**	3	8	11
EXPECTED	**COUNT**	4.3	6.7	11.0
TOTAL	**COUNT**	16	25	41

Table 4.74. shows the number of individuals per period and the number of stress episodes for males, females, indeterminate sex and subadults

Mesolithic	Individuals with one stress episode	Individuals with more than one stress episode (1+)
Males	1	4
Females	3	9
Indeterminate sex	3	0
Subadults	6	4
Total	13 (43%)	17 (56.56%)
Neolithic inside the Gorges		
Males	1	2
Females	4	1

Indeterminate sex	1	5
Subadults	2	6
Total	8 (36.36 %)	14 (63.63%)
Neolithic outside the Danube Gorges		
Males	1	0
Females	0	5
Indeterminate sex	2	3
Subadults	0	0
Total	3 (27.27 %)	8 (72.72 %)

4.9. Metric characteristics

4.9.1. Stature

Results showed that in Mesolithic females had an average stature of 166.12 cm, Neolithic inside the Gorges 162.34 cm, while outside the Gorges average female stature was the lowest, 154.00 cm (Figure 4.15). In the Danube Gorges, males in Mesolithic had an average height of 178.95 cm, while in Neolithic the average height was 171.19cm. In the Neolithic outside the Gorges it was possible to calculate the height of one male only, which was 170.58 cm (Figure 4.16).

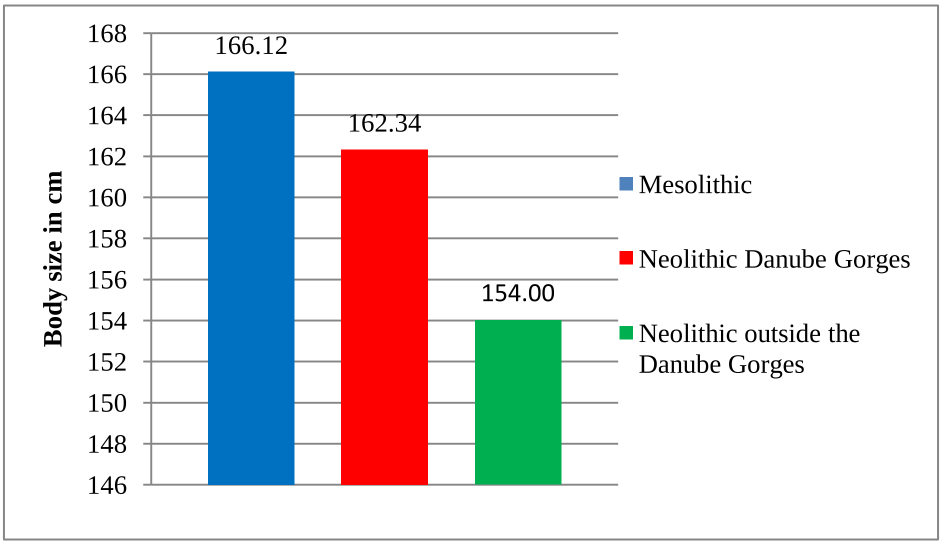

Fig. 4.15. The average female stature in Mesolithic and Neolithic studied regions

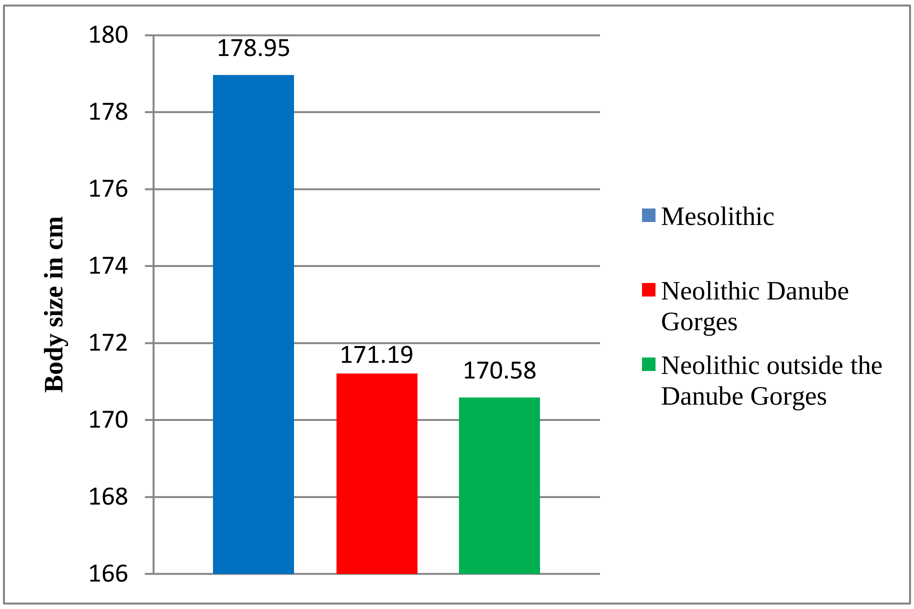

Fig. 4.16. The average male stature in Mesolithic and Neolithic studied regions

4.9.2. Body mass

The average body mass of Mesolithic females was 64.48 kg. In the Danube Gorges Neolithic females had lower weight (58.10 kg), while outside the Gorges the average female weight was 60.83 kg (Figure 4.17).

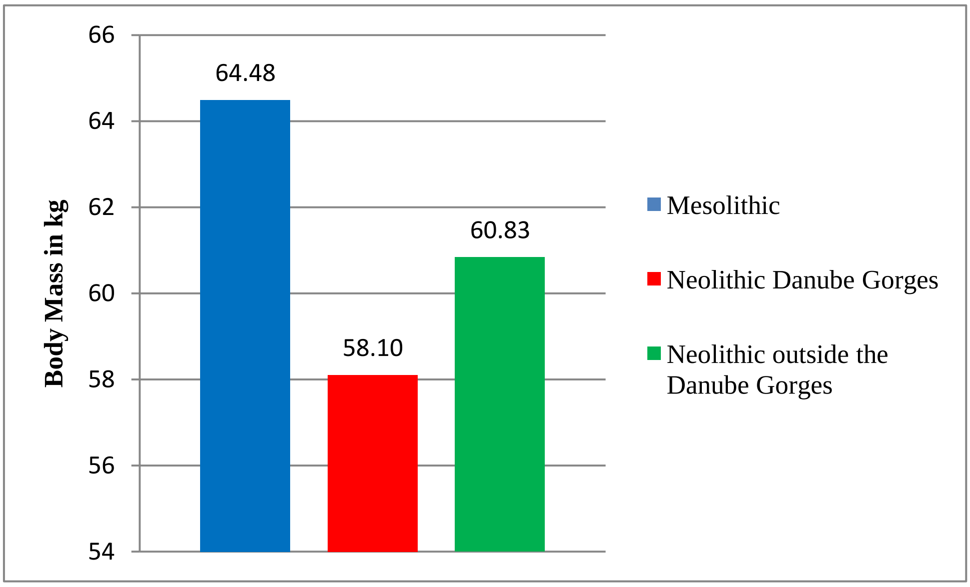

Fig. 4.17. The average female body mass in Mesolithic and Neolithic studied regions

The results for males showed a different pattern. In Mesolithic the average male weight was 68.22 kg while in Neolithic in the Danube Gorges the average weight for males was higher – 71.71 kg (Figure 4.18). In the Neolithic outside the Gorges it was not possible to calculate the weight for any male due to preservation state of the material.

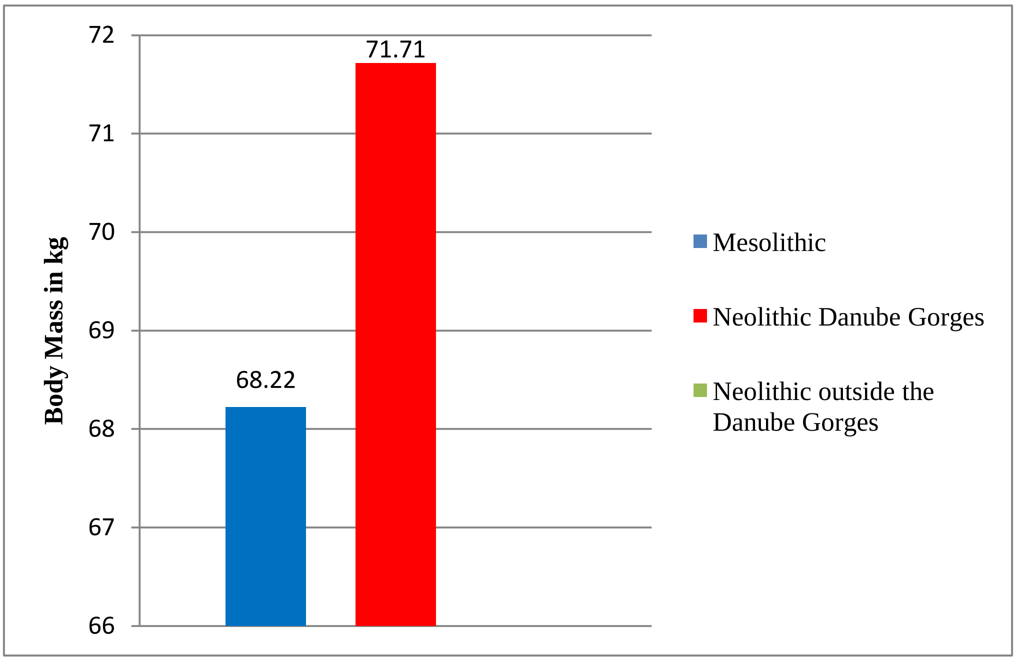

Fig. 4.18. The average males body mass in Mesolithic and Neolithic studied regions

4.9.3. Body mass index

The body mass index results are presented in Table 6, in Appendix 2. The results showed that normal body mass index was the most common throughout the Mesolithic and Neolithic sequence (Figure 4.19). In Mesolithic, 90 % (27/30) of individuals had normal body mass index, while only 10% (3/1984) of individuals were overweight. In Neolithic (both inside and outside the Danube Gorges) 82.60 % (19/23) individuals had normal body mass index; 13.04 % of them were overweight and one individual (4.34 %) was underweight. For comparison of differences between body mass indices (BMIs) in Mesolithic and Neolithic, the independent t-test was applied to calculate the differences between means in two independent samples. The result of t- test showed that the observed difference among periods is not statistically significant (p = 0.796).

However, when Mesolithic (n=30) and only Neolithic outside the Danube Gorges (n=3) were considered, the results were not statistically significant (t = -1.441, df = 31, p = 0.160), with low effect (r = 0.251), with higher values of BMI in Neolithic (M = 24.2800, SE = 2.12351) than in Mesolithic (M = 22.7377, SE = 1.73985).

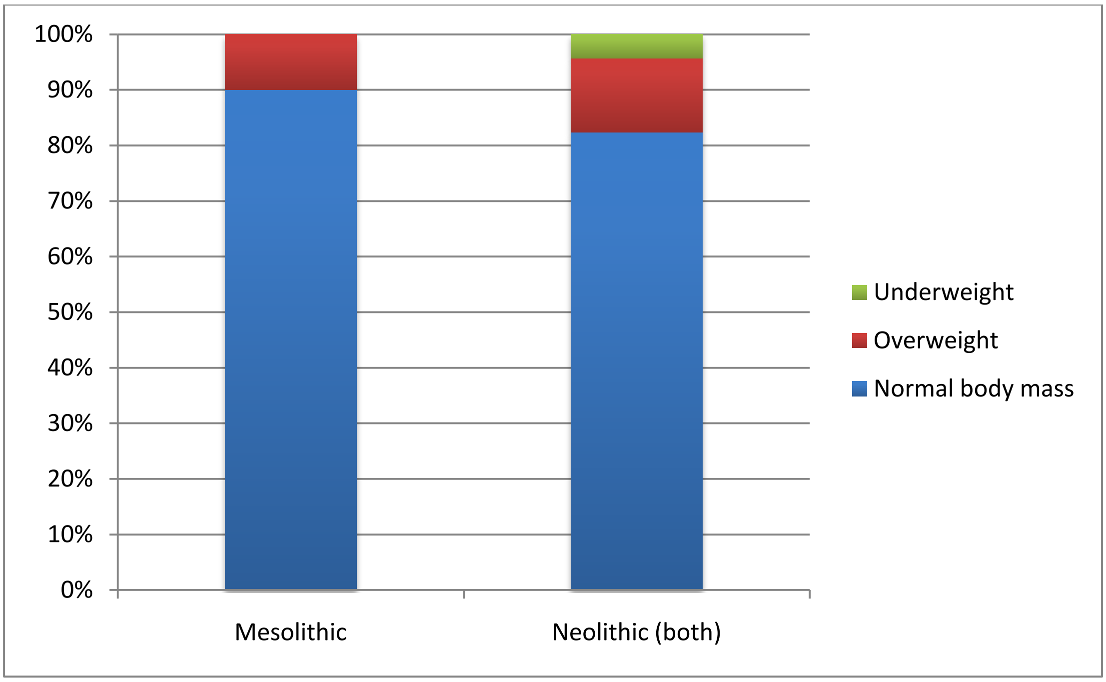

Fig. 4.19. The body mass index types in Mesolithic and Neolithic population in both studied regions

5. DISCUSSION AND CONCLUSION

In this chapter, the obtained results will be discussed and compared with those available in the literature. First, dietary indicators (produced through stable isotope and starch analysis) will be considered as they provide information on dietary pathways and are necessary for further consideration of the health indicators. Second, the presence of dental caries, calculus, and AMTL will be discussed in more detail as they represent both dietary and health-related proxy. Third, the markers of physiological stress (cribra orbitalia, porotic hyperostosis, enamel hypoplasia) will be considered in the light of the results of the aforementioned analysis. Lastly, the discussion of body proportions will be presented since the diet and health of the examined individuals could have had influence on it. At the end of the chapter a thesis conclusion will be presented.

5.1. DIETARY INDICATORS

5.1.1. Stable isotope analysis

This section will first present the dietary choices of the Mesolithic adult individuals, and will then proceed to the discussion of the impact that the process of Neolithisation had on dietary trends in the different regions of the Central Balkans. Following this, the results will be considered in comparison to those on the other European and Near Eastern populations associated with the Mesolithic-Neolithic transitional period. Subsequently, the age- and sex-specific differences will be discussed, as well as the apparent contribution of non-local groups of people to the dietary choices of the local communities.

Finally, the children feeding practices in the Central Balkans during the process of Neolithisation will be discussed and interpreted, using the information on the duration of breastfeeding and the health patterns.

5.1.1.1. Human adult diet in the Central Balkans

5.1.1.1.1. Mesolithic

The published[29] isotopic values of $\delta^{13}C$ (carbon), $\delta^{15}N$ (nitrogen) and $\delta^{34}S$ (sulphur) (Grupe et al. 2003; Borić et al. 2004; Nehlich et al. 2010; Jovanović et al. submitted) suggest that the Mesolithic–Neolithic transition in the Danube Gorges was, from the dietary perspective, a slow and gradual process. The values of $\delta^{13}C$ and $\delta^{15}N$ remain very high from the Early Mesolithic to the Late Mesolithic, which indicates that aquatic resources played a major role in the diet over this period. The analysed individuals from the Late Mesolithic site of Schela Cladovei on the Romanian side of the Danube (Bonsall et al. 1997[30]) had similar $\delta^{13}C$ and $\delta^{15}N$ values to humans living on the right bank of the Danube Gorges. Although values of $\delta^{13}C$ and $\delta^{15}N$ remain very high in both the Early and the Late Mesolithic, there is an increase in $\delta^{13}C$ and a significant rise in $\delta^{34}S$ values from one period to the other. The Principal Component Analysis[31] (Fig. 5.1) clearly discriminates between Early and Late Mesolithic individuals based on their isotopic ratios.

There are several factors that could have caused the differences in $\delta^{34}S$ values, one of them being a possible change in the $\delta^{34}S$ values of the local environment. However, since the animal collagen data are diachronically consistent, it is unlikely that environmental factors are behind these differences. The observed increase in $\delta^{13}C$ and $\delta^{34}S$ between the Early Mesolithic and the Late Mesolithic are most likely related to the increased importance of anadromous and potamodromous fish in the local diet (Bonsall et al. 2015a, 2015b; Jovanović et al. submitted). Furthermore, as shown in a recent study by Jovanović and colleagues (submitted), stable isotope results for the humans and fish suggest that the values of $\delta^{13}C$ and $\delta^{34}S$ are actually related to the migrating behaviour of selected fish species. Namely, higher $\delta^{13}C$ and $\delta^{34}S$ values are connected with the anadromous and potamodromous species, while lower $\delta^{13}C$ and $\delta^{34}S$ values

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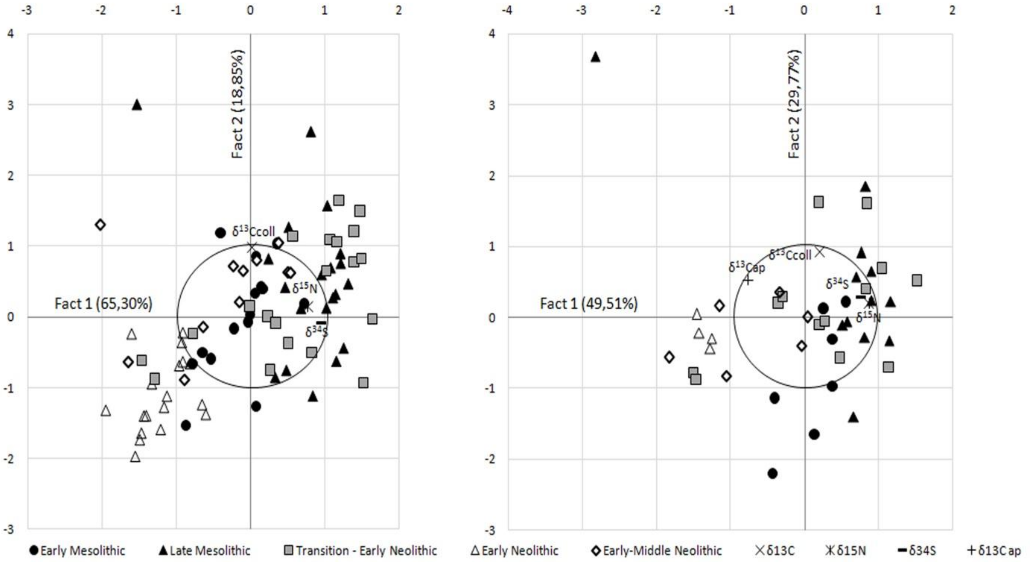
[29] Only individuals with adequate C/N and C/S ratios and sufficient C, N and S content were included in the discussion and the diagrams.

[30] The individuals are not included in the diagrams because the C/N ratios were not published at the time (in Bonsall et al., 1997).

[31] In a recent study, Jovanović and colleagues (submitted) performed the Principal Component Analysis (PCA) in order to summarize, analyze and present results on the dietary habits obtained using different stable isotope variables ($\delta^{13}C_{coll}$, $\delta^{15}N$, $\delta^{34}S$, $\delta^{13}C_{ap}$). The Principal Component Analysis used in the discussion was carried out by Camille de Becdelièvre.

reflect the use of local freshwater fish (Fig.5.2a and b). However, some cyprinid species produced variable data which correspond to both the stable isotope signal of freshwater fish and that of the anadromous/potamodromous fish.



	Correlation matrix	Stat. sig. (one-tailed)	Correlation matrix	Stat. sig. (one-tailed)	Correlation matrix	Stat. sig. (one-tailed)	Extracted communalities
	δ13Ccoll		δ15N		δ34S		
δ13Ccoll	1,000		,473	,000	,443	,000	,987
δ15N	,473	,000	1,000		,521	,000	,721
δ34S	,443	,000	,521	,000	1,000		,818

	Corr. matrix	Stat. Sig. (one-tailed)	Corr. matrix	Stat. sig. (one-tailed)	Corr. matrix	Stat. sig. (one-tailed)	Corr. matrix	Stat. sig. (one-tailed)	Extracted Com.
	δ13Ccoll		δ15N		δ34S		δ13Cap		
δ13C coll	1,000		,320	,019	,278	,037	,194	,109	,878
δ15N	,320	,019	1,000		,535	,000	-,497	,000	,785
δ34S	,278	,037	,535	,000	1,000		-,320	,020	,655
δ13C ap	,194	,109	-,497	,000	-,320	,020	1,000		,853

Fig. 5.1. Left: PCA 1a (n=84, humans), δ^{15}Ncoll, δ^{13}Ccoll, δ^{34}Scoll, with an oblimin rotation (components correlation: 0,501), associated correlation matrix and extracted communalities. KMO index: 0,681, Bartlett test significant ($p<0.05$ level);
Right: PCA 1b (n=42, humans), δ^{15}Ncoll, δ^{13}Ccoll, δ^{34}Scoll, δ^{13}Cap , with a varimax rotation (components correlation using an oblimin rotation: 0.057), associated correlation matrix and extracted communalities. KMO index: 0.522, Bartlett test significant ($p<0.05$ level) (from: Jovanović et al. submitted)

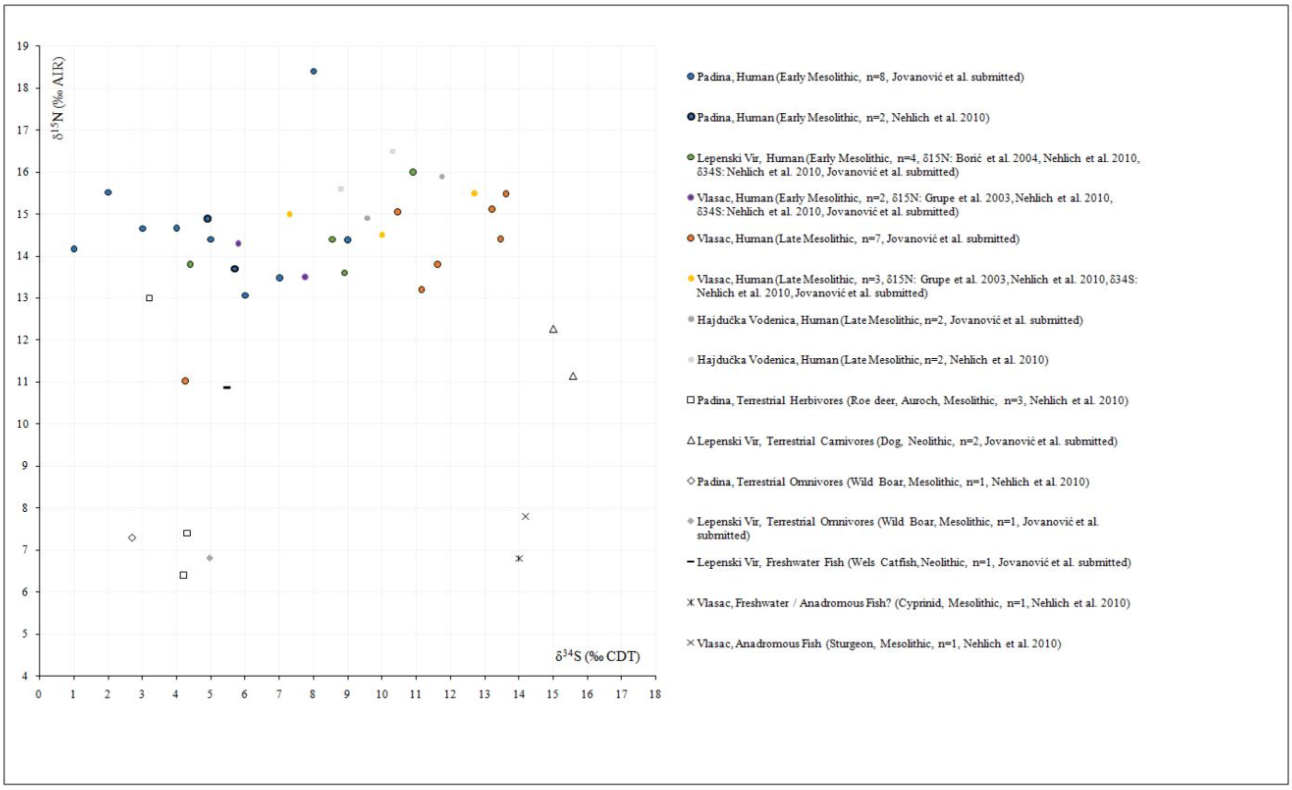


Fig. 5.2a and b. (5.2a - δ^{13}C and δ^{15}N values of human and animals from the Danube Gorges Mesolithic sites; 5.2b - δ^{34}S and δ^{15}N values of human and animals from the Danube Gorges Mesolithic sites)(adapted from Jovanović et al. submitted)

In the recent study, Živaljević and colleagues (submitted) performed aDNA analysis of fish samples which revealed the evidence of an anadromous cyprinid species (vyrezub (*Rutilus frisii*)) previously unrecorded in the area of the Danube Gorges. Nowadays, this species lives in the Black Sea, the Azov Sea and the Caspian Sea and often migrates to rivers in autumn and spring (to spawn) (Živaljević et al. submitted). This species could have contributed to the variability of isotopic signatures observed in the cyprinid bone samples; it could especially account for the difference in $\delta^{13}C$ and $\delta^{34}S$ values observed for cyprinids bone samples from the sites of Vlasac and Padina (Jovanović et al. submitted), indicating that the sampled individuals probably belonged to freshwater and anadromous cyprinids.

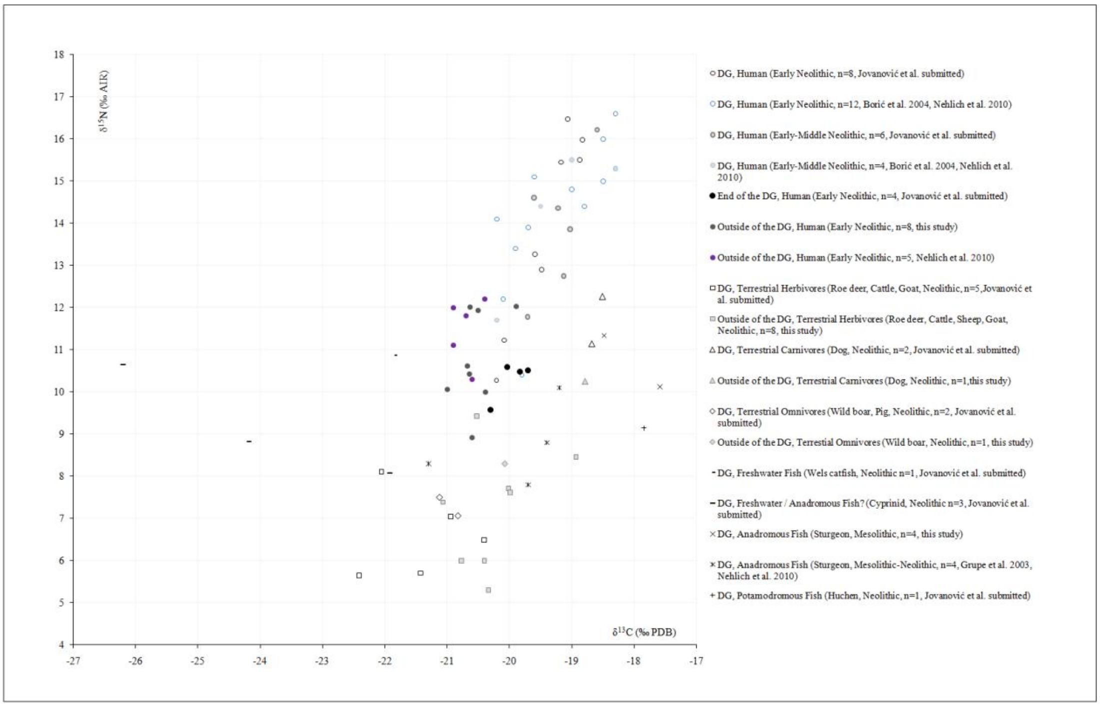
In contrast to the stable isotope data, the aDNA results suggest that, although the aquatic resources were important throughout the Mesolithic in the Gorges (as exemplified by high $\delta^{15}N$), the Late Mesolithic communities started to include more anadromous and potamodromous fish in their diet (visibled in the shift in $\delta^{34}S$ and $\delta^{13}C$ values). In a previous study (Nehlich and Borić 2015), it was proposed that the high $\delta^{15}N$ values of Early Mesolithic humans are connected to the consumption of suckling animals. However, this hypothesis can be rejected, since it does not take into account the parallel change observed in the $\delta^{13}C$ and $\delta^{34}S$ values (Jovanović et al. submitted).

The importance of fish consumption in the Late Mesolithic is not surprising given the fact that fishing played a crucial role in the formation of the Danube Gorges prehistoric settlements (Jovanović 1969; Srejović 1969, 1972; Bartosiewicz et al. 1995; Radovanović 1996, 1997; Bartosiewicz et al. 2001; Borić 2001; Borić and Dimitrijević 2007; Jovanović 2008; Dinu 2010; Živaljević 2012). The development of more permanent settlements during the Late Mesolithic could be therefore related to specific fishing method that allowed humans to catch different species of anadromous and potamodromous fish. A recent study on the seasonality of food resource exploitation by Dimitrijević and colleagues (in press) points at a significant degree of human sedentism in the Danube Gorges already in the Late Mesolithic.

However, the shifts in $\delta^{34}S$ and $\delta^{13}C$ values from the Early to the Late Mesolithic can also be correlated with the potential consumption of dogs (Jovanović et al. submitted). Dog was the only domesticated species at the time and the analysed dog bones show similar isotopic ratios to humans. Since the domestication brought a new relationship between dogs and humans, it is possible that dogs consumed human food leftovers or that humans ate dogs (Borić et al. 2004; Jovanović et al. submitted). The latter explanation is supported by the traces of butchery marks on dog bones (Clason 1980; Dimitrijević 2008) and by the fact that $\delta^{15}N$ values of dogs are very high. Another possibility is that dogs consumed remains of other dogs since traces of gnawing marks are found on some of the bones. It is probably a combination of the three practices that lie behind the similarity between the human and dog stable isotope values (Jovanović et al. submitted). Finally, the variation in $\delta^{34}S$ could be also explained by the fact that Late Mesolithic people included more fish (especially anadromous and potamodromous fish) and dogs in their diet (Jovanović et al. submitted). These results are important for the understanding of Late Mesolithic settlement pattern and may imply that targeting specific fish species played a major role or that it was a consequence of the increased sedentism (Borić et al. 2004; Jovanović et al. submitted).

The importance of fish consumption in the Mesolithic human diet is also suggested by a recent stable isotope study of carbon from apatite (Jovanović et al. submitted). This study produced lower $\delta^{13}C_{ap}$ ratios of Mesolithic humans in comparison to the Neolithic (Fig.5.1; Fig. 5.3a and b), indicating that these human groups consumed different (amounts of) energy-rich foods. Mesolithic humans probably had higher levels of fat in their diet, potentially coming from the consumption of anadromous or potamodromous fish (e.g. sturgeons, huchen, freshwater catfish) (Jovanović et al. submitted). The authors hypothesize that most species of the Salmonidae family have higher fat content (ca. 4-13%) then found in (cattle?) milk (ca. 4%)[32], which could explain lower $\delta^{13}C_{ap}$ ratios of Mesolithic humans when compared to the Neolithic people who consumed less fish and probably more milk and dairy. Further, it suggests that the Neolithic diet had a higher carbohydrate content, that is – less fat and protein from fish and more carbohydrates and protein from terrestrial resources (cereals and milk/meat from domestic animals) (Jovanović et al. submitted).

[32] based on the USDA database https://ndb.nal.usda.gov/ndb/



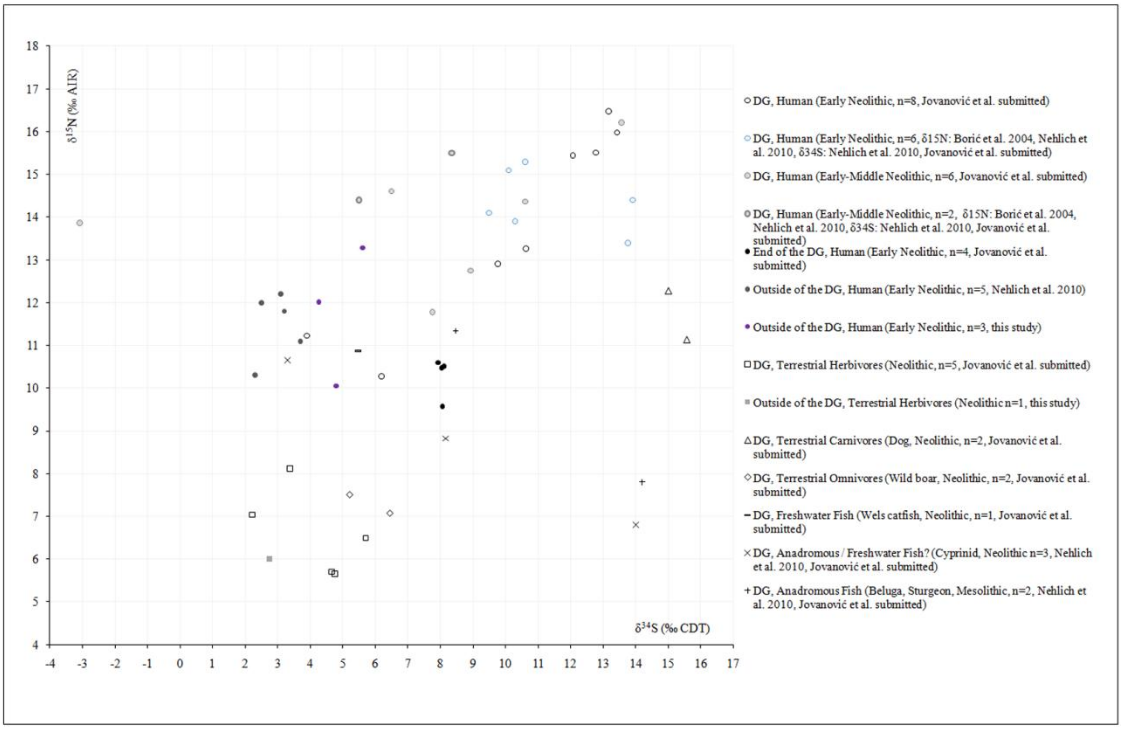


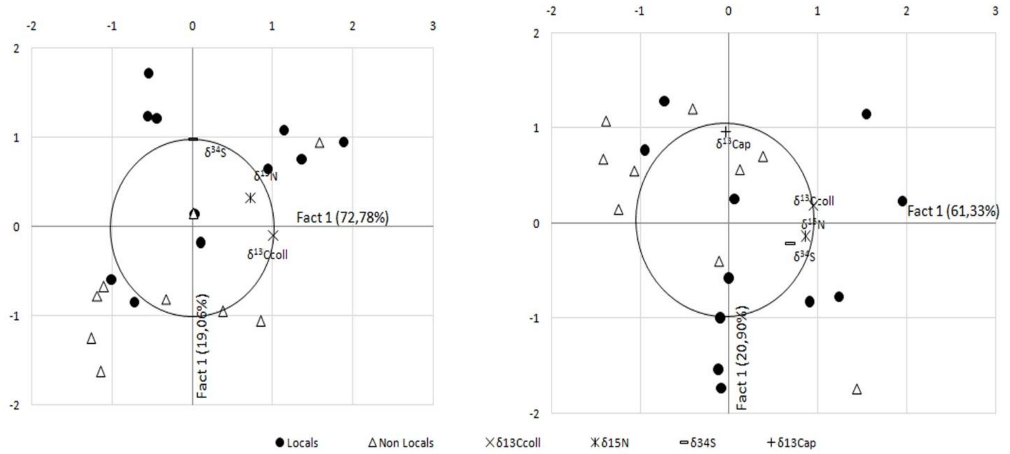
Fig.5.3a and b (5.3a - Comparison of δ^{13}C and δ^{15}N values of human and animals from the different Neolithic sites; 5.3b- Comparison of δ^{34} S and δ^{15} N values of human and animals from the different Neolithic sites) (adapted from Jovanović et al. submitted)

5.1.1.1.2. The Transitional- Early Neolithic and the Early/Middle Neolithic in the Danube Gorges

The published isotopic values show a high dependence on aquatic products throughout the Danube Gorges sequence (Bonsall et al. 1997; Grupe et al. 2003; Borić et al. 2004; de Becdelièvre et al. 2015a, 2015b, 2015c). However, an increase in the consumption of terrestrial resources has been noted at some sites from the Mesolithic-Neolithic Transition through to the Early/Middle Neolithic (Nehlich et al. 2010; Nehlich and Borić 2015; Jovanović et al. submitted). While the consumption of aquatic resources remained very important during the Transitional and Early/Middle Neolithic periods at the sites of Padina, Hajdučka Vodenica and Icoana, some individuals from the site of Lepenski Vir show a trend toward greater consumption of terrestrial food resources. This variability has also been noticed for some individuals from the site of Schela Cladovei (Bonsall et al. 1997).

During the Transition and through the Early/Middle Neolithic, strontium isotope ratios recorded on human enamel indicate the presence of non-local people at Lepenski Vir, possibly related to the arrival of farming communities in the Balkans (Borić and Price 2013). Noteworthy, some of these non-local individuals from Lepenski Vir (32a, 88, 122) have typical terrestrial isotopic values. The PCA for $\delta^{15}N$, $\delta^{13}C_{coll}$, $\delta^{34}S$ and $\delta^{13}C_{ap}$ illustrates the possible distinction between local and non-local individuals (Fig. 5.4). Most of the non-locals belong to the "terrestrial pool" and to the group which consumed food with different amount of fats and/or carbohydrates than the resources usually acquired by local individuals. A recent anthropological analysis (de Becdelièvre et al. 2015a) compared non-metric anatomical variations[33] and the cranial morphology with body proportions and long bones cross-section properties and it also revealed significant differences between the Neolithic local and non-local individuals, despite a certain biological continuity within the Danube Gorges prehistoric population throughout the sequence (de Becdelièvre et al. 2015a). It is, therefore, possible that some of these individuals migrated, taking with their own dietary habits with them, and contributed to the subtle changes in the local Early Neolithic

[33] Only variation with a genetic aetiology were selected for this study (de Becdelièvre et al. 2015a).



	Correlation matrix	Stat. sig. (one-tailed)	Correlation matrix	Stat. sig. (one-tailed)	Correlation matrix	Stat. sig. (one-tailed)	Extracted communalities
	δ13Ccoll		δ15N		δ34S		
δ13Ccoll	1,000		,714	,000	,437	,027	,925
δ15N	,714	,000	1,000		,613	,002	,854
δ34S	,437	,027	,613	,002	1,000		,977

	Corr. matrix	Stat. sig. (one-tailed)	Corr. matrix	Stat. sig. (one-tailed)	Corr. matrix	Stat. sig. (one-tailed)	Corr. matrix	Stat. sig. (one-tailed)	Extracted com.
	δ13Ccoll		δ15N		δ34S		δ13ap		
δ13Ccoll	1,000		,714	,000	,437	,027	-,192	,209	,880
δ15N	,714	,000	1,000		,613	,002	-,460	,021	,855
δ34S	,437	,027	,613	,002	1,000		-,422	,032	,652
δ13Cap	-,192	,209	-,460	,021	-,422	,032	1,000		,902

Fig. 5.4. Left: PCA 3a (n=20, humans), δ^{15}Ncoll, δ^{13}Ccoll, δ^{34}Scoll, with an oblimin rotation (components correlation: 0.490), associated correlation matrix and extracted communalities. KMO index: 0.633, Bartlett test significant ($p<0.05$ level).
Right: PCA 3b (n=20, humans), δ^{15}Ncoll, δ^{13}Ccoll, δ^{34}Scoll, δ^{13}Cap, with an oblimin rotation (components correlation: -0,342), associated correlation matrix and extracted communalities. KMO index: 0,659, Bartlett test significant ($p<0.05$ level)(from Jovanović et al. submitted)

daily subsistence (i.e. broadening of the dietary spectrum – Borić and Price 2013). During the Early/Middle Neolithic in the Danube Gorges, a few domesticated species, such as pig, goat and cattle appear in the archaeozoological record (Borić and Dimitrijević 2007). Their consumption, in addition to that of wild herbivores, may explain the slight shift toward more terrestrial-looking isotopic ratios recorded for this period.

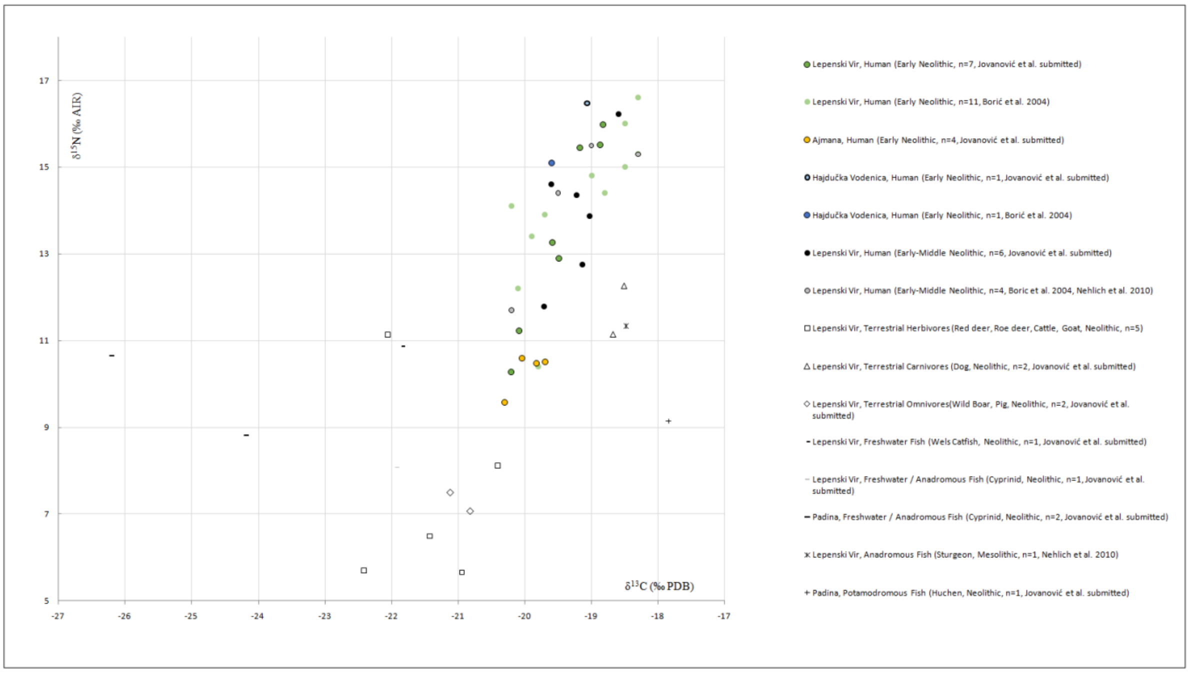
Concerning the apatite carbon isotope values, the higher and more varied $\delta^{13}C_{ap}$ ratios (from -15.7‰ to -12.4‰) of Neolithic individuals show (Fig.5.1; Fig. 5.3a and b) they had a diet that included less fat (from aquatic resources) and more carbohydrates (from cereal?) and protein (from terrestrial animals) (Jovanović et al. submitted).

Isotopic values of the individuals inhumated at the site of Ajmana also suggest a terrestrial diet with little input from aquatic resources (Fig. 5.5ab; Fig. 5.6). The occupation of this site, that yielded typical Starčevo features, started at the end of the 7[th] millennium BC (ca. 6200-6000 cal BC – Borić 2011), in contrast to most of the sites in the inner Gorges where occupied started long before this. It is worth mentioning that Ajmana is located downstream, in an environment more suitable for agricultural production than at the sites located upstream, inside the Gorges. Humans buried at Velesnica, the site that is located very close to Ajmana and in a similar environment, yielded isotope values similar those of the humans at Ajmana (Bonsall et al. 2015a,b).

It is therefore possible that, the Early Neolithic communities inhabiting sites located just downstream from the Gorges at the end of the 7th millennium BC represented, or directly descended from, the first farmers of the region which maintained contacts with the communities of the Gorges, and that the contacts had impact on the socio-cultural and economic context of the Transition/Early Neolithic Period within the Gorges. Other newly established Early Neolithic settlements downstream from the Gorges, such as Ušće Kameničkog Potoka and Knjepište as well as the Neolithic occupation at Kula and Velesnica, were probably part of this regional Early Neolithic settlement network. These communities, which may have originated from the Neolithic groups of the Wallachian Plain, must have had contacts with the contemporary hunter/fisher/gatherer communities living within the Gorges (Borić 2011).

5.1.1.1.3. The variability in Neolithic subsistence – a comparison between the Danube Gorges and the sites in the western part of the central Balkans

For the central Balkan Early Neolithic communities documented in the hilly region and river valleys to the west from the Danube Gorges, the stable isotope data indicate different dietary patterns. Instead of a major reliance on aquatic resources characteristic of the Danube Gorges, Neolithic communities outside the Gorges had predominantly terrestrial diet with only little input of aquatic food (Fig.5.6; Fig. 5.7ab; Fig.5.8; Fig.5.9). Interestingly, the stable isotopes values of the latter also exhibit certain variability. The analysed individuals from the sites of Vinča, Grivac and Perlez-Batka yielded higher $\delta^{15}N$ and $\delta^{34}S$ and lower $\delta^{13}C$ values compared to the other sites in this region, suggesting that they had a higher intake of aquatic protein.



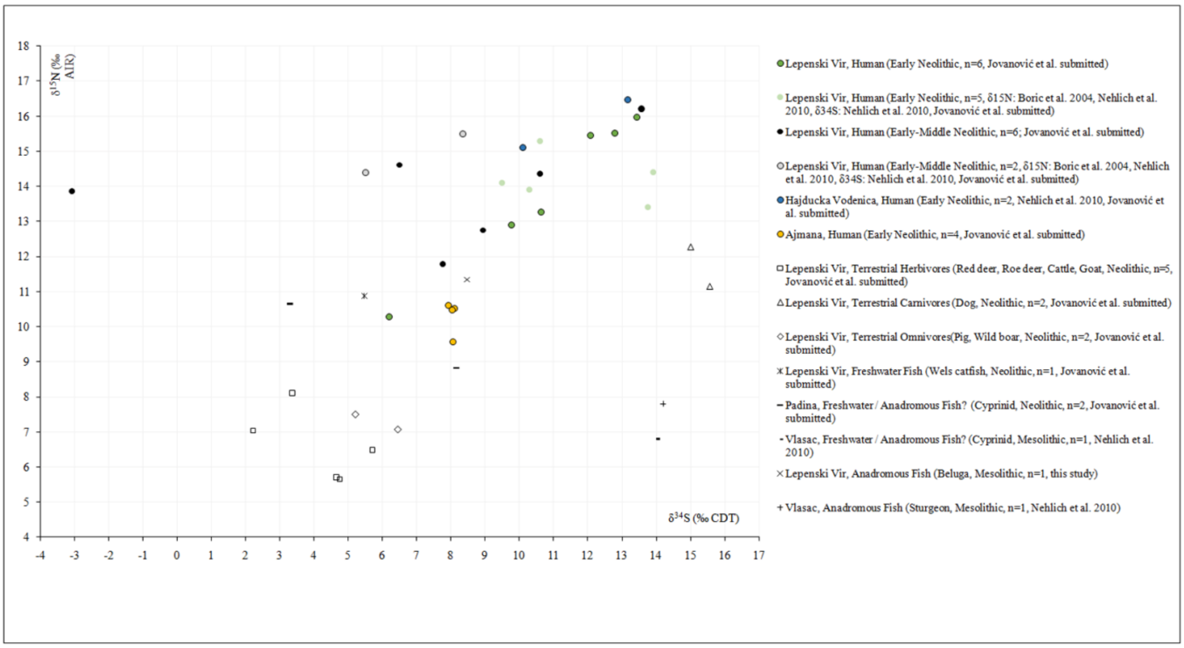
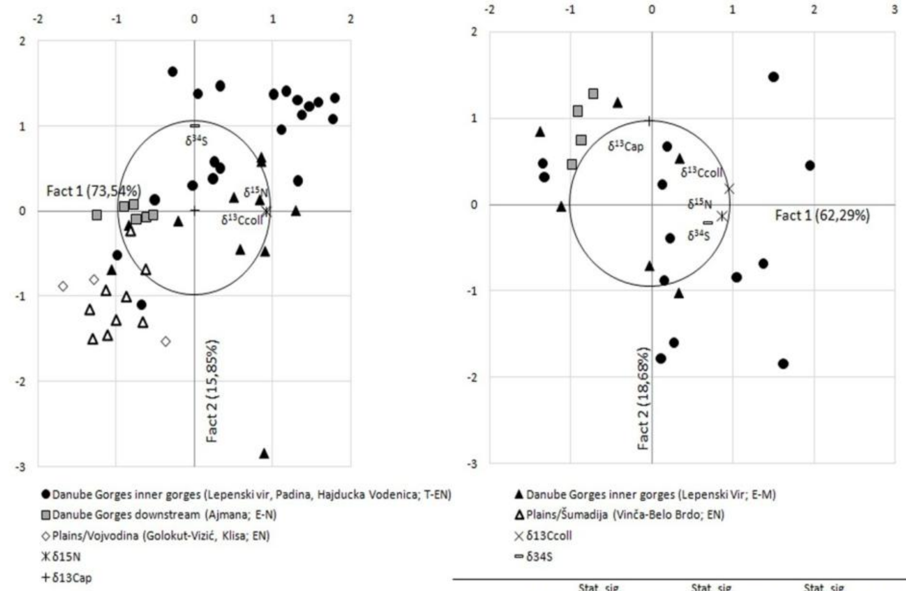


Fig. 5.5ab (5.5a. $\delta^{13}C$ and $\delta^{15}N$ values of human and animals from the Danube Gorges Neolithic sites; 5.5b. $\delta^{34}S$ and $\delta^{15}N$ values of human and animals from the Danube Gorges Neolithic sites) (adapted from Jovanović et al. submitted)

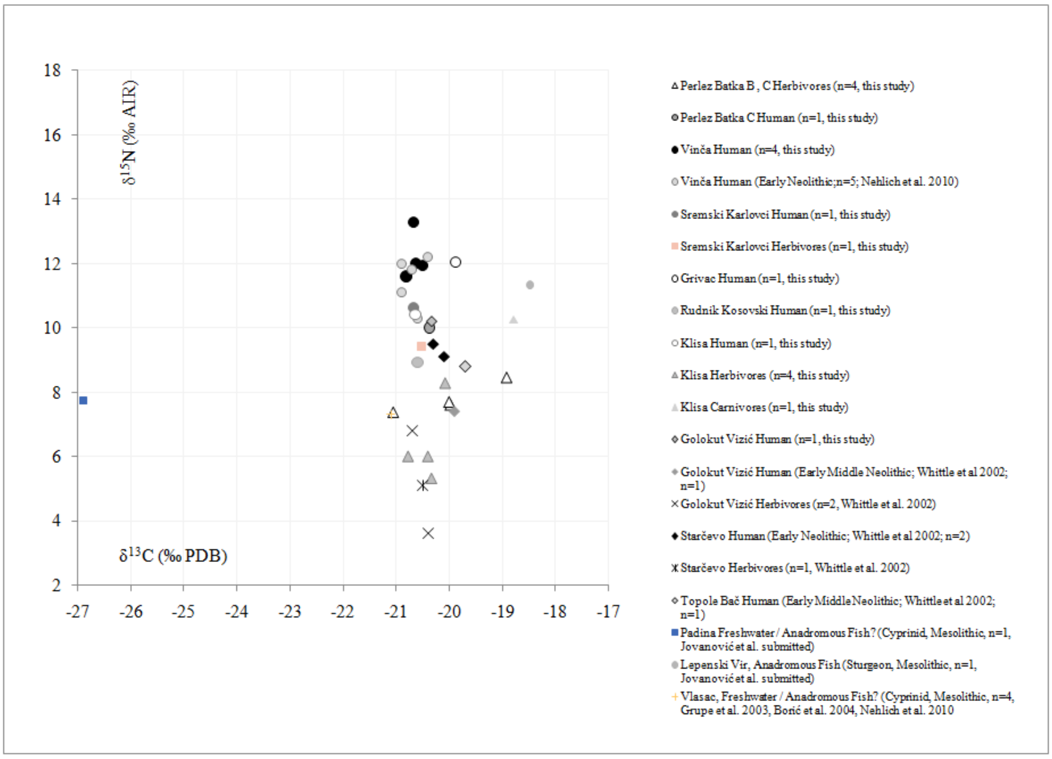


	Correlation matrix	Stat. sig. (one-tailed)	Correlation matrix	Stat. sig. (one-tailed)	Correlation matrix	Stat. sig. (one-tailed)	Extracted communalities
	δ13Ccoll		δ15N		δ34S		
δ13C	1,000		,681	,000	,564	,000	,839
δ15N	,681	,000	1,000		,561	,000	,842
δ34S	,564	,000	,561	,000	1,000		1,000

	Corr. matrix	Stat. sig. (one-tailed)	Corr. matrix	Stat. sig. (one-tailed)	Corr. matrix	Stat. sig. (one-tailed)	Corr. matrix	Stat. sig. (one-tailed)	Extracted com.
	δ13Ccoll		δ15N		δ34S		δ13Cap		
δ13Ccoll	1,000		,708	,000	,462	,013	-,284	,095	,806
δ15N	,708	,000	1,000		,633	,001	-,459	,014	,845
δ34S	,462	,013	,633	,001	1,000		-,378	,038	,629
δ13Cap	-,284	,095	-,459	,014	-,378	,038	1,000		,958

Fig. 5.6. Left: PCA 2a (n=49, humans), δ^{15}Ncoll, δ^{13}Ccoll, δ^{34}Scoll with an oblimin rotation (components correlation: 0.613), associated correlation matrix and extracted communalities. KMO index: 0,704, Bartlett test significant (p<0.05 level); Right: PCA 2b (n=23, humans), δ^{15}Ncoll, δ^{13}Ccoll, δ^{34}Scoll, δ^{13}Cap, with an oblimin rotation (components correlation: -0373), associated correlation matrix and extracted communalities. KMO index: 0,706 , Bartlett test significant (p<0.05 level) (from Jovanović et al. submitted)

However,it is worth mentioning that both the sites in the Danube Gorges and those in the western central Balkans are located in the proximity of rivers. This is, for instance, well-exemplified by the highest δ^{34}S values recorded at Vinča which is located in the immediate vicinity of the Danube.



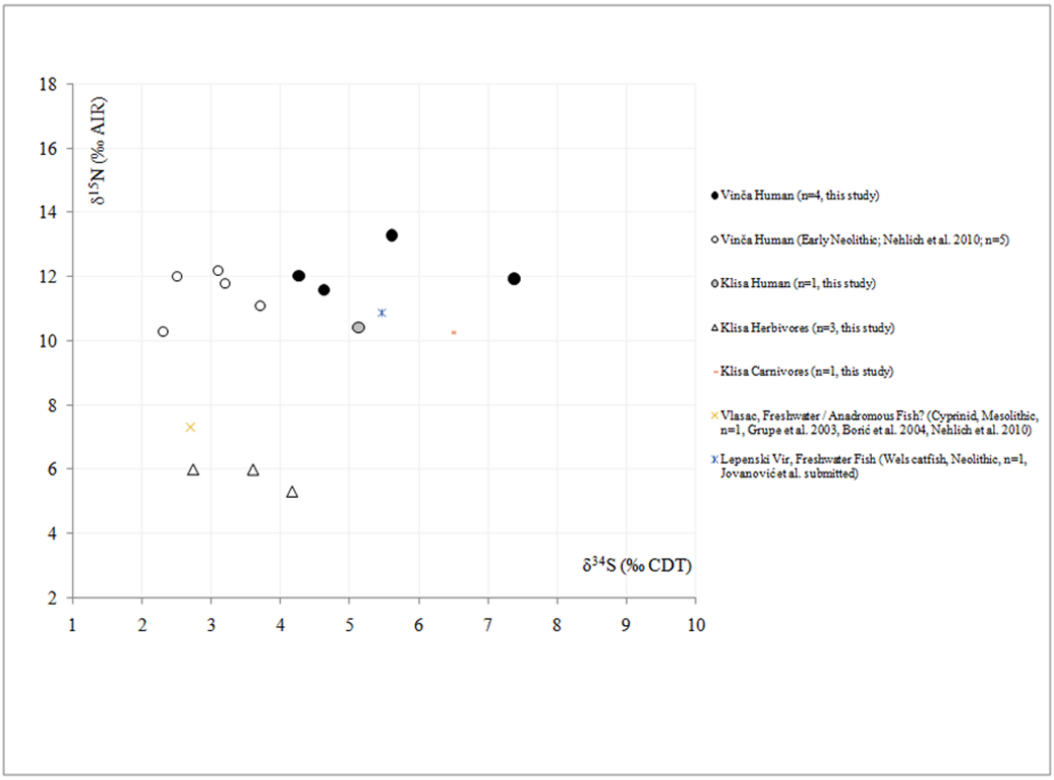


Fig. 5.7ab (5.7a.- $\delta^{13}C$ and $\delta^{15}N$ values of human and animals from the areas outside the Danube Gorges, Neolithic; 5.7b - $\delta^{34}S$ and $\delta^{15}N$ values of human and animals from the areas outside the Danube Gorges, Neolithic) (adapted from Jovanović et al. submitted)

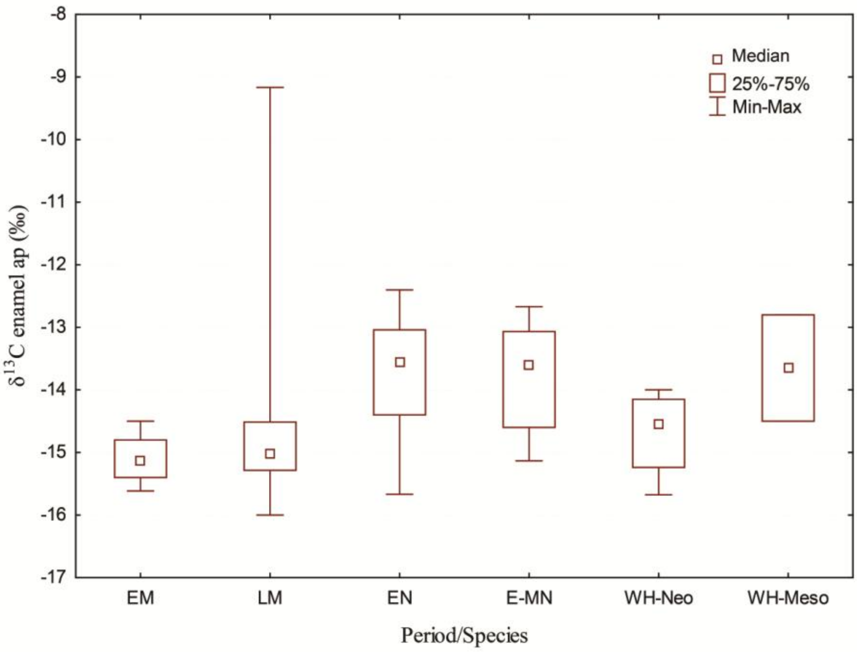


Fig. 5.8. Box plot of the isotopic signatures of human collagen according to chronological distribution (Abbreviations: **EM** Early Mesolithic; **LM** Late Mesolithic; **EN** Early Neolithic; **EMN** Early Middle Neolithic; **WH-Neo** Neolithic Wild Herbivore; **WH-Meso** Mesolithic Wild Herbivore) (from Jovanović et al. submitted)

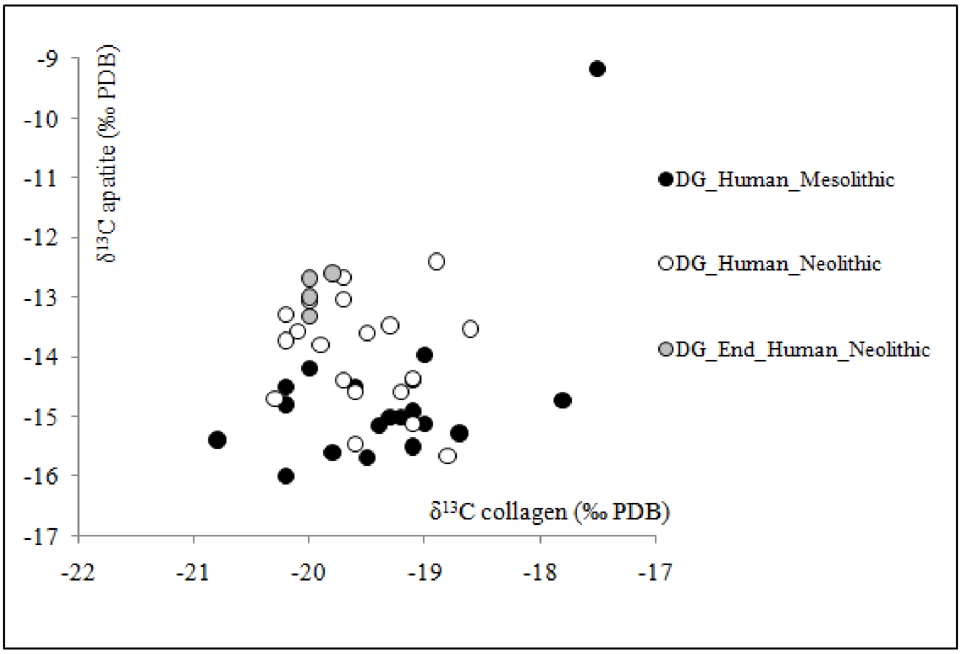


Fig. 5.9. $\delta^{13}C_{coll}$ and $\delta^{13}C_{ap}$ human values from Mesolithic and Neolithic sites (from Jovanović et al. submitted)

5.1.1.1.4. Neolithisation and the human dietary patterns: comparison of the Balkan and the other Early Neolithic communities in Europe

Multiple results show that the Mesolithic-Neolithic transition was not a linear shift from foraging to food production but, rather, that it encompassed significant regional differences related to environmental conditions, cultural traditions, and/or the dietary habits of the Neolithic newcomers. Interestingly, although Starčevo communities outside the Danube Gorges had access to rivers and/or lakes, fish does not seem to have played an important role in the diet. A comparable situation was observed in the Fertile Crescent area. For instance, stable isotope analysis of individuals from Çatalhöyük in central Anatolia suggests that their diet was mostly based on the combination of plant and animal proteins (Richards et al. 2003). Animal protein was derived mainly from goat and sheep feeding on C_3 plants. In southeast Anatolia, occupants of the site of Nevali Çori had a mostly plant based diet based on protein-rich pulses (Lösch et al. 2006). In northwest Anatolia, at the site of Aktopraklik, the isotope values indicate a diet based on C_3 terrestrial resources. Although the site sits close to freshwater and marine environments, the Neolithic inhabitants of did not exploit these resources (Budd et al. 2013). Further to the west, in Greece, Neolithic human diets relied primarily on terrestrial sources, with only a minor use of aquatic resources at coastal sites (Papathanasiou 2003). A similar situation is observed for other Neolithic communities in the Mediterranean (e.g. in Croatia, Italy and France) which were colonized by Neolithic farmers from the Aegean (ca. 5500-3400 BC). The $\delta^{13}C$ and $\delta^{15}N$ stable isotope data indicate that, despite the relatively close proximity to the sea, there is as yet no evidence of significant consumption of marine resources (Giorgi et al. 2005; Le Bras-Goude et al. 2006; Goude 2007; Le Bras-Goude et al. 2010; Lightfoot et al. 2011; Lelli et al. 2012; Goude et al. 2012-2013; Tafuri et al. 2014). Instead, the dietary pattern appears to have been quite homogeneous, with subsistence strategies strongly focused on herding animals for meat and milk. Inland, the stable isotope data from the Early Neolithic of Slovenia (4400-3300 BC) also indicate a diet heavily reliant on terrestrial resources (Ogrinc and Budja 2005). To the north of the Balkans, in the Pannonian Plain, Neolithic diet was mainly composed of terrestrial plants and animals (Whittle et al. 2002; Pearson and Hedges 2007; Giblin 2011). In central Europe, Early

Neolithic LBK groups display a great dietary diversity. Although several studies from this area show evidence of diets chiefly based on terrestrial resources, with only minor input of freshwater fish (Durrwachter et al. 2006; Nehlich et al. 2009), the data from some of the sites, such as Swifterbant (4300-4000 cal BC) and Schipluiden (3600-3400 cal BC), indicate a strong dependence on aquatic resources (Smits et al. 2010). Smits and colleagues (2010) saw similarities in the isotopic values between Schipluiden and the Danube Gorges sites of Lepenski Vir and Vlasac, and they emphasize that at all three sites sturgeon remains are present.

Drawing upon the data presented above, it appears that the Early Neolithic inhabitants of the Balkans had a mixed terrestrial and aquatic diet, and generally relied on locally available wild resources. This pattern reflects a common practice apparently shared by Early Neolithic communities living both in and outside the Danube Gorges that had direct access to rivers/lakes. This picture fits well with the one proposed for the Neolithic communities in Central Europe – they seem to have gradually adopted and adapted local Mesolithic subsistence practices, such as specialised hunting and fishing, along with practicing crop cultivation and animal herding. On the other hand, the first farmers that occupied the Mediterranean coasts directed their food economy almost exclusively towards agro-pastoralism. The debate on the apparent lack of exploitation of marine resources in the Neolithic in the Mediterranean region is ongoing. Indeed, some new/ongoing research shows that marine protein could, although in a much smaller degree than terrestrial protein, have contributed to the protein content of the diet of several Early Neolithic individuals from southeast France (Goude et al. forthcoming; Pruvost et al. submitted). Further research focusing on, for example, amino acids in collagen or proteomes in dental calculus (e.g. Naito et al. 2013) may help explain the observed trend (Richards and Schulting 2003; Fa 2008).

In sum, although cultural factors were important for dietary patterns of some Early Neolithic agropastoralist societies, it seems that the environment and the possibilities for its exploitations were of crucial importance when making dietary choices. For instance, although some of the Early Neolithic sites in southeast Europe and the Near East were located in the proximity of rivers, these rivers were (much) smaller compared to the Danube. Thus, although these communities had (direct) access to rivers, the size of the river and its abundance in natural resources constituted a major factor in the composition of diet of the earliest Neolithic communities.

5.1.1.2. Age-related differences in the stable isotope values of the Neolithic adult individuals from the central Balkans

When the isotopic ratios of $\delta^{13}C$ and $\delta^{15}N$ are cross-compared with the age categories, no significant differences can be observed in the diet between young, middle-aged and older adults in the Neolithic of the Danube Gorges (Fig. 5.10). It can be only noted that the middle-aged adults display greater isotopic variability. The variation is also visible at the sites outside the Danube Gorges, but here it is connected to differences in sex, not age. Young adults appear to have had more protein-based diet, but the results vary between the sites. The mentioned young adults come from the site of Vinča where the consumption of aquatic resources was much higher than at other Early Neolithic outside the Gorges.

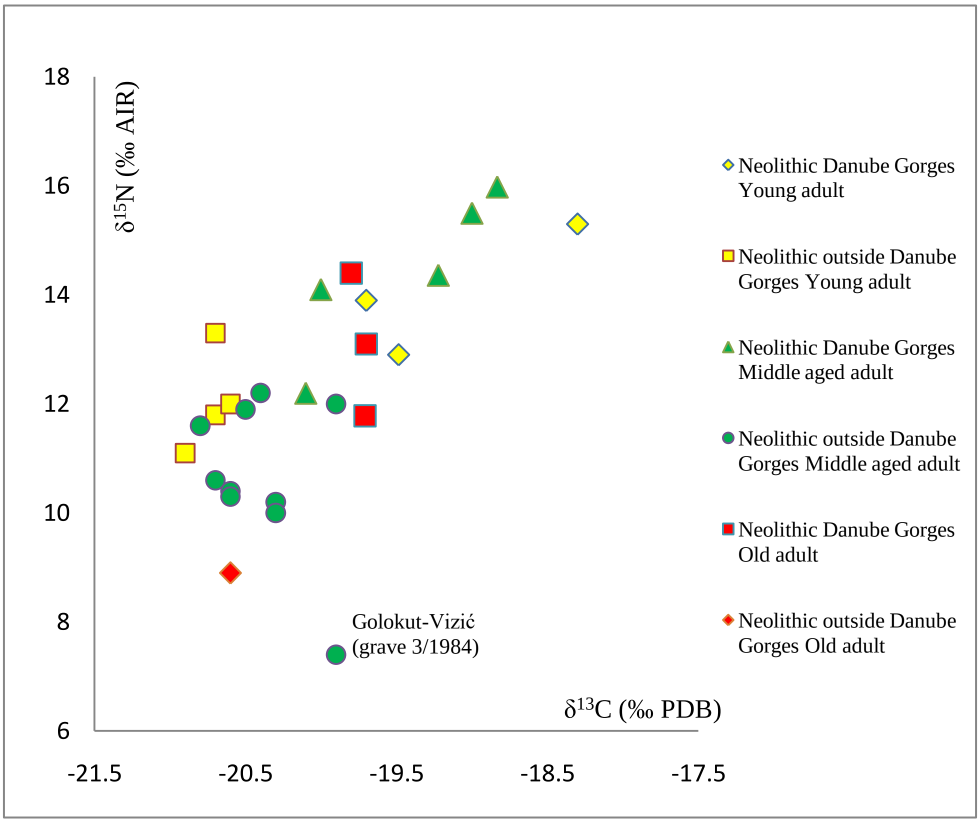


Fig. 5.10. $\delta^{13}C$ and $\delta^{15}N$ values of different age - categories[34]

[34]Stable isotope data for the Danube Gorges sites were taken from Jovanović et al. submitted.

Middle-aged woman from the site of Golokut-Vizić (3/1984) exhibits very low $\delta^{15}N$ value, signalling that her animal protein intake was very low, which could have affected her health status. During her childhood, the women experiences two stressful events between 3 and 5 years of age, as evidenced by linear enamel hypoplasia. She survived this childhood nutritional stress, but she continued to suffer from health issues in her adulthood. This is confirmed by the presence of another non-specific stress marker, cribra orbitalia and its partially active lesions at the time of death. In addition, her mainly terrestrial diet with low animal protein intake and the presence of starch grains in the calculus on her teeth point at a high consumption of carbohydrates, which probably also caused the development of dental caries.

Remains of children with the lowest $\delta^{15}N$ values recorded outside the Danube Gorges were discovered at the same site. It seems that the occupants of the site Golokut-Vizić preferred carbohydrate-rich foods (such as cereals) which had negative effects to their health since, as has been commonly shown, this type of diet with low fish and meat intake could lead to vitamins and minerals deficiency (Cordain 1999; Cordain et al. 2005).

5.1.1.3. Sex-specific differences

There were no sex-specific differences between males and females in terms of the diet in either of the Neolithic human groups studied here (Fig. 5.11). A similar observation was made for the LBK populations across Europe (Dürrwächter et al. 2006; Bickle et al. 2011; Oelze et al. 2011) and in the Mesolithic-Neolithic Transition in Ukraine (Lillie and Richards 2000). On the other hand, some studies (Pearson 2013; Whittle and Bickle 2013) detected differences between the diet of males and females during the Neolithic that were interpreted as indicating larger animal protein intake in males.

The only trend discernible for the central Balkans is that the females show greater isotopic variability then the males. This phenomenon is also seen in different phases of the Neolithic in France (e.g. Le Bras-Goude et al. 2006; Goude 20; Rey et al. 2016). It suggests that females either had 1) wider food choice; labour division between males (e.g. hunting, fishing) and females (e.g. gathering plants) could have meant a differential access to particular foods, or 2) that some of them arrived from different environment(s) with different dietary habits, as was the case with few non-local females identified in the Danube Gorges.

Concerning the first hypothesis, the study by Stefanović and Porčić (2009) confirmed the existence of sex-based division of labour which could have affected dietary choices/food availability of males and females. For example, it is possible that females fished and collected plants, whereas males fished and hunted. On the other hand, and in relation to the second hypothesis, as Bonsall and colleagues (1997) already suggested, women would more likely have left a group and joined another one (for example, because of marriage) then would males. And, since collagen in adults has a slow turnover and reflects last ca. 15 years of diet, the recorded isotopic signal of non-local individuals most likely reflects the diet characteristic of their previous community/location. Thus, the greater variability in females' isotopic ratios could be a result of both of the proposed models.

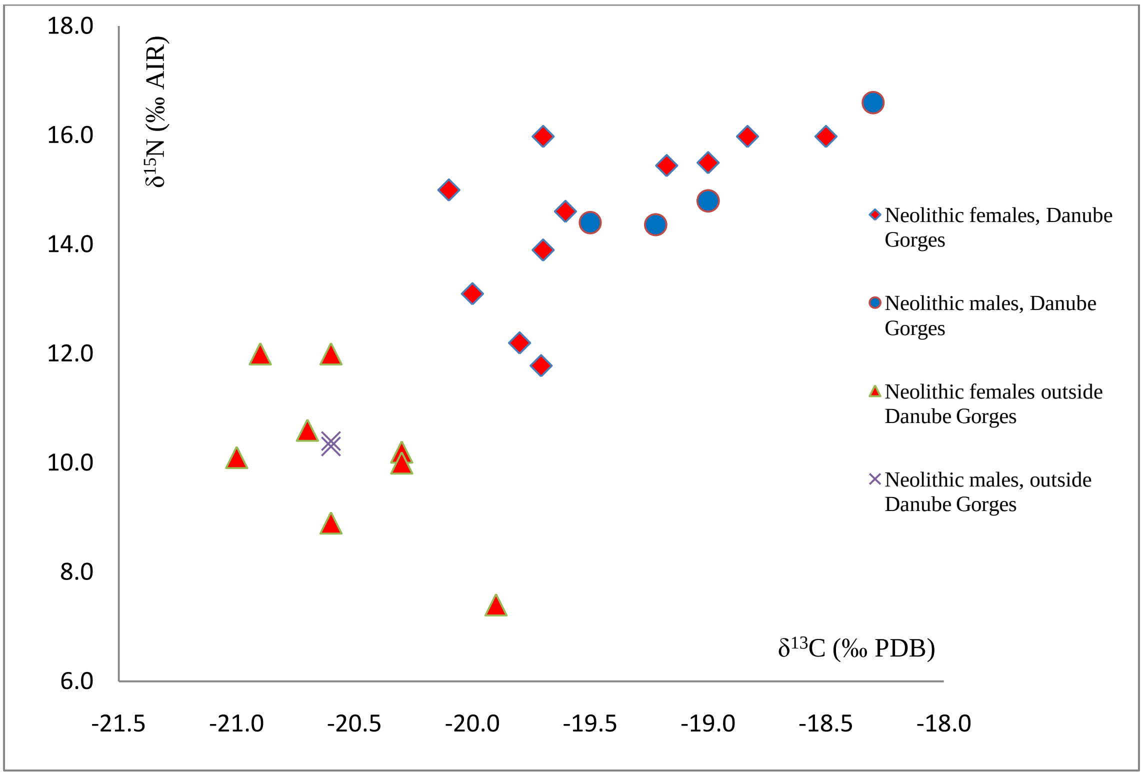


Fig. 5.11. $\delta^{13}C$ and $\delta^{15}N$ values of females and males in the studied regions[35]

[35]Stable isotope data for the Danube Gorges sites were taken from Jovanović et al. submitted.

5.1.1.4. Comparison of the stable isotope values of the local and non-local human groups in the Danube Gorges

The results of the analysis of strontium stable isotope ratios ($^{87}Sr/^{86}Sr$) conducted on 153 mostly adult individuals document an increasing number of non-local people among the local population starting from the Transitional period (Borić and Price 2013). When $\delta^{13}C$ and $\delta^{15}N$ values of local and non-local humans are compared, some specific observations can be made (Fig. 5.12).

From the Early Mesolithic period the only non-local individual is a female from Padina (Grave 30) which has a more terrestrial dietary pattern then the local people. It is possible that she came to the Danube Gorges from a different environment. Beside this, her body shows traces of a healed cribra orbitalia and porotic hyperostosis lesions as well as presence of linear enamel hypoplasia. This shows that she survived two stress episodes when she was around 3 years old. Non-locals of the Late Mesolithic period have the same diet like the Late Mesolithic local human groups.

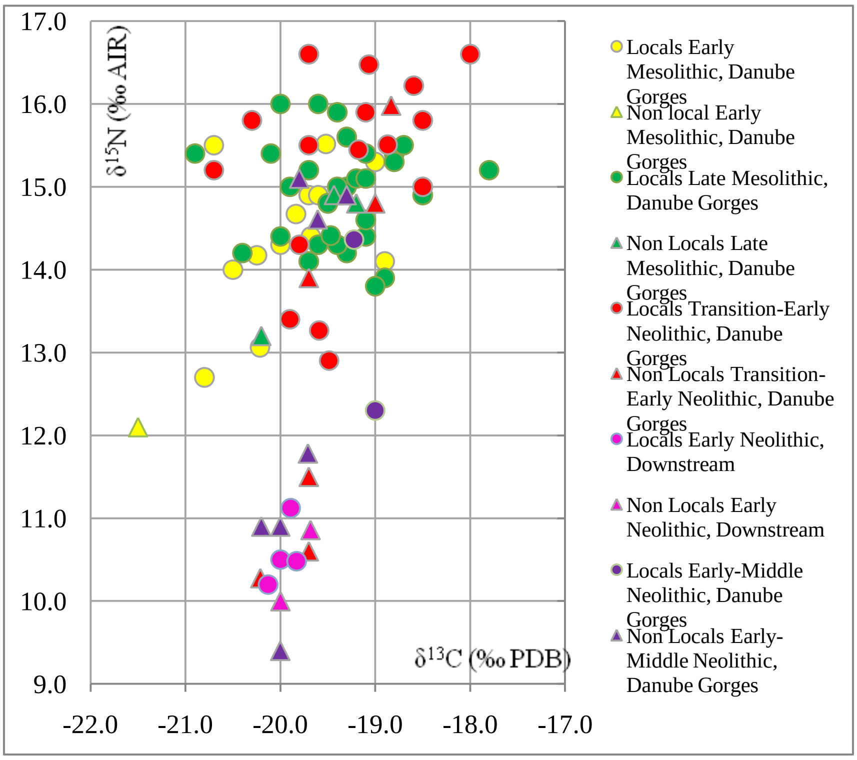


Fig.5.12. $\delta^{13}C$ and $\delta^{15}N$ values of local and non-local individuals from the Danube Gorges (source: de Becdelièvre, in prep.)

In the following, Transitional/Early Neolithic phase, the number of non-local inhabitants increased. While some of them (Lepenski Vir 7/Ia, 26, 122) clearly show terrestrial dietary pattern with a little input from freshwater resources, the others (Lepenski Vir 13, 27a, 54e) have high input of proteins from aquatic products. Furthermore, when isotopic data are cross-compared with the health-related and other dietary parameters, these two groups of non-local people also display different health conditions. The group belonging to "terrestrial consumer" pool has more pathological conditions: LV 7/Ia (healed porotic hyperostosis); LV 26 (active porotic hyperostosis, linear enamel hypoplasia, presence of dental caries), LV 122 (active cribra orbitalia, pit hypoplasia). On the contrary, the non-local “aquatic pool” consumers have fewer pathology issues (LV 54e has healed porotic hyperostosis, while LV 13 has a line of linear enamel hypoplasia). The degree of dental calculus is higher in the aquatic pool consumers (probably due to more animal protein in the diet), while the terrestrial pool consumers have a lower degree of dental calculus. Also, in the dental calculus of the male from Grave 7/Ia a starch grain of a species from Poaceae family has been detected that could belong to Triticeae tribe (to which domestic cereals belong).

At the same time downstream, at the site of Ajmana, non-local individuals also appeared. However, their diet was not different to the diet of the local Ajmana population – the one composed of terrestrial and a mixture of aquatic resources. There are no differences in the health status either. The Early/Middle Neolithic was a period when most of the individuals of non-local origin appeared. While the locals (Lepenski Vir 73, 83a) preferred diet rich in aquatic products, non-locals exhibit variability in their food choice, as indicated by their isotopic ratios. Two groups have been identified among them: one with mainly terrestrial diet (Lepenski Vir 8, 17, 32a, 88) and the other that favoured freshwater proteins (Lepenski Vir 7/IIb, 20, 66). The locals and non-locals identified as aquatic pool consumers were generally of good health (they mostly have traces of healed porotic hyperostosis or cribra orbitalia, whilst two of them (Lepenski Vir 20, 83a) lost some teeth before death). In contrast, the non-locals with terrestrial diet seem to have had more health issues. Besides mixed and healed porotic hyperostosis, two of them (Lepenski Vir 32a and 88) (Fig.5.13) had dental caries, while one (Lepenski Vir 8) had precarious lesion. They all have lower degree of calculus, which is probably connected to more carbohydrates in the diet and less proteins.

It is possible that some of the non-locals from appearing from the Transitional to the Early/Middle Neolithic brought dietary habits from the place of their origin, whereas other migrants possibly adopted the local diet. Noteworthy, they could also have had influence on the Neolithic changes in the daily subsistence strategies (i.e. broadening of the dietary spectrum).

Fig. 5.13. Presence of caries detected on the lower molar, Lepenski Vir , grave 88

5.1.1.5. Children-feeding practices in the central Balkans

5.1.1.5.1. Weaning patterns

The information on the length of lactation period in the regions outside the Danube Gorges is limited, since for several of the analysed children the $\delta^{13}C$ and $\delta^{15}N$ isotopic ratios were non-valid and therefore could not be used in this study.

The multi-sampling strategy was successful only in case of two Early Neolithic children: from Klisa (grave 6) and from Obrež-Baštine (grave 1) (Fig. 5.14). The child from Klisa, 4-5 years old, exhibited high $\delta^{15}N$ values of tooth crowns (both m1 and M1) indicating that it was possibly breastfed until around 2 years of age. After this time, the bone isotope values show a decrease in δ^{15}N, which implies that weaning food, was introduced. Because of the faster remodelling of bones in children which, in the case of Klisa child (4-5 years old), is approximately 56% per year (Valentin 2003), this signal actually reflects average diet between the age of 2.5-4.5 years[36]. Subsequently, δ^{15}N value increased again, just prior to death, possibly as a consequence of disease or a nutritional stress. The presence of linear enamel hypoplasia confirms this child experienced some stressful event, which could have contributed to its death. δ^{13}C, δ^{15}N and δ^{34}S values indicate that its weaning food was mostly based on terrestrial resources.

For the child (4-6 years old) from the site of Obrež-Baštine isotope signature of the crown of deciduous first molar shows that, during the first six month of life the child was breastfed. The later signal (the bone value), which reflects the diet from approximately between 3-5 years of age (due to the rapid bone remodelling) shows a decrease in δ^{15}N, suggesting that the child was not breastfed at the age of 3.

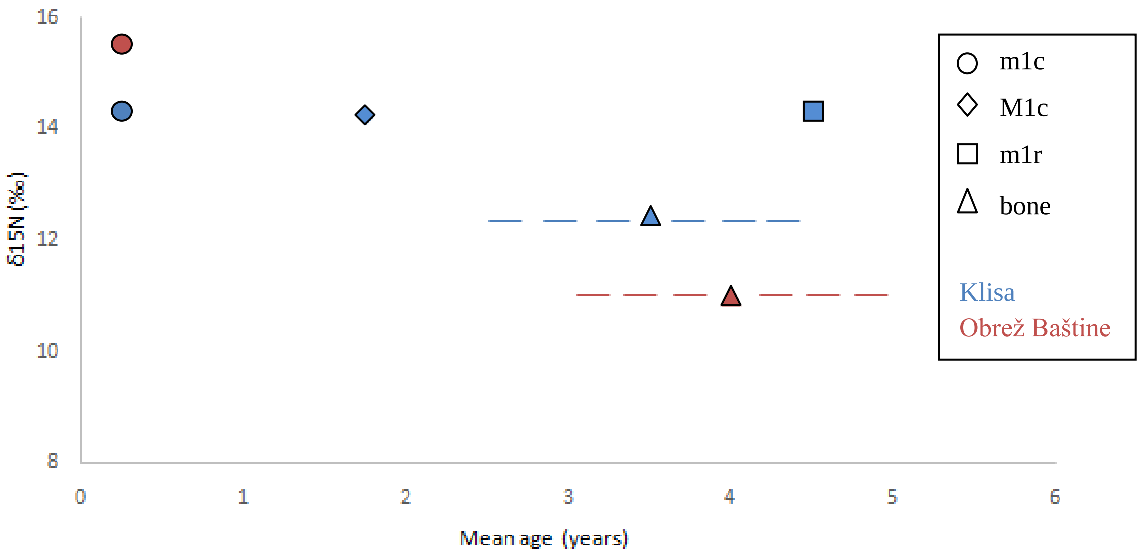


Fig. 5.14. δ^{15}N value of bone-tooth collagen for Klisa and Obrež Baštine children

[36] In adults, due to the slow process of remodelling, the recorded isotopic signal reflects the diet from the last ca. 10 years of life, whilst in children, due to the fast turnover velocity (remodelling of the bone), the recorded isotopic signal of the bone reflects the diet some time before death. The isotope values for the time before death are not the same for every child because the turnover velocity is not the same at every age. The rates of turnover velocity related to the age of child are given in Valentin 2003.

Since the dietary signal for the period between 6 month and 3 years of age is lacking, it is hard to estimate until what age this child was exclusively breastfed. Thus one can only conclude that, at the age of 3 this child was not exclusively breastfed. The isotopic bone values of $\delta^{13}C$ and $\delta^{15}N$ reflect a generally terrestrial dietary pattern, while $\delta^{34}S$ suggests little input of aquatic food resources. The presence of cribra orbitalia of low intensity confirms that this child had some kind of nutritional misbalance. However, at the time of death the lesions were healed, and the diet slightly enriched in aquatic resources could have had positive effects on it.

5.1.1.5.2. The length of breastfeeding in the Danube Gorges

In a recent study (de Becdelièvre et al. 2015b; de Becdelièvre in preparation; Јовановић et al. 2015), the age at which weaning started was assessed for 25 children from the Danube Gorges. The study showed important differences in feeding practices between the Mesolithic children (Fig 5.15), the Neolithic children buried inside the Gorges (Fig 5.16) and the Early-Neolithic children discovered at the western entrance to the Gorges (Fig 5.17). The $\delta^{15}N$ and $\delta^{13}C$ isotopic ratios indicate that, during the Mesolithic, children breastfed over a longer period whilst in the Neolithic, the length of breastfeeding was shorter (de Becdelièvre et al. 2015b; de Becdelièvre in preparation; Јовановић et al. 2015). The Mesolithic isotope data (high $\delta^{15}N$ and $\delta^{34}S$ and low $\delta^{13}C$) suggest that the children had an additional food source and/or that mothers' diet was strongly based on high-in-protein aquatic resources. On the other hand, the Neolithic values (low $\delta^{15}N$ and $\delta^{34}S$ as well as high $\delta^{13}C$) point at a more terrestrial dietary pattern, especially at the site of Ajmana. In addition, the presence of starch grains in the dental calculus of three children from Ajmana indicates a terrestrial diet.

Noteworthy is the fact that, among all of the Danube Gorges children, the presence of caries was only noticed in four children from the Neolithic site of Ajmana. Weaning food that may have been made from ground cereals grain and milk, with its sticky texture, must have contributed to the development of caries.

While the Ajmana children diet is more consistent with a terrestrial pattern, the children at Lepenski Vir had a mixed aquatic and terrestrial diet (de Becdelièvre et al. 2015b; de Becdelièvre in preparation; Јовановић et al. 2015). Their length of breastfeeding was also longer then in case of children at Ajmana but, on the other hand, shorter than the Mesolithic breastfeeding period.

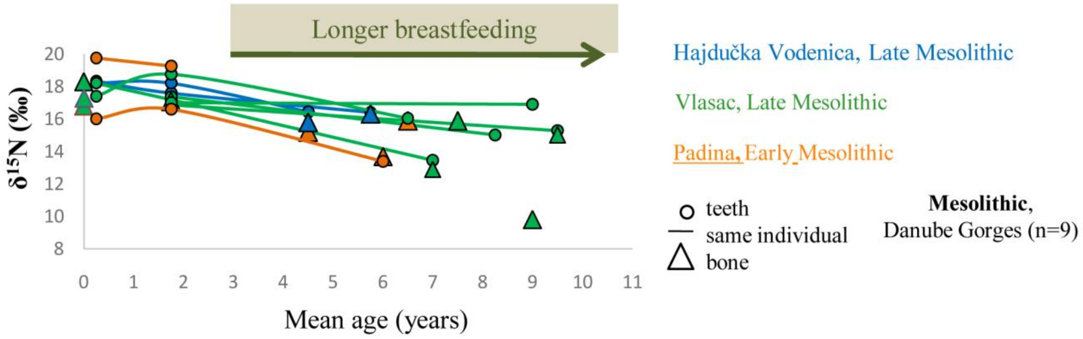


Fig. 5.15. $\delta^{15}N$ value of bone-tooth collagen for Mesolithic children (from de Becdelièvre et al. 2015b)

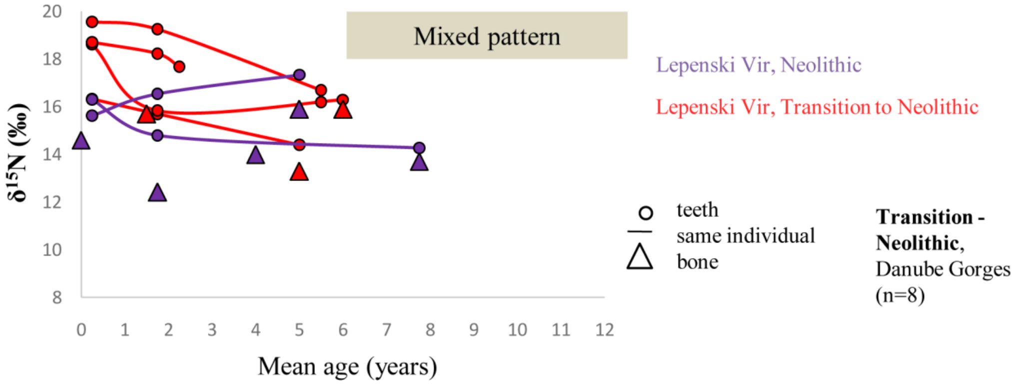


Fig. 5.16. $\delta^{15}N$ value of bone-tooth collagen for Transition-Neolithic children (from de Becdelièvre et al. 2015b)

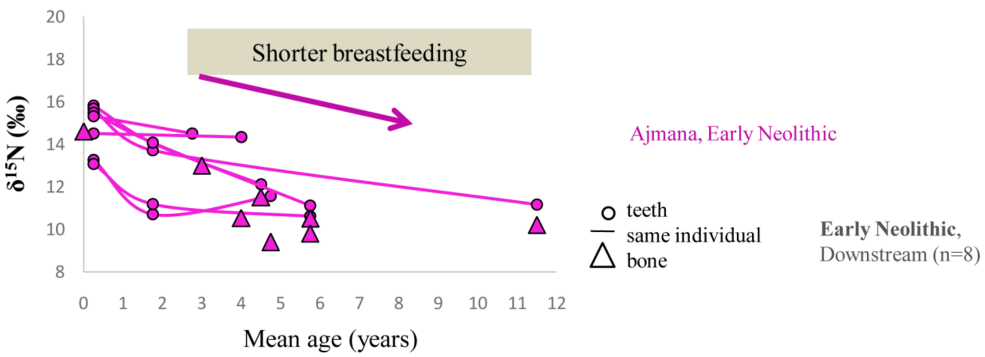


Fig. 5.17. $\delta^{15}N$ value of bone-tooth collagen for Ajmana children (from de Becdelièvre et al. 2015b)

The analysis of linear enamel hypoplasia (LEH) shows that children at the age of between 2 and 4 years had the most stress events, suggesting a possible link with the beginning of weaning. However, although the analysis of linear enamel hypoplasia shows a trend in reduction of systematic childhood stress (in the Mesolithic 5.77% of teeth affected (13/225), whilst in the Neolithic 3.94% of teeth had LEH (12/304)), the timings of LEH occurrence are different. The longer breastfeeding in the Mesolithic could have positively influenced children's health status, which is supported by the results of LEH examination which show that the Mesolithic children experienced stress at the end of the weaning period or later in their life. In contrast, shorter breastfeeding period in the Neolithic resulted in stress earlier in the children's life.

Although data on the amount of dental calculus can be biased (due to excavation methods and the easy removal of calculus), there is an important declining trend where dental calculus was present on 26.6% of the analysed Mesolithic teeth (60/225) whilst it is only recorded on 12.5% of the Neolithic teeth (38/304). Coupled with the isotopic data, which suggest significant input of aquatic resources for the Mesolithic children, the high amount of dental calculus in the Mesolithic could be a consequence of the consumption of protein-rich food (e.g. fish).

The potential for comparison of these results with those obtained for the children outside the Gorges is limited due to the small sample size. However, it should be noted that the children from Klisa and Obrež-Baštine were, at the end of their weaning period (the complete cessation of breastfeeding), of similar age to the Early Neolithic children at Lepenski Vir and Ajmana. Also, the breastfeeding pattern for Klisa child resembles the one at Lepenski Vir more than the one recorded at Ajmana, although the composition of the diet corresponds better to the one at Ajmana. More data are necessary in order to have a better view on infant feeding practices in the central Balkan regions outside the Danube Gorges.

Overall, the presented results reveal significant differences in terms of infant feeding strategies between the foragers and the agriculturalists. These bio-cultural differences may have contributed to the important demographic changes observed for the period of the Mesolithic-Neolithic transition. The appearance of new food (milk and cereals, which was a good replacement for mother's milk) could have led to the shorter period of breastfeeding which is evident in the Neolithic. The reduction in the length of breastfeeding, which *de facto* had an effect on shorter lactation amenorrhea, may have resulted in a reduction of the interval between births and may have allowed females to get pregnant more times in their life. Furthermore, several studies already suggested that the earlier age of children at weaning may have been related to an increase in fertility as well as children mortality (Pearson et al. 2010; Howcroft et al. 2013; Tsutsaya et al. 2015), especially at the time when hunter-gatherers established contacts with farming societies (Schurr 1998) or experienced important dietary changes (Waters-Rist et al. 2011). Although most of the studies found that the duration of breastfeeding was longer in hunter-gatherer populations, some of them suggest that there is no evidence that hunter-gatherers lacked food appropriate for weaning (Swellen and Smay 2001). However, whether hunter- gatherers diet (mostly fish and fibrous meat from wild animals which is hard to chew) was appropriate for babies or not, it was probably richer in essential nutrients then Neolithic gruels made of milk and cereals. The transition to new food had a two-fold effect. Even though Mesolithic baby food was healthier, it was harder to find year-round; the appearance in the Neolithic of new food (albeit of poorer quality) enabled steady food supply (cereals could be stored) and, consequently, influenced weaning patterns.

Nevertheless, when investigating the weaning process, one should bear in mind that environmental and socio-cultural factors may play a (major) role. This certainly has an impact on breastfeeding patterns and leads to development of diverse models applied to hunter-gatherers and agro-pastoralists. What is without doubt is that not all transitional Mesolithic-Neolithic populations had the same breastfeeding tradition.

5.1.1.5.3. The diet of subadults

The Mesolithic children had diet based on aquatic sources which had a positive effect on their overall health since no major stress incidences were recorded (mostly cribra orbitalia and porotic hyperostosis, with low-degree and healed lesions).

When all of the Neolithic children are observed together (including those for which breastfeeding was not possible to analyse) (Fig. 5.18), one can clearly notice different dietary pathways between Neolithic children in the Gorges and those from the regions outside the Gorges. The children from Ajmana had a diet similar to that of the

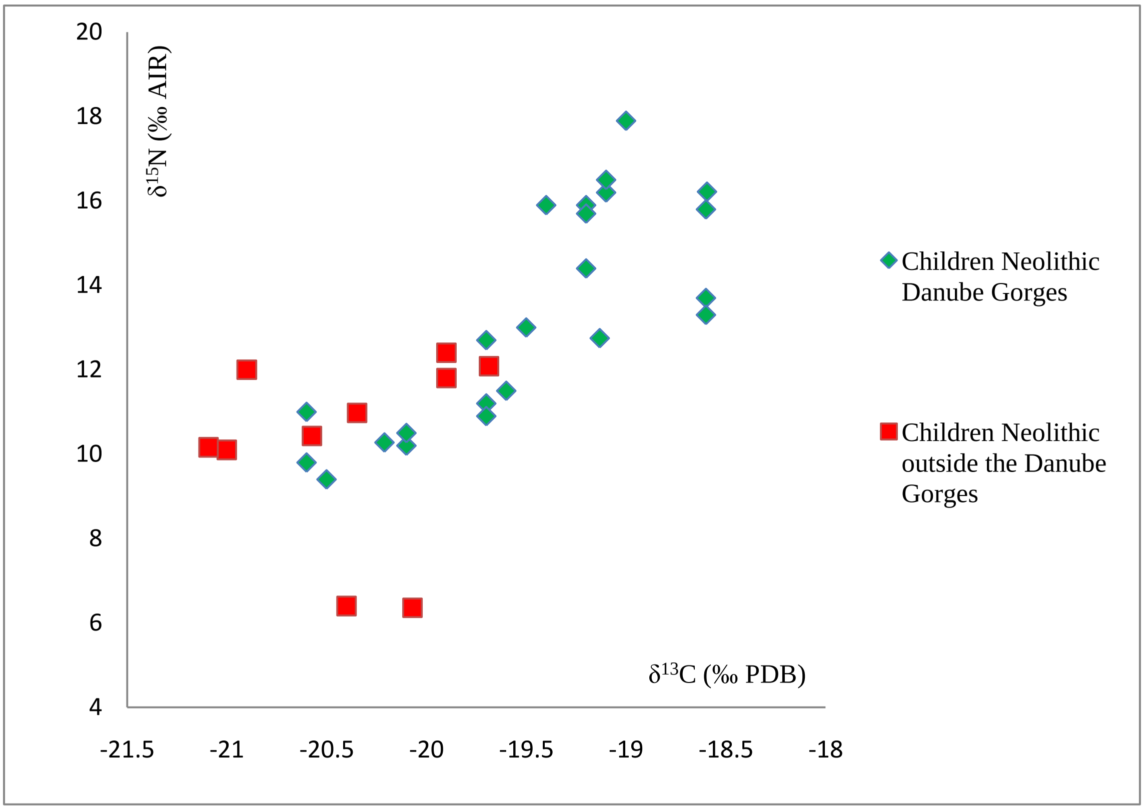


Fig. 5.18. $\delta^{13}C$ and $\delta^{15}N$ values for Neolithic children in the studied regions[37]

children outside the Gorges. Only few children from Lepenski Vir (35, 72, 122) show more terrestrial values that are close to the values obtained for Ajmana and the individuals outside the Gorges. This is not surprising since, as has already been noted at the population level, some individuals from the site of Lepenski Vir show a trend toward greater consumption of terrestrial food resources at the start of the transition to the Neolithic. Worth noting is that one of those individuals (LV 122) had active cribra orbitalia lesions and hypoplasia for which low-protein diet could have been the cause.

Concerning the children outside the Gorges, two children from the site of Golokut-Vizić (1/2003 and 2/2003) have very low $\delta^{15}N$ values. This indicates that their animal protein intake was very low which, together with other factors (e.g. environmental), could eventually have caused the death. It is of note that the child buried in Grave 1/2003 had both caries and hypoplasia, whilst the other child (2/2003)

[37] Stable isotope data for the Danube Gorges children were taken from Grupe et al. 2003; Borić et al. 2004; de Becdelièvre et al. 2015b.

had cribra orbitalia with mixed-activity type of lesions. These conditions could also have been caused by low animal protein intake and the diet rich in carbohydrates.

There were no differences in the diet across the age groups. This suggests that all of the children had a similar diet regardless of their age.

5.1.1.5.4. Conclusion

At the beginning of 7th millennium, the Danube Gorges hunter/fisher/gatherers, who heavily relied on fishing for subsistence, underwent a change. In the Danube Gorges, this was a gradual process since many Neolithic individuals remained reliant on aquatic products. One of the possible explanations for a high input of aquatic products generally unusual for Neolithic communities, as demonstrated at sites across Europe, is the fact that the Mesolithic traditions were still respected at the time. Although the stable isotope analysis shows a high dependence on aquatic products throughout the Danube Gorges Mesolithic-Neolithic sequence, an increase in the consumption of terrestrial resources (visible as the smaller intake of aquatic proteins and possibly more carbohydrates) has been noted at some sites from the Neolithic period (Grupe et al. 2003; Borić et al. 2004; Nehlich et al. 2010; Jovanović et al. submitted). Whilst at Lepenski Vir the diet remained mostly reliant on aquatic proteins (though some individuals preferred terrestrial resources), for the later-founded site of Ajmana the isotopic values suggest a terrestrial diet with little input from aquatic resources (Borić and Price 2013; Jovanović et al. submitted).

In contrast with the emphasis placed on aquatic resources in the diet of the individuals from the Danube Gorges, the stable isotope values of the Neolithic communities outside the Gorges reflect a predominantly terrestrial diet with only small contribution of aquatic resources, although in both regions the inhabitants had access to rivers. However, there are no rivers as big as the Danube in these other regions and the sites do not occupy highly favourable riverside locations and there are no whirlpools such as those in the Danube Gorges which would have enabled specialized and large-scale fishing (Bartosiewicz et al. 2008; Dinu 2010; Živaljević 2012). The only site outside this region where people lived very close to the Danube is Vinča. Indeed, the Vinča inhabitants had a diet much more abundant in aquatic protein than the inhabitants of contemporary settlements outside the Gorges, which demonstrates the importance of environment in dietary patterns. Overall, the results of the analysis of dietary patterns show that, in the wider region (in and out of the Danube Gorges), the Mesolithic-Neolithic transition was not a simple, linear process from foraging to food production, but that it encompassed significant regional differences related to environmental factors, cultural traditions, and/or dietary habits of the Neolithic newcomers.

The appearance of new foods (rich in carbohydrates, i.e. cereals and milk) and the novel food preparation techniques (cooking in pots) in the central Balkans Neolithic enabled shorter breastfeeding period since mothers were provided a good replacement for their own milk and a possibility to make baby porridges from the resources available year-round. This could have had a positive effect on female's fertility rates and, in combination with the increase of their energy intake and sedentism (de Becdelievre et al. 2015a), it may have allowed women to have more children and more times in the course of their lifetime which, eventually, resulted in a higher number of people worldwide. Thus the bio-cultural shift in infant feeding practices may have contributed to the important demographic changes observed across the Mesolithic-Neolithic transition.

Running counter to the demographic growth is the consequence of the shorter breastfeeding in the Neolithic that had an adverse effect on the overall health of the populations. In hunter-gatherer communities, humans probably breastfed their offspring for an extended period of time. However, with the advent of the Neolithic, and for the first time in human evolution, breastfeeding period was reduced, and this represented a significant physiological stress which had had a major impact on children's growth and development and, ultimately, their health.

5.1.2. Starch grain analysis

In this section, the results obtained from starch grain analysis will be presented and evaluated together with the results from stable isotope analysis in light of the Mesolithic-Neolithic transition in the studied regions of the central Balkans (Fig. 5.19, 5.20, 5.21). Further, the age- and sex-related differences will be discussed and interpreted together with other dietary and health markers.

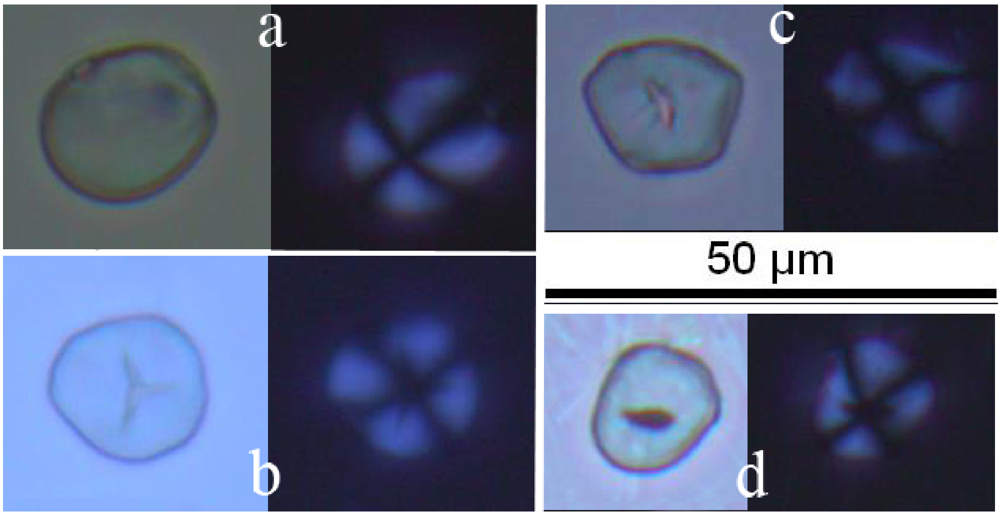


Fig. 5.19. Starch grains recovered from the dental calculus from Neolithic studied sites: a) Ajmana 13; b) Lepenski Vir 57(1); c) Lepenski Vir 7/I; d) Vinča IX (left image shows the starch under brightfield light and right shows it under cross-polarized light)

5.1.2.1. Interpretation of results obtained through starch grain analysis

The results show more frequent presence of starch grains at the studied Neolithic sites, especially at the sites outside the Danube Gorges. This pattern is seen on individual level as well as when the overall number of starches is considered. As starch grains represent carbohydrates, and are found in plants, the simple conclusion would be that Neolithic people consumed more carbohydrates. However, this straightforward conclusion has many limits and, therefore, a more nuanced consideration is needed.

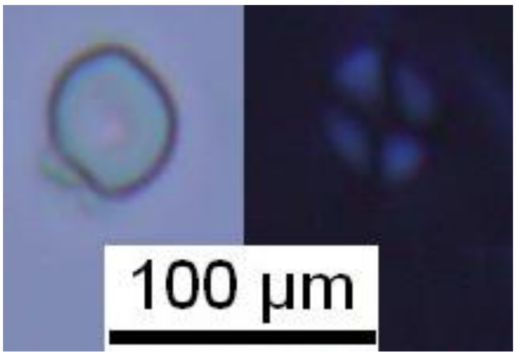


Fig. 5.20. Starch grains recovered from the dental calculus Vinča site, individual II (left image shows the starch under brightfield light and right shows it under cross-polarized light)

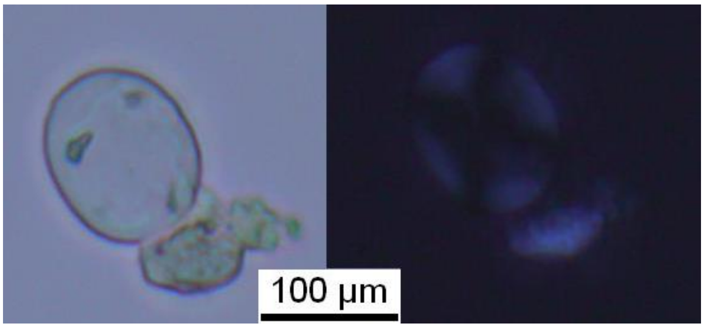


Fig. 5.21. Starch grains recovered from the dental calculus from Golokut-Vizić, grave 3/1984 (left image shows the starch under brightfield light and right shows it under cross-polarized light)

The stable isotope data point at changes in the Neolithic diet. In the Danube Gorges, this was a gradual process since lots of individuals were still relying on aquatic products. At Ajmana, the only site in the Gorges where stable isotope data indicated a predominantly terrestrial diet, 66.7% of individuals show presence of starch grains. On contrary, at Lepenski Vir, with mixed dietary pathway, 33.3 % of individuals had starch grains in the dental calculus. The preliminary analysis of dental calculus from Neolithic individuals from Lepenski Vir, carried out within the ERC-funded BIRTH project in 2016 (Filipović et al. 2016), also showed presence of starch grains in the plaque, most probably coming from wheat. Importantly though, the highest number of individuals with starches (77%) is detected outside the Danube Gorges, where terrestrial diet prevails. Although, there are many factors complicating the attempt at estimating the degree of consumption of starch-producing plants, the higher quantity of starch grains in the calculus of Neolithic individuals is indicative. Therefore, it is plausible that greater consumption of starch-rich food in the Neolithic resulted in more starch grains becoming trapped in the calculus.

5.1.2.2. Age- and sex-related distribution of starch grains

The distribution of identified starch grains across different sex shows no significant differences between males and females. This result is in accordance with the stable isotope data that also suggested no important differences between the diet of males and females.

Most of the individuals with starch grains in the dental calculus were middle-aged adults and children. This is not surprising, since older individuals had more time for formation of calculus deposits and more chances of starch grains becoming trapped in it. However, in children other factors can contribute. Neolithic children were breastfed for a shorter period of time than the Mesolithic, probably because Neolithic mothers were able to feed them a replacement in the form of new food which likely included a cooked porridge (that could have been made from mixed cereals and milk and was probably more suitable for children than the Mesolithic baby food). The presence of distorted starch grains in the calculus is a possible sign of cooking of food. The sticky texture of porridge would make it adhere to the teeth, forming a residue that was hard to remove. At Ajmana, more than 50% of children suffered from dental caries. The Fisher's exact test carried on the population level in both Mesolithic and Neolithic studied regions detect significant correlation between the occurrence of caries and the presence of starch grains (Fisher's exact $p = 0.017$), with medium effect (Cramer's V = 0.472) (Table 5.1).

As highlighted above, there are many lines of evidence indicating a connection between the terrestrial diet, the occurrence of caries and the presence of starch grains. However, further research producing more robust data is necessary. For now, the data on starch are combined with the stable isotope ratios and other dietary indicators, which are then together used to assess a possible dietary trend towards higher intake of carbohydrates in the Neolithic.

Table 5.1. Crosstabulation results for presence of caries and starch grains among Mesolithic and Neolithic population

			Starch		Total
			Absent	Present	
Caries	Absent	Count	0	15	15
		Expected Count	2.6	12.4	15.0
	Present	Count	5	9	14
		Expected Count	2.4	11.6	14.0
Total		Count	5	24	29

5.1.2.3. Conclusion

The presence of starch grains was detected mostly in the individuals for which the stable isotope analysis indicated a terrestrial dietary pattern. The majority of these individuals were recovered at the sites located outside the Danube Gorges which supports the previous impression that the diet of communities outside the Gorges includes less protein and more cooked carbohydrates than in the case of Neolithic groups in the Gorges. The consumption of cooked starchy food could, due to its dense and sticky texture, have led to build-up of food residues on teeth which were subsequently hard to remove, especially in children. For instance, at Ajmana, more than 50% of children developed dental caries, probably due to consumption of starchy carbohydrate cooked food.

Although further research and a much larger sample size is needed, the considered lines of evidences reveal a connection between the terrestrial diet, the occurrence of caries and the presence of starch grains, especially with the advent of the Neolithic in the central Balkans.

5.2. Dietary and health parameters

In the following sections, several markers of diet and health (dental caries, dental calculus and ante mortem tooth loss) are interpreted in the light of the Mesolithic-Neolithic transition in the central Balkans. Further, the differences between the two study regions are identified and discussed, and the observations compared with the results obtained for the same parameters analysed for some Early Neolithic communities in Europe and the Near East. In addition, wherever possible, age- and sex-specific differences are interpreted.

5.2.1. Presence of dental caries

Dental caries was not frequent among the Mesolithic population – only 2.5% of the individuals from the Gorges were affected. By contrast, the presence of dental caries is significantly higher in both of the Neolithic human groups studied in this thesis.

Moreover, in the Neolithic phase of the Danube Gorges 15% of the individuals were affected, whereas in the regions outside the Gorges the number of individuals with

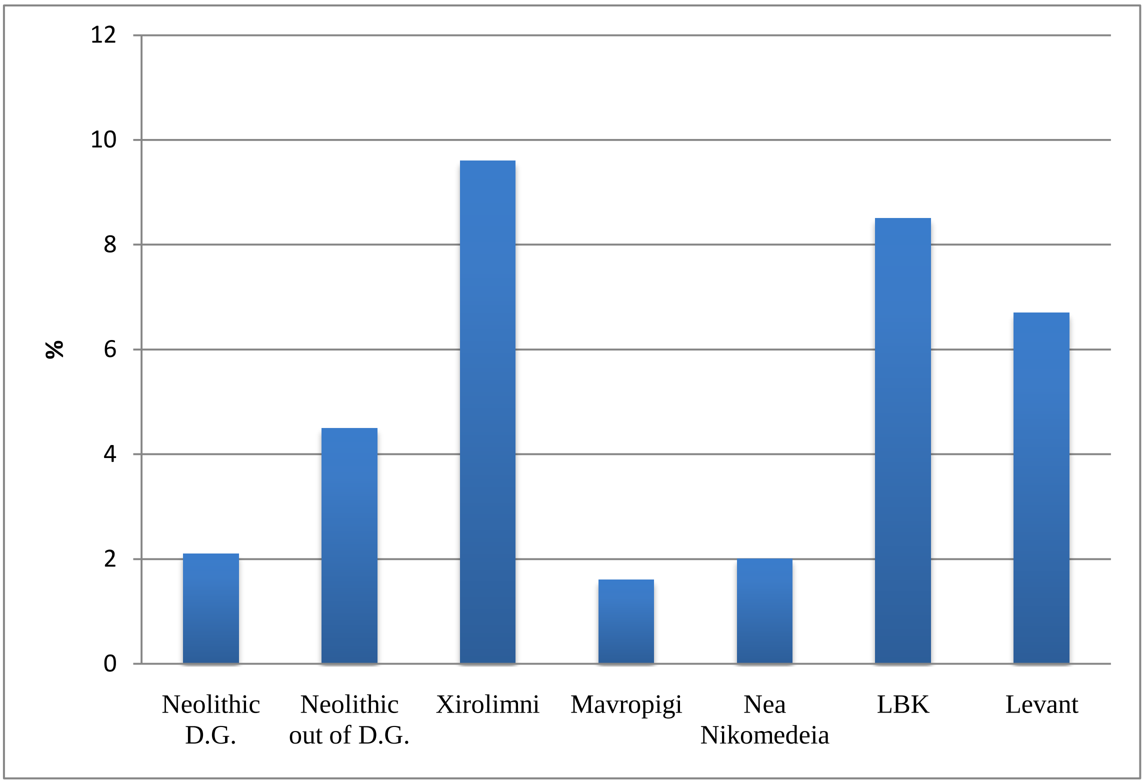


Fig. 5.22. The prevalence of caries in the Neolithic study regions and other Early Neolithic sites/regions[38]

dental caries is much higher (30%). When the number of the affected teeth was considered, similar results were obtained: 0.2% in the Mesolithic, 2.1% in the Neolithic of the Danube Gorges and 4.5% in the Neolithic outside the Gorges.

The introduction of new terrestrial food in the Neolithic certainly had a positive influence on caries rates as the consumption of carbohydrates is considered one of the main causes of caries, especially in case of foods that contain both starch and sugars. The stable isotope analysis shows that the Neolithic people, especially those from outside the Danube Gorges, consumed more terrestrial products, including more carbohydrate-containing food. Starch grain analysis also showed a likely trend toward greater consumption of starchy food in the Neolithic.

[38] The data for other Early Neolithic sites/regions were taken from: Hershkovitz and Gopher 2008; Papathanasiou 2011; Nicklisch et al. 2016.

In contrast, the Mesolithic population had a lower incidence of caries, had a diet containing more aquatic proteins and was likely acquiring more fat from fish than from terrestrial sources (Jovanović et al. submitted). The diet high in proteins and fats had a protective effect, since these nutrients may inhibit bacterial activity (Powel 1985). Also, high rates of teeth abrasion (Радовић 2013) recorded in the Mesolithic buffered the teeth from caries.

Based on a global population study, Turner (1979) set out average frequencies of teeth affected by caries for different subsistence groups: 1.7% for foragers, 4.8% for mixed foraging and farming communities, and 8.6% for fully-fledged agriculturalists. Compared to these, the occurrence of caries in the Mesolithic Danube Gorges is extremely low, whilst the rates for the Neolithic individuals are between the averages for foraging and mixed foraging/farming communities. This is in accordance with the archaeozoological (Bökönyi 1969; Clason 1980; Greenfield 2008; Dimitrijević 2000, 2008) and the stable isotope data (Grupe et al. 2003; Borić et al. 2004; Nehlich et al 2010; Jovanović et al. submitted) which show that the Neolithic communities in the Gorges were still highly dependent on foraging. The low incidence of caries in the Neolithic of the Danube Gorges is, however, unusual since numerous studies demonstrated increases in caries rates during the Early Neolithic (Larsen 1995; Jarošová and Dočkalová 2008; Wittwer-Backofen-Tomo 2008; Papathanasiou 2011; Masson 2014; Nicklisch et al. 2016) (Fig. 5.22). However, there are also some other Early Neolithic communities that have similarly low frequency of caries (e.g. Aşikli Höyük in central Anatolia (Özbek 1998, cited in Pearson et al. 2010); some sites in Greece (Papathanasiou 2011)) as those in the Danube Gorges.

The Neolithic communities that occupied the regions outside the Gorges had a higher rate of caries, resembling in that aspect many other Early Neolithic communities across Europe. Their diet dominated by terrestrial products was highly conducive to the development of caries.

It is worth mentioning that, although carbohydrates play a major role in the development of caries, the way food is prepared and its structure are also of relevance (Duggal and Van Loveren 2001; Touger-Decker and Van Loveren 2003). The new, Neolithic food (possibly made from cereals and milk) was likely dense and of high viscosity, and would have tightly adhered to the teeth. This would have promoted bacterial activity by increasing the time needed to clean the teeth and would have thus led to higher caries rates.

5.2.1.1. Adults

In the Danube Gorges, the individuals with caries were registered at two sites – Lepenski Vir (n=5) and Ajmana (n=6). Interestingly, whilst at Lepenski Vir caries was detected only in adults, at Ajmana it is mostly children who had caries. This difference is probably a result of the different infant feeding practices, and will be discussed in the section on caries distribution in children. Noteworthy, among the total of seven adult individuals with caries, three were of non-local origin (Ajmana 7, Lepenski Vir 32a and Lepenski Vir 88). All of the individuals with caries had a predominantly terrestrial dietary pattern. Furthermore, starch grains were detected in dental calculus of three of the individuals with caries (Ajmana 7, 9 and Lepenski Vir 32a).

In the Neolithic outside the Gorges, only one child shows the presence of caries (Golokut-Vizić 1/2003, Fig. 5.23), whilst the others individuals with caries are adults (n=6) and mostly females. The highest number of adult individuals with caries is recorded at Golokut-Vizić (n=3), and is followed by the number of such at Vinča (n=2). Among the four analysed individuals with caries, three also calculus in which starch grains were detected (Vinča II, X and Golokut-Vizić 3/2003) (Fig. 5.24).

Fig. 5.23. Presence of caries detected on the upper molar, Golokut-Vizić, grave 1/2003

Fig. 5.24. Presence of caries detected on the molars, left: Golokut-Vizić, grave 3/2003; right : Ajmana 15

For both the Neolithic adults in the Gorges and those outside of it, there seems to be a positive correlation between the presence of starch grains in calculus and the presence of caries.

The individuals with caries had a diet based on terrestrial sources, although two of them from Vinča also had a moderate input from freshwater resources. While at Vinča no progressive caries decay was observed, in two females from Golokut (3/2003) and Rudnik Kosovski (1) the so called gross-gross caries was noted which could be connected to their strong potential reliance on terrestrial food sources.

5.2.1.2. Sex-related differences

Among the Mesolithic individuals, only three show presence of caries – two males and one female. The stable isotope data[39] were available only for a middle-aged male from Vlasac (Grave 26) and this individual had completely different isotopic values than the rest of the Mesolithic ones. The appearance of caries can be correlated with his predominantly terrestrial diet, which is unusual for the Mesolithic period in the Danube Gorges.

[39] collagen values only valid

Taking together males and females from the Neolithic phase of the Danube Gorges, the females show higher caries rates, particularly when the numbers of affected teeth are compared. The available isotopic data show a prevalence of terrestrial dietary pattern for these individuals. Furthermore, starch grains were detected in the calculus of two females (Lepenski Vir 32a and Ajmana 9). Interestingly, two out of five females with caries were of non-local origin; these are Lepenski Vir 32a and 88 (Borić and Price 2013). Also, among the females which had caries, only these two had it on more than one tooth. It is possible that they belonged to an agricultural community where high intake of carbohydrates could have led to the development of caries and its development on multiple teeth. The only male individual with caries also had a terrestrial diet. Although in the Neolithic assemblage from outside the Danube Gorges the potential for comparison is limited due to the small number of available male individuals, there is a similar trend in which again caries is more common in females.

Numerous studies have demonstrated that the increase in dental caries rate with agriculture was higher in females than in males (Larsen 1983; Walker and Hewlett 1990; Lukacs 2008). Clinical studies carried out on present-day population generally show the same trend (Ramezani et al. 2003, cited in Lukacs and Largaespada 2006; Saravanan et al. 2003; Ferraro and Vieira 2010). There are several factors that scholars usually use to explain these differences such as: different access to food resources between males and females, where females consume more carbohydrates; earlier eruption of teeth in girls; and pregnancies (Lukacs and Largaespada 2006). Lukacs (2011) suggests that pregnant women have higher demands for high-energy resources, such as sweet foods, and that this is accompanied by an aversion to meat products.

In the present research, the stable isotope data do not show any significant differences in the diet between males and females from the Neolithic, although females do show wider isotopic variability. Also, although there are more females with terrestrial diet and the presence of caries, there are also males with terrestrial diet, but without caries. This suggests that dietary differences cannot explain the differences in the development of caries in the Neolithic between males and females. However, the aforementioned greater isotopic variability could suggest that cariogenic plant products were more accessible to women (e.g. women could have been more involved in collecting and processing of plants for food preparation, or in non-masticatory activities[40]).

One other possible explanation is lay that girls' teeth erupt earlier than boys' and are thus exposed to bacteria and cariogenic environment for a longer period. Some studies have found a correlation between the nursing caries and sex. It appears that the occurrence of nursing caries is more common in girls than in boys (Ramezani et al. 2003). However, there are also studies that did not register this connection (Jose and Joseph 2003; Menghini et al. 2008) and that propose that answers should be sought in other parameters, such as genetic factors or hormones.

In the study from 2006, Lukacs and Largaespada demonstrated that, actually, hormonal fluctuations and the life history events can have a strong effect on the development of caries in females. It showed that the greater caries rates in women are influenced by three main factors: female sex hormones, composition and rates of female saliva, and the food cravings during pregnancy. More specifically, Lukacs and Largaespada (2006) found that female sex hormones such as oestrogen and its fluctuations in puberty as well as its high levels during pregnancy can have a strong impact on the formation of cavities. Further, the composition and flow rates of saliva are very important, because females produce less saliva than males and this reduces the removal of food from teeth. Finally, during puberty, menstrual cycles and pregnancy, the biochemical composition of female saliva is highly influenced by hormones, and it changes during these phases/events. This results in a reduced antimicrobial capacity of saliva and creates a more cariogenic environment for women (Lukacs and Largaespada 2006).

Hence, both biological (e.g. hormones, reproductive history and genetics) and behavioural factors should be taken into consideration since they can all lead to the development of caries. As Lukacs (2011) has already suggested, with the intensification of agriculture, females' reproductive capacities increased, leading to higher fertility rates but, at the same time, in combination with a new poor diet, women's oral health deteriorated.

[40] The traces of non-masticatory activities are documented in the Mesolithic-Neolithic transition in the Danube Gorges and they reveal that, more than man, women used their teeth as a tool, especially in the Neolithic (Радовић 2013).

5.2.1.3. Children

The results show that none of the Mesolithic children had caries, whilst it appeared in the Neolithic children. In the regions outside the Danube Gorges, caries was most frequent in adults (based both on the number of affected teeth and the number of individuals). However, the small sample size of children with preserved teeth perhaps distorts the picture. A larger sample of children is needed in order to gain a better view of the distribution of caries across adults and children. In the Danube Gorges, the rates of caries are similar in children and adults, though are higher in children when the data are compared on individual level.

In the Danube Gorges, the children with caries are detected only at the site of Ajmana where 50% of the children were affected (Table 5.24). The presence of caries was detected only on deciduous teeth. On the contrary, at the site of Lepenski Vir, none of the children exhibited the presence of dental caries. These significant differences are probably a consequence of the different infant feeding practices. The stable isotope analysis (de Becdelièvre et al. 2015a, 2015b; de Becdelièvre in prep.; Јовановић et al. 2015) show that children buried at Lepenski Vir had a mixed diet (terrestrial and aquatic) and a longer period of breastfeeding, whereas the children buried downstream, at Ajmana, show a mostly terrestrial dietary signal, with a small input of aquatic resources. Further, they were breastfed for a shorter period of time, i.e. were of younger age at start of weaning.

As the study by Stefanović and colleagues (2016) recently suggested, a special risk for deciduous teeth in the Neolithic was the new weaning food. Children could have eaten some kind of porridge made of ground cereal grain and milk. Noteworthy is that three out of four children with caries also show presence of starch grains in the calculus. The new baby food, which may have formed a sticky layer over the teeth, most likely caused dental caries already during childhood. In the same study, Stefanović and colleagues supply further evidence that new type of baby food appeared in the Neolithic, namely numerous traces of deciduous teeth detected on the Neolithic "spoons" which signal that the spoons were used for feeding babies whilst at the same time they represent an indirect evidence for the existence of baby food (Стефановић et al. 2016). The study concludes that the quantity of spoons in the Neolithic could be an indicator of a widespread practice of porridge consumption which, in turn, contributed to the higher caries rates in the Neolithic. Caries affected deciduous teeth probably also caused damage to the developing permanent teeth. Ultimately, the new type of food could have also caused caries in adults whose teeth were probably often in contact with sticky, starchy food such as porridge or some kind of Neolithic bread.

5.2.1.4. Conclusion

The introduction of new terrestrial food and the consumption of carbohydrates in the Neolithic resulted in higher caries rates. By contrast, in the Mesolithic, caries incidences are low because of the diet rich in protein and the high teeth abrasion that had a buffering effect. However, there are regional differences between the two studied Neolithic groups. While the Neolithic shift in the diet towards somewhat greater consumption of carbohydrates left evidence on the teeth of the Danube Gorges people, in the form of the higher caries rates than observed for the Mesolithic, the rates are still lower than seen in some other Early Neolithic populations, including the Neolithic communities from outside the Gorges who consumed more terrestrial foods. The reason why the Neolithic human groups in the Gorges differ from the patter seen in the Early Neolithic trends in caries rates in Europe may be that they had a greater preference for aquatic products compared to the contemporary communities elsewhere.

The two analysed Neolithic groups (in- and outside the Gorges) differ in terms of the frequency of caries occurrence, but show a similarity in the caries rates of females, indicating that females were generally more affected. Although many factors could have played a part in this, it can be suggested that, with the intensification of agriculture, females' reproductive capacity increased and led to, *inter alia*, reduced antimicrobial activity which, in combination with a new protein/mineral-poor diet, eventually resulted in a decline in women's oral health. Children were also significantly affected, probably because of the consumption of new, cooked baby food which might have formed a sticky layer over their teeth and caused dental caries already during childhood. The new method of food preparation could have caused caries not only in children, but also in adults whose teeth were probably also in contact with sticky food that had a form of porridge or some kind of Neolithic "bread".

5.2.2. Dental calculus

5.2.2.1. The Danube Gorges

The occurrence of dental calculus was significantly higher in the Danube Gorges Mesolithic sequence (17.2% individuals were affected, or 3.5% of teeth had the highest degree 3). On the other hand, 12% of the Neolithic individuals were affected or 1.9% of teeth. Noteworthy is that only degree 3 represents a heavy calculus deposits[41].

The high amounts of calculus can be correlated with a protein-based diet because the deposition of calculus is facilitated by the alkaline oral environment and the diet high in protein increases oral alkalinity (Hillson 1979). Many studies confirm that the accumulation of calculus is associated with meat-based diet in which large amount of animal protein results in moderate to heavy deposits of calculus on the teeth (Pechenkina et al. 2002; Delgado-Darias et al. 2006). The high occurrence of supragingival calculus, mostly connected to dietary factors rather a pathological condition, and the low presence of subgingival calculus (resulting from pathological conditions), lends weight to the argument that the calculus formation in the Mesolithic Danube Gorges was a result of high protein content of the diet. The observation is in accordance with the stable isotope data which show that people in the Mesolithic had a very high protein intake, mostly from aquatic resources. In contrast, the Neolithic people consumed lower amounts of animal protein and thus have lower calculus rates. However, although the Neolithic people exhibit lower-than-Mesolithic proportion of heavy calculus deposits, the number of affected Neolithic individuals is relatively high (Fig.5.25). This can be also explained by the stable isotope data which indicate that, although the Neolithic individuals based their diet on terrestrial resources, fish continued to play an important role.

The low incidence of caries and the high amounts of calculus are in (expected) agreement because of their relationship with the plaque pH value (Hillson 1979). Therefore, these results represent another evidence of the tendency among the inhabitants of the Danube Gorges (with low caries rates and high calculus deposits) to

[41] The numbers of affected teeth at the degree 0, 1 and 2 are available in Table 4 in the Appendix 2. When the degree 0, 1 and 2 teeth are taken into account, one notices prevalence of degree 1 and 2 teeth in the Mesolithic. However, in order to avoid the biased caused by specific factors which can influence the degree of presence of calculus, the degree 0, 1 and 2 teeth were excluded from further study, as already explained in the Materials and Methods chapter.

have a very high protein intake and a low intake of carbohydrates and sugar, through the whole Mesolithic-Neolithic sequence. A similar situation (Lillie 1996) is observed during the Neolithic Transition in the Dnieper Rapids region where animals remained staple food throughout (Lillie and Richards 2000).

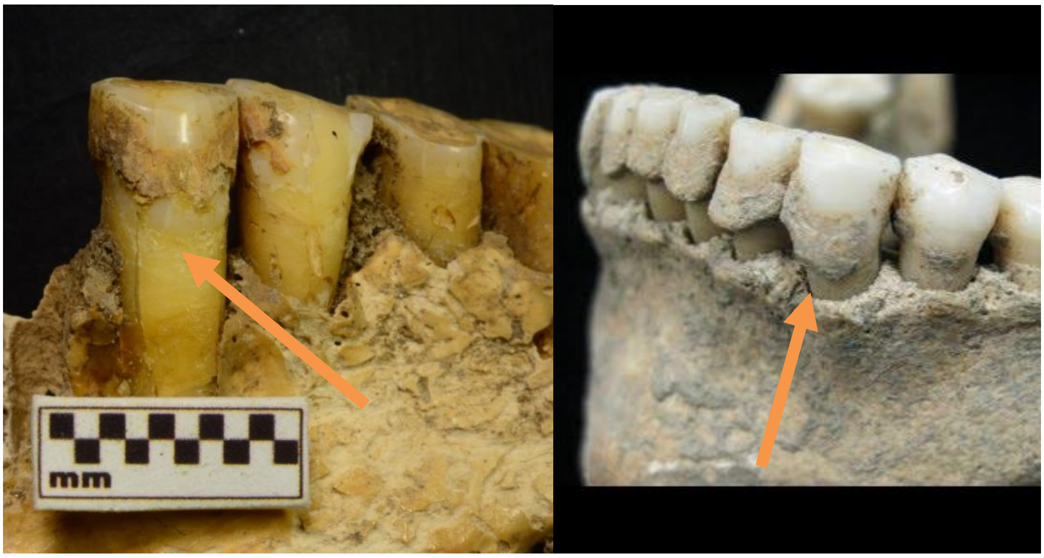


Fig. 5.25. Presence of dental calculus on mandibular teeth, left: Lepenski Vir, grave 14; right: Lepenski Vir, grave 50

The analysis of supragingival (SPG) and subgingival (SBG) calculus show that SPG calculus was the most represented in both periods. Since the origin of SPG calculus is connected to diet, it is likely that most of the calculus deposits from the Mesolithic and the Neolithic are of dietary origin. On the other hand, SBG calculus is usually linked with some pathological conditions, implying a low presence of tooth pathological conditions in the Mesolithic-Neolithic inhabitants of the Danube Gorges.

Although in the Danube Gorges many lines of evidence demonstrate that high protein intake played a major role in the formation of calculus deposits, there are other factors that can influence the build-up of calculus. It is necessary to keep in mind that variations between individuals in salivary flow rate, age, sex, oral hygiene, level of calcium in blood, mineral content of drinkable water, patterns of cultural behaviour, and food preparation methods can also have effect on the calculus deposition rates (Lieverse 1999).

Another important factor may have also contributed to the calculus formation, and these are highly-worn teeth because they facilitate interdental food retention and thus promote calculus formation. A high degree of abrasion is documented in the Mesolithic Neolithic inhabitants in the Danube Gorges (Радовић 2013). Thus, while the diet may have played a key role in the calculus formation, there are various aspects of it that need to be considered, as well as a number of cultural and environmental factors.

5.2.2.1.1. Sex-related differences

Males and females from both of the periods follow the same trend observed at the population level, i.e. males and females in the Mesolithic show higher incidence of calculus than males and females in the Neolithic. When males and females from the Neolithic are compared, a statistical test suggests that females had significantly higher amounts of dental calculus than did males. This would imply that females had a diet more abundant in protein. By contrast, the stable isotope data suggest a similar diet of males and females, with the latter displaying a wider isotopic variability.

It is interesting to note that, of the five females with calculus deposits most had a terrestrial diet. Further, three of them were of non-local origin (Borić and Price 2013), three had caries and precarious lesion, three had traces of non-masticatory activities, and two also had subgingival calculus. The single registered male with calculus had an aquatic diet and no traces of caries or non-masticatory activities. Here, one should consider multiple causes of the variation. First, most of the non-local females with calculus perhaps arrived from a different environment where the mineral content of water may have been different, influencing the calculus deposition.

Second, most of them had a terrestrial diet, which certainly did not include solely animal protein as caries was detected on their teeth, implying that they also consumed carbohydrates. Most of the relevant studies recognise a link between the formation of plaque and the diet rich in protein (Pechenkina et al. 2002; Lillie and Richards 2000), whilst they establish that carbohydrates also play a role in the accumulation of calculus (Lukacs 1989). It is proposed that carbohydrate-rich diets with less abrasive components and soft texture facilitate plaque deposition and mineralization

(Littleton and Frohlich 1993; Pechenkina et al. 2002). This could be one of the explanations for a greater amount of calculus in females.

Third, subgingival calculus is mostly present in females, suggesting a non-dietary origin of their calculus deposits. Thus, the observed differences should not be taken as resulting only from the characteristics of diet. Females may have had poorer oral hygiene than males. Also, the likely use of teeth as a tool may have contributed to the calculus formation due to the possibility of bacterial infections during the process, whilst processing of certain plants could have also contributed to the high calculus rates.

However, as explained above, calculus formation is a complex process and a comprehensive interpretation is needed.

5.2.2.2. Outside the Danube Gorges

Neolithic communities that lived outside the Danube Gorges had significantly fewer calculus deposits than the Mesolithic and the Neolithic people in the Gorges (Fig. 5.26). The most represented is the supragingival type suggesting that it was probably the dietary habits that influenced calculus formation rather than pathological conditions.

The Mesolithic people, with more calculus deposits, had a diet based on more protein compared to the Neolithic diet, especially compared to the diet of people outside the Danube Gorges. On the other hand, people who lived outside the Danube Gorges had a predominantly terrestrial diet and low levels of calculus deposits. Although calculus formation is mostly connected to high protein content in the diet, carbohydrate-rich diet can also play a role. However, this does not have to be necessary correlated to carbohydrates themselves, it can (also) be connected to the way in which the food is prepared. Namely, in the Neolithic people start to cook and eat more food that likely had a dense, sticky texture due to which it was hard to remove it from the teeth surface. This would have resulted in poor oral hygiene and more bacterial activity, leading to the formation of calculus deposits. Thus, changes in the food preparation techniques could have caused the appearance of calculus in the Neolithic. The results, however, suggest that the impact on the calculus formation of the diet dominated by cooked carbohydrates was lower than the effect of the protein-rich diet.

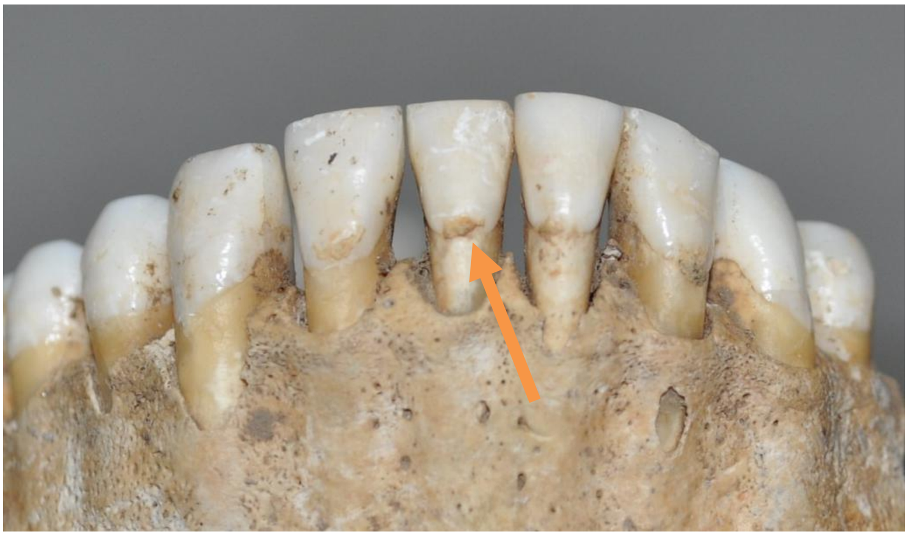


Fig. 5.26. Presence of calculus on mandibular teeth, Golokut-Vizić, grave 3/2003

5.2.2.1.2. Sex-related differences

Males and females in the Mesolithic and the Neolithic display the same trend observed at the population level. The potential differences between males and females in the Neolithic could not be assessed due to the small sample size[42].

5.2.2.3. Conclusion

The presence of dental calculus was the highest in the Mesolithic due to the protein-dominated diet and possibly also due to severe dental attrition. Since in both of the chronological human groups supragingival type of calculus was the most represented, it is highly likely that the majority of calculus deposits from the Mesolithic and the Neolithic are a result of diet. In the Neolithic, both studied geographical groups also show high frequency of dental calculus. Whilst in the Danube Gorges the same factors valid for the Mesolithic groups could explain the marked presence of calculus, in the Neolithic outside the Danube Gorges calculus formation may have had a different aetiology, probably linked to the introduction of high-viscosity cooked carbohydrate-

[42] Calculus was recorded in only one female individual (1/8), whilst none of the males showed the presence of calculus (0/2).

rich food. In the Danube Gorges, the occurrence of calculus in females is higher than in males and the reasons could be multiple and different from one female to another (e.g. non-local origin, terrestrial diet with less animal protein, dental disease, poor oral hygiene). In sum, whilst the diet may have played a key role in the calculus formation, there are various aspects of diet and diverse food preparation methods that must be considered, as well as a number of cultural and environmental factors.

5.2.3. Ante mortem tooth loss

5.2.3.1. In the Danube Gorges

In the Mesolithic, ante-mortem tooth loss (AMTL) is present in 16% of the individuals (3.1% of the teeth), which is a relatively high percentage (Larsen 1997). It was detected mostly in middle-aged and old adults from the sites of Vlasac, Padina and Hajdučka Vodenica. The majority of AMTL teeth are molars and incisors. In the Neolithic, the frequency of teeth lost before death is lower (6.5% of the individuals or 0.7% of the teeth). In total, only 8 teeth were lost before death, mostly molars and incisors. The individuals who experienced AMTL come from the sites of Padina, Hajdučka Vodenica and Lepenski Vir (Fig.5.27) and are mostly middle-aged and old adults.

Fig. 5.27. Individuals with mandibular AMTL, left: Lepenski Vir, grave 50; right: Perlez-Batka C, grave 1

The observed differences between the Mesolithic and the Neolithic are not in accordance with the general notion that Neolithic populations saw increase in ante mortem tooth loose. Indeed, the shift in diet was accompanied by an increase in tooth loss as well as periodontal disease (Clarke et al. 1986; Larsen 1997). For instance, at the Early Neolithic site of Xirolimni in Greece the AMTL occurred in 13.5% of the population (Papathanasiou 2011) and at Körös culture sites in Hungary in 75% (Masson 2014) (Fig. 5.28). Although aetiology of AMTL is a process defined by a number of factors, the major ones associated with pre-mortem loss of teeth are high caries rates, severe

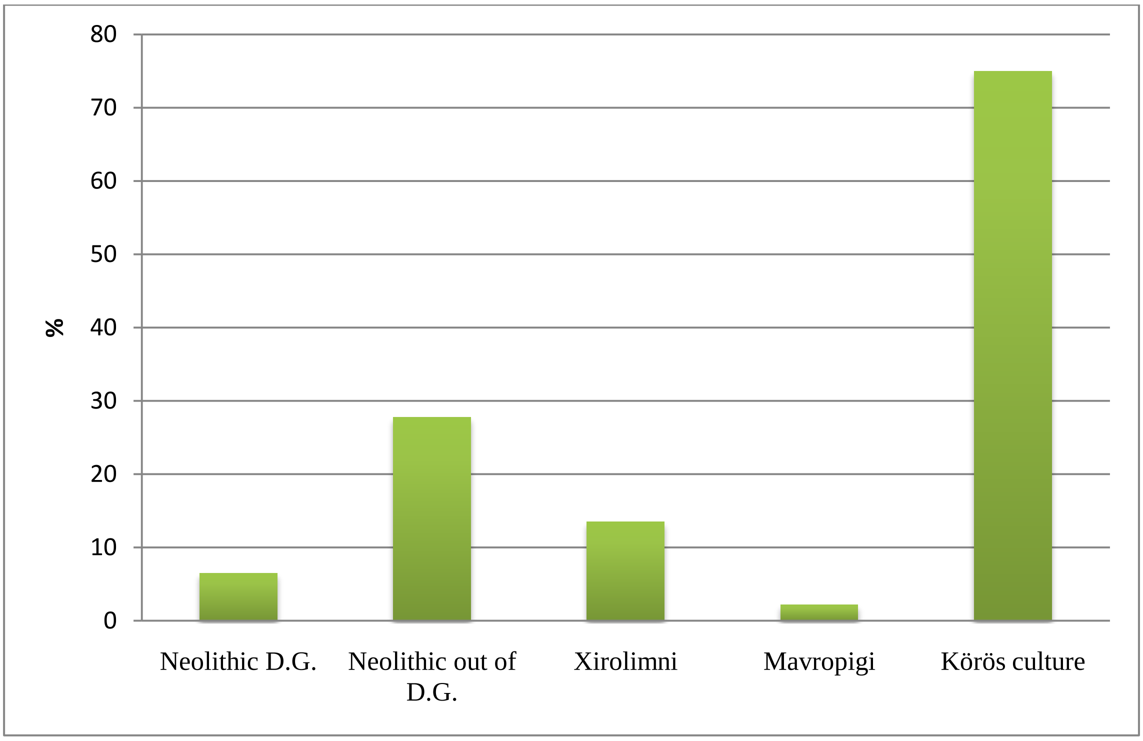


Fig. 5.28. The frequency of AMTL in the Neolithic study regions and other Early Neolithic sites/regions[43]

attrition, periodontitis and, consequently, calculus accumulation (Hillson 2005; Lukacs 1989).

A high degree of tooth wear, in which the pulp exposure led to tooth infection and periodontitis, was recorded in the Mesolithic inhabitants of the Danube Gorges

[43] The data for other Early Neolithic sites/regions were taken from: Masson 2014; Papathanasiou 2011.

(Радовић 2013). In addition, high calculus deposits, linked with periodontal diseases (Lukacs 1989), loss of alveolar bone and, ultimately, loss of teeth, are also very frequent in the Mesolithic inhabitants. Thus, the observed high AMTL frequencies in the Mesolithic population can be explained by either severe tooth abrasion or high frequency of calculus deposits.

A low occurrence of AMTL in the Neolithic in the Gorges corresponds with a situation observed in other Early Neolithic populations. In the Danube Gorges Neolithic, the AMTL is only seen in three females (Lepenski Vir 20, 32a; Padina 5), one male (Hajdučka Vodenica 13) and one adult of unidentified sex (Lepenski Vir 83a). What is common for them is that they all show severe dental attrition (Радовић 2013)[44] followed by high calculus deposits. Among females, two of them were of non-local origin (Lepenski Vir 20, 32a) (Borić and Price 2013) and in case of one of them (Lepenski Vir 32) the presence of caries and starch grain was also detected. Additionally, in the same two females, as well as in the individual buried in Grave 83a at Lepenski Vir, traces of non-masticatory activities were detected (Радовић 2013).

It seems that, here, different factors contributed to pre-mortem loss of teeth. Firstly, severe tooth wear, followed by significant build-up of dental calculus were the main contributors to AMTL in these individuals. Moreover, the female buried in grave 32a had caries and, almost certainly, a terrestrial diet which, besides high tooth wear and the presence of calculus, could also have contributed to tooth loss. In addition, traces of non-masticatory activities could have facilitated the process of AMTL since contact with foreign particles can result in high dental wear and cause it to become pathological.

5.2.3.1.1. Sex related differences

In both of the periods females were more affected then males. This can be connected to the fact that females were worse-affected by high rates of dental calculus than males and that they may have used their teeth as a tool more often than males (Радовић 2013). The consequence of severe attrition is the retention of food between interdental surfaces, which facilitates calculus accumulation (Aufderheide and

[44] Since Radović (2013) in her PhD thesis did not include samples from Hajdučka Vodenica, I examined the male buried in Grave 13 at this site and observed the tooth wear pattern, as an additional analysis within this thesis.

Rodriguez Martin 1998) and ultimately leads to periodontitis and AMTL. Noteworthy is the observation that pregnancy can also cause or contribute to periodontal diseases (Pirie et al. 2007). During pregnancy, due to the hormonal changes, the inflammatory response to dental calculus is increased, leading to gingivitis (Pirie et al. 2007). Thus, this was most likely one of the reasons why the Mesolithic and the Neolithic females were affected more than males by calculus and, consequently, AMTL.

5.2.3.2. Outside the Danube Gorges

The record of AMTL in the Neolithic individuals from outside the Danube Gorges was much higher (27.8% of the individuals or 7.3% of the teeth) than in both Mesolithic and Neolithic communities in the Danube Gorges. This higher rate of AMTL is also seen in some other Neolithic communities across Europe (Papathanasiou 2011; Masson 2014) and the Near East (Smith et al. 1984).

As mentioned above, the AMTL is a process which can be caused by many factors (e.g. poor oral hygiene, high dental wear and calculus, caries, periodontitis, cultural behaviour, age). The main difference between the Mesolithic and Neolithic communities in the Danube Gorges and those from outside the Gorges lies in the fact that the latter had lower tooth abrasion (see Appendix 1), fewer calculus deposits and greater caries rates. It suggests that the presence of caries in this human group was the main contributor to AMTL, rather than tooth wear and calculus deposits. The development of caries can lead to pulp exposure and infection of the affected teeth, which subsequently results in AMTL.

The results obtained for the Neolithic populations outside the Gorges, which show that they had more AMTL than the population in the Gorges, indicate that caries has more impact on AMTL than high dental wear and the calculus deposits.

All individuals with AMTL outside the Gorges (Perlez Batka C 1 (Fig. 5.27); Golokut-Vizić 2/1984; Starčevo 1; Vinča II, III; Rudnik Kosovski 1) were middle-aged and old adults, and their age must have contributed to AMTL. Among them, presence of caries was detected in three individuals. It is possible that the individuals without caries actually had caries prior to tooth loss.

Due to the small sample size, the differences between males and females could not be fully assessed. However, of the six individuals with AMTL, four were females. This seems to be the same trend seen in the Danube Gorges, i.e. toward more AMTL in females compared to males. However, in order to test whether females in the Neolithic communities outside the Gorges were also more affected, a larger sample size is needed.

5.2.3.3. Conclusion

A high rate of AMTL in the Mesolithic could have been caused by severe dental attrition and high calculus deposits. On the contrary, low rate of AMTL in the Danube Gorges Neolithic is comparable to the rate reported for many other Early Neolithic populations, as well as to rate observed in the Mesolithic period in the Gorges. The reasons for the low frequency of AMTL may lie in the fact that, in general, there are fewer cases in the Neolithic of dental wear and calculus deposits – the elements that would have been the major contributors to AMTL in the Mesolithic. In addition, it seems that softer food (cooked food) and relatively good dietary balance between the amount of proteins and carbohydrates had buffering effect on AMTL in these people. Namely, the only Neolithic humans with AMTL from the Danube Gorges also had high dental wear and high degree of calculus. Among them, AMTL was mostly present in females. This may relate to the fact that females were more heavily affected by high rates of dental calculus and that they used their teeth as tools more often than males. However, the difference may also be caused by biological differences between males and females, where the latter are more susceptible to calculus formation and periodontal diseases due to hormonal changes during pregnancy. This was certainly one of the reasons why the Mesolithic and the Neolithic females were more affected by calculus and, consequently, AMTL than males.

On the other hand, the highest prevalence of AMTL was recorded in the Neolithic human groups from outside the Danube Gorges. They show similar rates of occurrence to those seen in other parts of Early Neolithic Europe. A higher occurrence of caries suggests that its presence was the likely cause of AMTL, rather than tooth wear and the calculus deposits.

5.3. The non specific stress indicators

Here, three non-specific stress indicators, cribra orbitalia, porotic hyperostosis and enamel hypoplasia, are discussed in combination with the results of the stable isotope and starch grain analysis and the analysis of other dietary markers. The observations are interpreted in the light of the Mesolithic-Neolithic transition in different regions of the Central Balkans, and are compared to the relevant data from the Early Neolithic Europe and the Near East. Additionally, wherever possible, the age- and sex-related differences are discussed.

5.3.1. Cribra orbitalia

5.3.1.1. The Danube Gorges

The frequency of cribra orbitalia is similar for the Mesolithic and the Neolithic period; there is no significant increase which was seen in other European Mesolithic-Neolithic transitional populations (Wittwer-Backofen and Tomo 2008; Masson 2014; Ash et al. 2016) (Fig. 5.29; Fig. 5.30). However, while some of the Early Neolithic sites show high prevalence, there are also some sites which show lower frequencies (Papathanasiou 2011; Ash et al. 2016).

Characteristic for both periods is a very low degree with barely discernible lesions. The only difference is visible in the activity of the lesions. Whilst in the Mesolithic the most common are healed lesions, most common in the Neolithic are active lesions. This shows that the Mesolithic humans in most cases successfully healed, whilst the Neolithic ones failed to cure.

Scholars often interpret high frequency of cribra orbitalia as a consequence of a dietary deficiency (e.g. iron deficiency, lack of vitamin C and B12) (Stuart-Macadam 1985; Walker 2009). However, the lesions are probably a result of multiple health conditions and are caused by more than one factor so one should be careful when interpreting cribra orbitalia. Today most of the researchers agree that some form of dietary deficiency and the nutritional misbalance are connected with the increase in the number of cribra orbitalia cases.

The stable isotope analysis showed that, the Danube Gorges Mesolithic people had a generally healthy diet and maintained the nutritional balance. Their diet, rich in aquatic proteins, would certainly have had positive influence on their health status. Although during the Neolithic fish was still an important source for human subsistence, some members of the community started eating more terrestrial products than their co-residents. A recent study (Jovanović et al. submitted) shows that the Neolithic humans consumed more carbohydrates (perhaps cereals) and proteins (from terrestrial animals) and less aquatic resources. This new type of diet suffered from the lack of essential nutrients and could have contributed to the higher number of non-healed lesions of cribra orbitalia in the Neolithic. Furthermore, the high likelihood that early Neolithic humans were intolerant to lactose (Gerbault et al. 2013) could also have led to a number of gastrointestinal problems which could, in turn, have caused nutritional misbalance and poor health in general.

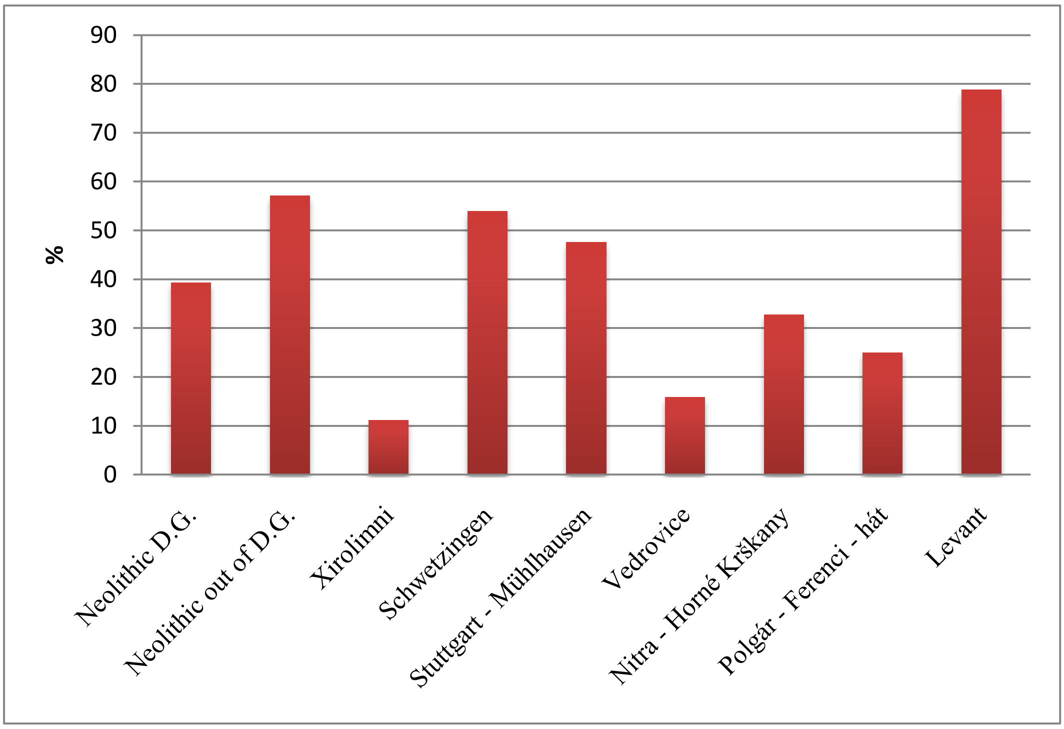


Fig.5.29. The frequency of cribra orbitalia in the Neolithic study regions and other Early Neolithic sites/regions[45]

[45] The data for other Early Neolithic sites/regions were taken from: Hershkovitz and Gopher 2008; Papathanasiou 2011; Ash et al. 2016.

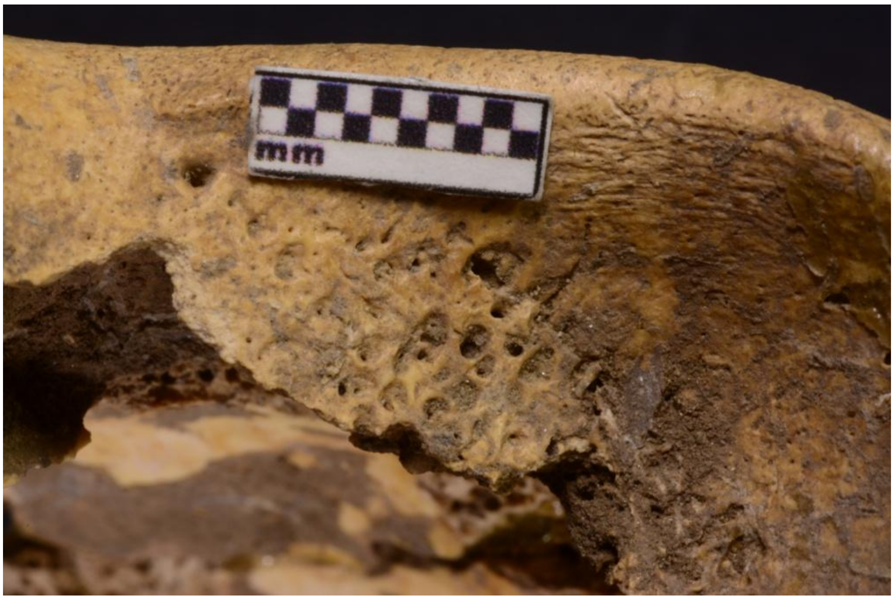


Fig. 5.30. Cribra orbitalia on the left orbital roof, Lepenski Vir, grave 45a

5.3.1.1.1. Sex related differences

There were no significant sex differences in the distribution of cribra orbitalia either between or within the periods. Males follow the same trend seen on the population level, whilst the Neolithic females show lower presence of cribra orbitalia, although these results are not statistically significant (see chapter Results). It is of interest to note that the main difference relates to activity patterns and reveals that there are more healed females in the Mesolithic than in the Neolithic where a single women with cribra orbitalia which showed signs of healing, but died before she could completely heal.

5.3.1.1.2. Children

Children, as the most sensitive category, were in both periods more affected than the adults. The striking result here is that all Neolithic children had cribra orbitalia. Although for both Mesolithic and Neolithic children the degree 1 is most common, the activity type is different and more active lesions occurred in the Neolithic. Noteworthy is that all of the analysed Neolithic children come from the sites of Lepenski Vir and

Ajmana and that their stable isotope ratios indicated a dietary pattern different to the one in the Mesolithic, i.e. with greater consumption of terrestrial products. A recent study (de Becdelièvre et al. 2015; de Becdelièvre in preparation; Јовановић et al. 2015) showed that these children had shorter period of breastfeeding and a diet dominated by terrestrial sources which could have had negative consequences to their health. Furthermore, the gruels they likely have consumed would have been made from cereals and milk. The new diet was deficient in essential nutrients; the different dietary patterns are the likely reason behind the differences in the distribution and activity types of cribra orbitalia between the Neolithic and the Mesolithic children.

5.3.1.2. The interpretation of results from outside the Danube Gorges

While in the Danube Gorges the frequency of cribra orbitalia is similar across both periods, results are different for the Neolithic human groups in regions outside the Danube Gorges (Fig.5.31; 5.32). Although not statistically significant, the results show higher frequency of cribra orbitalia in the Neolithic outside the Gorges, suggesting an important increase in nutritional stress during the Neolithic. The similar percentages are also seen in some Early Neolithic communities across Europe (Wittwer-Backofen and Tomo 2008; Masson 2014; Ash et al. 2016). However, there are also some Early Neolithic sites which show lower percentages then seen in Neolithic outside Danube Gorges (Papathanasiou 2011; Ash et al. 2016).

The most common degree of cribra orbitalia for the Mesolithic and both of the analysed Neolithic groups is degree 1 with barely discernible lesions. Beside the higher frequency in the Neolithic, another main difference between the Mesolithic and Neolithic human groups is in the activity of lesions, where a prevalence of non-healed lesions is detected in the Neolithic. One of the main reasons for this pattern could be the predominantly terrestrial Neolithic diet.

5.3.1.2.1. Sex-based differences

Since the data for males are limited due to the small sample size, the potential for discussion of the sex-specific is highly limited.

Fig. 5.31. Cribra orbitalia on the right orbital roof, Obrež-Baštine, grave 1

Whilst in the Mesolithic both males and females mostly have healed lesions, in the Neolithic outside the Gorges females have lesions that were still active before death, but started to heal, and they also had completely healed lesions. A similar pattern is observed for the only female with cribra orbitalia in the Danube Gorges whose lesions started to heal, but were not entirely healed prior to death. The only male with cribra orbitalia in the Gorges shows healed lesions, while the male from outside the Gorges had a combination of active and healed lesions.

Fig. 5.32. Cribra orbitalia on the left orbital roof, Golokut-Vizić, grave 3/2003

5.3.1.2.2. Children

All Neolithic children outside the Danube Gorges show presence of cribra orbitalia, while in the Mesolithic children, the frequency is lower. For all of the three observed groups of children (the Mesolithic, and the Neolithic in and outside the Gorges) the most common is degree 1, although a Neolithic child from outside the Gorges had the presence of the highest degree of cribra orbitalia. Interestingly, the children from outside the Gorges had mostly healed lesions. This would indicate that they successfully healed more often, and faster, possibly thanks to the steady food supply year-round (e.g. stored crops), while in the Gorges they were generally dependent on the (seasonal) access to riverine food sources.

5.3.1.3. Conclusion

In the Danube Gorges, the frequency of cribra orbitalia in the Mesolithic was similar to that identified for the Neolithic period. The main difference between the two chronologically-defined human groups in the Gorges is in the activity of the lesions – the Neolithic people show higher occurrence of non-healed lesions, that is, they failed to heal before death. In the Gorges, no significant increase was detected with the advent of the Neolithic, otherwise characteristic for most of Neolithic Europe. In the regions outside the Gorges, however, the picture is similar to the one suggested for other parts of Neolithic Europe, with the higher occurrence of, and more active, lesions. The new, sedentary way of life that included zoonotic diseases and lower quality of food may have been the reason for more non-healed lesions in the Neolithic.

Noteworthy, in both of the studied Neolithic groups children were more affected then adults; the increase in the occurrence of cribra orbitalia may be a consequence of the shorter period of breastfeeding, combined with the predominantly terrestrial diet. However, although all of the Neolithic children outside the Danube Gorges show presence of cribra orbitalia, they apparently healed faster probably due to the steady, year-round food supply.

5.3.2. Porotic hyperostosis

5.3.2.1. The Danube Gorges

Porotic hyperostosis was very frequent among inhabitants of the Danube Gorges in both Mesolithic and Neolithic periods. Its high frequency is peculiar as it is much higher than in most Mesolithic and Neolithic communities across Europe and the Near East (Angel 1984; Herskowitz and Gopher 2008; Wittwer-Backofen and Tomo 2008; Papathanasiou 2011; Masson 2014; Ash et al. 2016) (Fig.5.33). Furthermore, the

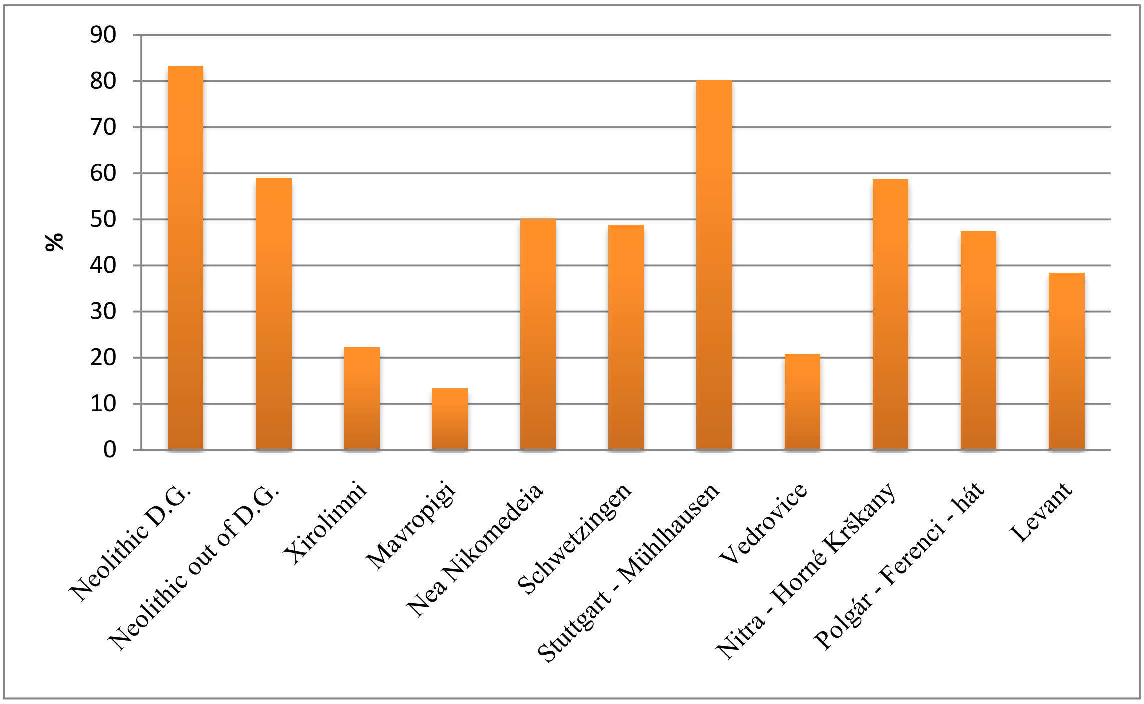


Fig.5.33. The frequency of porotic hyperostosis in the Neolithic study regions and other Early Neolithic sites/regions[46]

observed pattern of its increased occurrence in the Mesolithic is unusual as the situation in other regions is the opposite, and more porotic hyperostosis cases have been noted in the Neolithic. It is interesting to note is a similarly high percentage of porotic hyperostosis was attested at the LBK site of Stuttgart-Mühlhausen (with ca. 80% of the individuals affected – Ash et al. 2016).

This medical condition is a result of manifold process and is often interpreted as a nutritional stress indicator (El-Najjar et al. 1976; Mensforth et al. 1978; Goodman et al. 1988). However, dietary misbalance was probably not the cause of the condition in all of the identified cases in the here-studied prehistoric population, since all the other considered dietary parameters suggest the opposite – i.e. a balanced diet (especially for the Mesolithic period). There are some studies that link increase in porotic hyperostosis with the depletion of vitamin B12 (e.g. Walker et al. 2009). Since vitamin B12 is found exclusively in foods of animal origin, it is almost impossible that the Mesolithic population, which heavily relied on animal proteins in diet, would have suffered from vitamin B12 deficiency.

[46] The data for other Early Neolithic sites/regions were taken from: Hershkovitz and Gopher 2008; Papathanasiou 2011; Ash et al. 2016.

Besides poor nutrition, the condition can develop as a consequence of various diseases (Goodman and Martin 2002), bacterial infections and inflammatory processes after scalping (Schultz 2001). Traces of treponemal diseases have been detected in the Mesolithic-Neolithic inhabitants of the Danube Gorges (Стефановић 2012) and they perhaps point at these diseases as one of the possible causes. Furthermore, on some skulls traces of scalping are also noticed (Fig. 5.34), possibly indicating an intervention during healing process in order to remove infected tissues (Стефановић 2012). It is possible that the inflammation of bone tissue after scalping caused some of the porotic hyperostosis lesions, especially given that, in both periods, the most common degree is degree 2 and the higher degrees are less represented. Cultural habits are also identified as potentially having an impact on the formation of lesions (e.g. making hairstyles with a harmful use of comb or wearing ribbons around the head can produce lesions and result in porotic hyperostosis). This is usually linked with females. A possible evidence of the females in the Gorges wearing some kind of ribbons around the head (possibly used to enable carrying of load on the head) provides a Neolithic female buried at Lepenski Vir (Grave 8) (Stefanović in press). It is possible that some cases of porotic hyperostosis in the Danube Gorges were culturally induced.

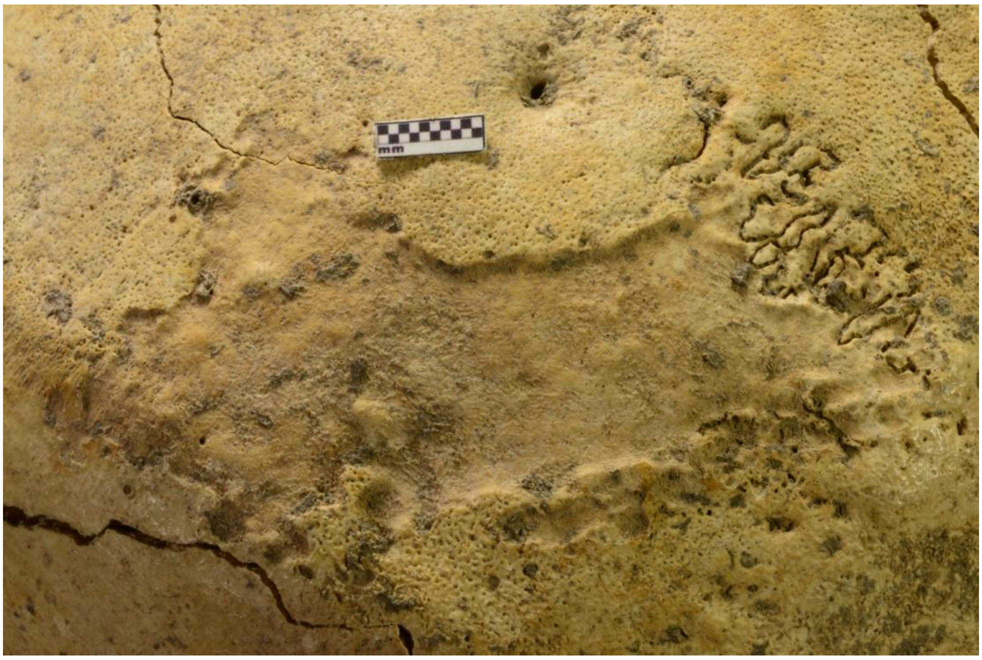


Fig. 5.34. Porotic hyperostosis with traces of scalping, Lepenski Vir, grave 45b

The main difference between the individuals from the two periods is in the activity patterns. Whilst 50% of the Mesolithic people succeed in healing, more individuals (40%) had non-healed lesions (category 1) in the Neolithic then in the Mesolithic. The new foods that people started to consume in the Neolithic, which lacked essential nutrients, and the reduction of the breastfeeding period may have contributed to the high occurrence of non-healed lesions. Thus, whatever the reason was for the common occurrence of porotic hyperostosis in this prehistoric population, the diet rich in proteins played a major role in the healing process. On the other hand, the increase in treponemal infections in the Neolithic (Стефановић 2012) may have resulted in the prevalence of non-healed lesions in this period.

5.3.2.1.1. Sex-related differences

Both the Mesolithic and the Neolithic males and females follow the same trend observed on the population level. However, in the Neolithic there is sex-specific difference – women have more non-healed lesions. This result is not surprising, since females generally show prevalence of other health indicators, and the causes for their medical conditions could have been many (e.g. greater susceptibility due to lower immunity connected with the higher number of pregnancies in the Neolithic, or the reduced mobility).

5.3.2.1.2. Children

Compared to the Mesolithic, the Neolithic children show lower number of cases of porotic hyperostosis. Although they have a similar number of lower degrees, the activity of lesion is different and indicates that, in the Neolithic, more children failed to heal. One of the possible explanations could be the shorter period of breastfeeding which certainly had negative effects on their immunity and led to more active lesions in the Neolithic.

5.3.2.2. Outside the Danube Gorges

In comparison with the Mesolithic-Neolithic human groups in the Danube Gorges, the Early Neolithic humans outside this region displayed extremely low frequencies of porotic hyperostosis. However, although less than the coeval population in the Gorges, they were still highly affected, with more than 50% of the population suffering from this condition, similar to the most communities across Europe (Wittwer-Backofen and Tomo 2008; Papathanasiou 2011; Ash et al. 2016).

Concerning the three studied groups, one can observe a decreasing trend through time in the frequency and degree of porotic hyperostosis but, at the same time, the differences in activity patterns. In the Mesolithic, only 18% of people had non-healed lesions, while in the Neolithic, in both of the study areas, the percentage of people with active lesions is higher than in the preceding period (between 30-40%). In the Mesolithic people successfully healed, whereas in the Neolithic most people did not heal.

In the Danube Gorges one of the possible causes could be treponemal diseases; in the region outside the Gorges one should look for a different explanation since the traces of the infectious diseases were not detected anywhere in this area. As already mentioned, porotic hyperostosis is a condition caused by many factors which can act individually or as a suite. The dietary pathways (lower protein intake, more carbohydrates) of the population outside the Gorges were different to those in the Mesolithic-(Neolithic) Gorges, and they could have had adverse effect on the healing process. In contrast to the Gorges, a possible depletion in vitamin B12 could have been a reason for the high incidence of porotic hyperostosis outside the Gorges. Moreover, the life in densely occupied settlements close to domesticates contributed to the development of more zoonotic diseases could also have been one of the factors. Besides, milk consumption and lactose intolerance (which causes gastrointestinal problems, leading to loss of essential nutrients) could have played a role in the frequent occurrence of porotic hyperostosis. In addition, some every day habits are also known to have influence on the formation of lesions (e.g. overly thorough use of comb can form lesions, or wearing ribbons around the head).

5.3.2.2.1. Sex specific differences

The females and males follow similar trends seen on the population level as well as those seen in when compared to the Danube Gorges Mesolithic-Neolithic human groups. Due to the small sample of male individuals, further consideration of the differences between the Neolithic females and males from outside the Danube Gorges is meaningless.

5.3.2.2.2. Children

The children from outside the Gorges were also significantly affected by porotic hyperostosis[47]. While most of them show the lowest degree (1), they also show the active state of lesions, meaning that they failed to heal prior to death[48]. The children from the Golokut-Vizić site (Grave 2/2003; 3/2003 (Fig.5.35); 4/2003) are the most affected. They all show terrestrial dietary pattern, especially the child from Grave 2/2003 which also exhibits a very low animal protein intake. All of the children also show the presence of Cribra orbitalia. The combined evidence suggests that these children suffered from nutritional misbalance, it is likely that the terrestrial diet could not provide enough of nutrients and boost the immunity to be able to cope with the condition.

5.3.2.3. Conclusion

In both Mesolithic and Neolithic period in the Danube Gorges porotic hyperostosis was very frequent, which is an unusual pattern rarely seen in other European Mesolithic-Neolithic transitional populations. Although porotic hyperostosis

[47] On the basis of the occipital bone evidence, 16.66% children were affected; when the evidence from other observed bones (frontal and pariteal) is considered, the proportion of affected children is as high as 66.66%. As explained in the methodology chapter, only the occipital bone evidence was included in the statistical analysis, since it is the best represented across the entire sample. However, although most of the individuals have porotic hyperostosis on both the occipital and the frontal or parietal bone, the studied children had porotic hyperostosis mostly on the frontal or parietal bone and much less on the occipital bone. From the aspect of the statistical analysis, the result is not significant when the whole age category is concerned, but is, however, significant when considered on the individual level. Thus, the children without porotic hyperostosis traces on the occipital bone are here also mentioned and included in the discussion.

[48] Except for the child from Grivac, for which the stable isotope data are not available.

Fig. 5.35. Porotic hyperostosis detected on parietal bones, Golokut-Vizić 3/2003

is known to be caused by multiple factors, it seems that, in this region, treponemal infections significantly contributed to the high occurrence. The main difference between the two periods is in the activity patterns, where the Mesolithic aquatic diet may have provided better chances for the recovery. On the other hand, with the increase in infectious diseases in the Neolithic, it became difficult for the inhabitants of the Danube Gorges to heal, especially for females.

For the Neolithic human groups from outside the Danube Gorges, a different explanation should be sought. Although porotic hyperostosis is as common here as in other Early Neolithic populations in Europe, it occurred in fewer cases than in the Mesolithic or the Neolithic datasets from the Gorges, or the two combined. One can observe a decreasing trend in frequency and degree of porotic hyperostosis over time but, on the other hand, an increase in the number of people who failed to heal. Therefore, although many people in the Mesolithic and Neolithic of the Gorges suffered from this condition, many of them successfully healed, probably owing to the benefits of the aquatic diet, whilst the contemporary communities outside the Gorges had a terrestrial diet which had an adverse effect on the healing process.

5.3.3. Enamel hypoplasia

5.3.3.1. The Danube Gorges

The inhabitants of Mesolithic-Neolithic settlements in the Danube Gorges had low occurrence of childhood physiological stress. There were no sex-related differences between the periods or within the Neolithic period. Although in the Neolithic the intensity of stress gradually increased (i.e. the proportion of individuals showing evidence of more than one stressful event is higher), the statistical test did not indicate significant differences on the population level or between males and females.

This human group was of relatively good health during childhood and the process of Neolithisation did not seem to have had as much impact as observed in other European Mesolithic-Neolithic transitional populations (Fig. 5.36). In most of the studied regions, the frequency and intensity increase through time (Roosevelt 1984; Hershkovitz and Gopher 2008; Wittwer-Backofen and Tomo 2008). For instance, among LBK populations, the occurrence of linear enamel hypoplasia affected between

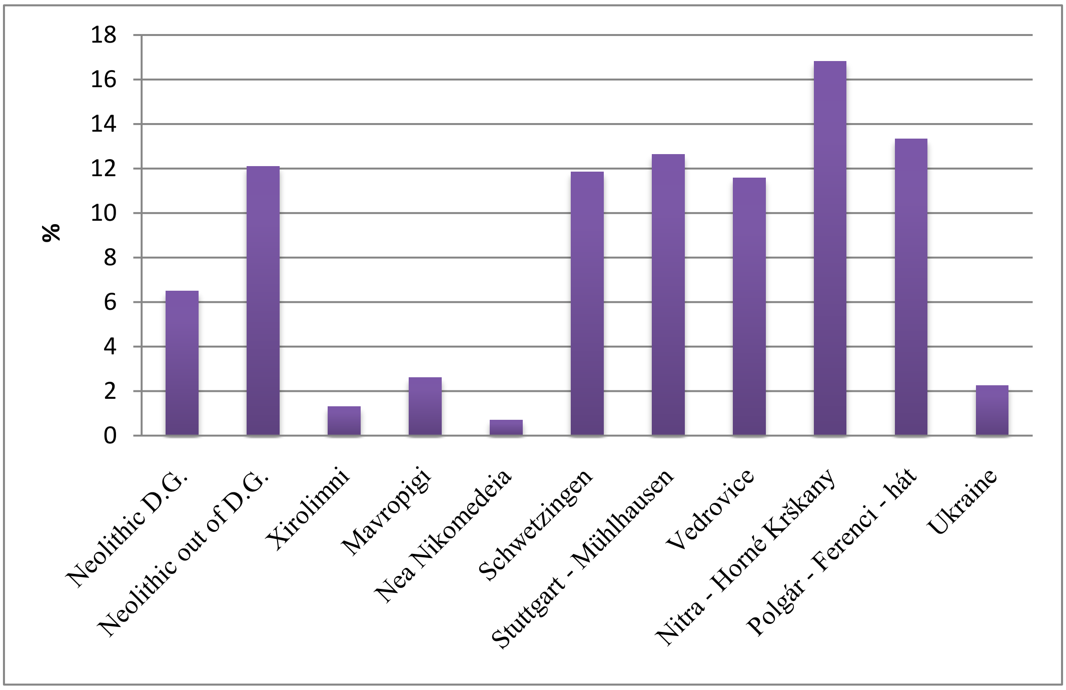


Fig.5.36. The prevalence of enamel hypoplasia in the Neolithic study regions and other Early Neolithic sites/regions[49]

[49]The data for other Early Neolithic sites/regions were taken from: Lillie 1996; Papathanasiou 2011; Ash et al. 2016.

12-17% of the analysed teeth (Ash et al. 2016) or 13.5% of the individuals (Jarošová and Dočkalová 2008). In the Levant, the occurrence is even higher – between 22-41% of the teeth are affected (Smith et al. 1984; Al-Abassi and Sarie 1998; Hershkovitz and Gopher 2008). In Anatolia, at Nevali Çori, 70% of the individuals exhibited hypoplastic defects (Teegen and Schultz 1997, 1998). However, although on Early Neolithic sites in Greece a low prevalence of EH (Papathanasiou 2011) were attested, the sample size from these sites is very small.

On the other hand, there are Early Neolithic communities with very low occurrence of enamel hypoplasia. For instance, in Ukraine, during the Mesolithic-Neolithic transition, very low rates of hypoplasia are attested for both periods (Mesolithic 1.21%; Neolithic 2.25% – Lillie 1996) suggesting lower levels of stress during childhood compared to the contemporaneous communities elsewhere. In the Early Neolithic of Greece a similarly low occurrence is observed (0.7-2.6% of affected teeth – Papathanaisou 2010). Based on these results, the proportions obtained for the Danube Gorges Neolithic communities correspond well to those of humans from the Dnieper Rapids region of Ukraine and the Greek Early Neolithic. These three communities are also characterised by low levels of other non-specific conditions as well as generally protein-rich diet. Whilst in the Dnieper region proteins were mostly derived from aquatic resources (Lillie et al. 1996), in the Early Neolithic of Greece proteins were obtained from meat of domestic animals and wild game (which provided sufficient protein despite the consumption of C_3 plants – Papathanaisou 2010). For the Neolithic human groups in the Danube Gorges aquatic products were important part of the diet despite the noted increase in the consumption of terrestrial resources (Grupe et al. 2003; Borić et al. 2004; Nehlich et al. 2010; Nehlich and Borić 2015; Jovanović et al. submitted).

The protein-dominated diet could have provided a certain degree of protection that also had impact on the levels of childhood nutritional stress. However, a small increase in the occurrence of enamel hypoplasia (6.5% of teeth affected), followed by an increase in the number of stress episodes (63.63% of the individuals had more than one stress episode), is observed for the Neolithic humans in the Danube Gorges. The increase, albeit minor, indicates that the Neolithic children witnessed more stress episodes than the Mesolithic children. Although slightly more Mesolithic children show the presence of hypoplasia, Neolithic sub-adults had more stress episodes. This could further be linked to the weaning stress and the introduction of new, agricultural food. This hypothesis is supported by the isotopic data indicating the reduction in the length of breastfeeding and revealing the differences in the children feeding practices between the Mesolithic and the Neolithic (Јовановић et al. 2015; de Becdelièvre in preparation). The Mesolithic children had predominantly aquatic diet and long breastfeeding. In contrast, the Neolithic children had a mixed terrestrial-aquatic diet and were breastfed for a shorter period than was the case in the Mesolithic. Furthermore, in the Neolithic, children developed linear enamel hypoplasia earlier in life (on average, at 3.0-3.4 years of age) than was the case with the Mesolithic children (who developed it at the age of 3.5-3.9 on average); this confirms that, in the Neolithic, children were exposed to stress earlier in life.

Some studies showed that enamel hypoplastic defects mostly appear when exclusive breastfeeding terminates and weaning food is being introduced (Goodman and Armelagos 1989). Weaning period is the period when infants start to eat solid foods, which can contain various pathogens. Therefore, this period can be very stressful for infants and can lead to a gradual loss of crucial nutrients and reduced immunity (Rodney 1983) which makes children more susceptible to pathogens (Moggi-Cecchi et al. 1994). There are, however, studies that did not detect a direct correlation between weaning and the formation of hypoplasia (e.g. Blakey et al. 1994). In general, though, it is accepted that there is a connection between the introduction of weaning food and the appearance of hypoplastic defects (Goodman and Martin 2002).

In the Danube Gorges, longer breastfeeding in the Mesolithic provided protection for children's health; the results show that the Mesolithic children experienced stress at the end of the weaning period or later in their life. In contrast, shorter breastfeeding in the Neolithic caused health stress earlier in children's life, since children protected by mother's milk over a shorter period of time which had a negative impact on their health. It is important to emphasise that the Neolithic weaning food (possibly made from cereals and milk), although filling, lacked essential vitamins and minerals. This could also have contributed to malnutrition and vitamin deficiency, leading to infectious diseases and higher EH occurrence.

Compared to the data for other Early Neolithic populations, where the occurrence of hypoplasia was much higher, one can suggest that the Danube Gorges Neolithic communities had favourable living conditions in which maintaining the dietary traditions of predecessors and the protein-rich diet protected their health, as indicated by their apparently high ability to cope with physiological stress.

5.3.3.2. Outside the Danube Gorges

As opposed to the Neolithic groups in the Danube Gorges, those from outside the Gorges show significantly higher levels of childhood stress, with more than 50% (54.2%) of individuals affected, or 12.1% of the teeth affected. When observed on the community level, of note is also the number of stress episodes – the Neolithic humans from outside the Gorges show the highest frequency of all of the groups observed (Fig. 5.37; Fig. 5.38). It appears that the process of Neolithisation had strong influence on them; their rates of hypoplasia are similar to those established for most of the studied Early Neolithic communities (Roosevelt 1984; Formicola 1987; Teegen and Schultz 1997, 1998; Hershkovitz and Gopher 2008; Wittwer-Backofen and Tomo 2008), especially the LBK communities (Jarošová and Dočkalová 2008; Ash et al. 2016).

Fig. 5.37. Linear enamel hypoplasia on maxillar teeth, Klisa, grave 8

A great number of studies (Rose et al. 1978; Smith et al. 1984; Teegen and Schultz 1997; Krenz-Niedbala 2001; Wittwer-Backofen and Tomo 2008) show that, with the adoption of agriculture, the occurrence of enamel hypoplasia became more frequent because the diet of the farmers was mostly based on domesticated plants. Indeed, consumption of cereals could inhibit absorption of important minerals. Namely,

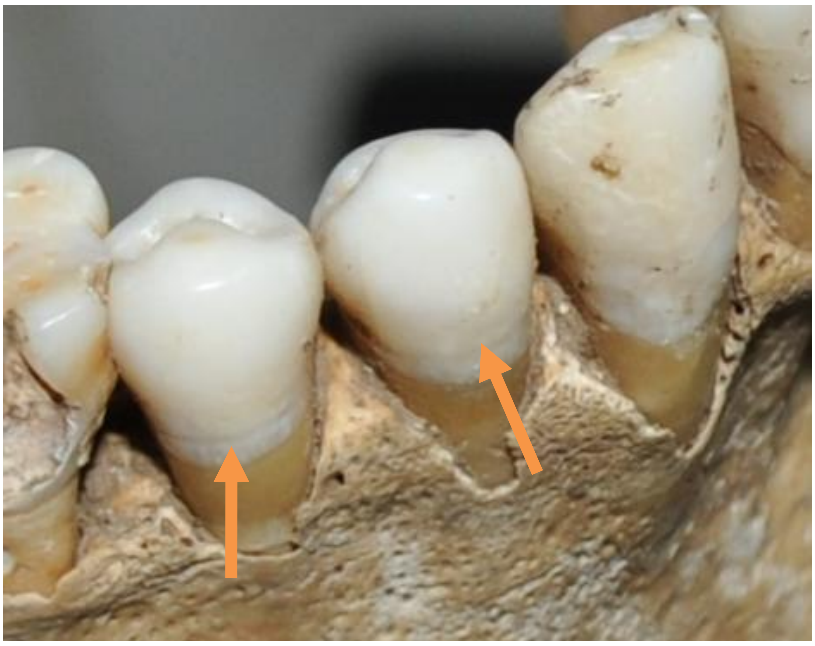


Fig. 5.38. Linear enamel hypoplasia on maxillar teeth, Klisa, grave 8

phytates from cereals are the most responsible for the inhibition of zinc, magnesium and iron, leading to anaemic conditions. Iron is more easily absorbed from animal products than plants, thus the greater consumption of plants in the Neolithic could have affected the absorption of iron. Also, the potentially widespread lactose intolerance of the Early Neolithic humans could have led to gastrointestinal problems that result in iron deficiency. The debate among scholars on the essential causes of increased hypoplastic defects is ongoing. Nevertheless, they all agree that there is a strong relationship between malnutrition and micronutrient deficiencies (e.g. Goodman and Armelagos 1989), and a number of systemic and physiological stressors (e.g. Infante and Gillespie 1977; Solomons and Keusch 1981; Goodman et al. 1991; Shell-Duncan 1997) and a range of diseases such as rubella, tetanus and syphilis (e.g. Pindborg 1982).

Despite the difficulty in identifying the exact source of the stress, it is likely that malnutrition and susceptibility to diseases led to the frequent occurrence of enamel hypoplasia. Thus the significantly high occurrence of enamel hypoplasia in the human groups from outside the Danube Gorges can be explained by several factors. The introduction of new type of food and bacteria from milk and the resulting infectious diseases could have led to more stress episodes in the Neolithic. As the dietary data show, these Neolithic communities had a different type of diet compared to the Mesolithic and Neolithic humans in the Danube Gorges. Their mainly terrestrial diet lacking essential nutrients is certainly one of the reasons for increased stress. Likewise, shorter breastfeeding in the Neolithic could have resulted in more stressful episodes than in the Mesolithic. The new, sedentary way of life also played an important role in the occurrence of stress. Neolithic humans lived close to one another and their domestic animals, which may have had as a consequence poor hygiene conditions and increased occurrence of zoonoses.

Concerning the timing of LEH, most of the hypoplastic defects occurred between 2-5 years of age, which can be correlated to weaning stress. A situation similar to the one observed for the Neolithic in the Danube Gorges is identified in the Neolithic children from outside the Gorges – all of the children up to around the age of 3 had similar proportions of hypoplastic defects. In the Neolithic, the highest rates of hypoplasia characterised children of the age of around 3, which is earlier than in the Mesolithic when the 'peak' in hypoplasia occurrence characterised children at the end of their third year of age; shorter breastfeeding period is the most plausible explanation for this. Although data on the length of breastfeeding for the Neolithic children from outside the Gorges are limited (they are available only for two children), they show a pattern similar to that observed for the Neolithic children from the Gorges. This may suggest that the noted differences in timing of LEH are related to the age at which weaning started.

5.3.3.3. Sex specific differences

Sex-specific differences in the occurrence of enamel hypoplasia were not detected in the Danube Gorges[50]. On the other hand, in the study regions outside the Gorges there is a trend towards greater number of enamel hypoplasia in females.

[50] Concerning the number of stress episodes for males and females in the Danube Gorges, the data are limited due to the small sample size and are, therefore, not discussed.

However, the data from outside the Gorges are few and therefore not suitable for consideration of sex-specific differences.[51]

The Neolithic females from outside the Danube Gorges show more stress episodes than do males in the Mesolithic and Neolithic of the Danube Gorges. In addition, outside the Gorges there were no females with a single crisis episode – they all had more than one stress event. This may indicate worse living conditions for the girls during childhood.

Although some aspects of enamel hypoplasia analysis are unclear, noteworthy is the greater number of affected females, especially outside the Gorges. The timing of the development of hypoplasia is different in males and females in all of the three observed groups and shows that females developed hypoplastic defects earlier in their lives than males (Table 5.2). Similar rates of occurrence and the differences between males and females were documented for LBK groups (Ash et al. 2016).

Period	Females	Males
Mesolithic	3.2	3.7
Neolithic in the Danube Gorges	3.7	3.9
Neolithic outside the Danube Gorges	3.2	-

Table 5.2. showing average age for the onset of linear enamel hypoplasia formation for males and females in the three studied groups

The higher occurrence rates and the earlier onset of hypoplastic defects in females can be explained by multiple biological and cultural factors. For instance, studies that detect higher occurrence in males usually explain this pattern as a consequence of genetic difference suggesting that males are more sensitive to stress than females (Van Gerven et al. 1990; Zhou 1995; Palubeckaite 2001), since females possess a better buffering mechanism. Namely, scholars argue that females, due to hormonal differences and their reproduction role, are better protected against

[51] Of the two males examined, only one showed the presence of dental hypoplasia.

environmental stress factors than males (Stinson 1985; Guatelli-Steinberg and Lukacs 1999). One the other hand, higher levels of EH in females may suggest better treatment of males in some cultures (Goodman et al. 1987; May et al. 1993). Since enamel hypoplasia reflects stressful event during childhood, it could be hypothesized that later average age at the onset of enamel hypoplasia formation in males suggests later start of weaning in boys. This could imply that, in the Neolithic, girls lived in worse conditions than boys and that they were treated differently. Further, after the cessation of breastfeeding, girls could have been weaned mainly with cereal gruels and milk/dairy whereas boys could have been weaned mostly with meat-based food. The diet that included more proteins and/or delayed weaning for boys could have caused differences in the timing of the onset of hypoplastic defects. Also, it is possible that the period of exclusive breastfeeding was shorter in girls, leading to the earlier average age at the onset of hypoplasia formation.

However, the earlier eruption of teeth in girls, which is on average 4-6 month earlier than in boys (Nystrom et al. 2001, cited in Almonaitiene et al. 2010), would have meant longer exposure of girls' teeth to environmental stress, leading to an earlier onset of hypoplastic defects. This could also have contributed to the earlier timing of LEH.

5.3.3.4. Conclusion

The Mesolithic-Neolithic inhabitants of the Danube Gorges had low levels of childhood physiological stress. The (aquatic) protein-based diet could have played a protective role. With the advent of the Neolithic there was a slight increase in childhood stress, with more number of stressed episodes, probably due to the introduction of new, predominantly terrestrial (cereals and milk) diet. Compared to the data from other Early Neolithic populations, where the occurrence rates of hypoplasia are much higher, one could argue that the Danube Gorges Neolithic population lived in favourable conditions, maintained old food traditions and consumed protein-rich food that protected their health, as indicated by their ability to successfully cope with physiological stress. However, Neolithic children were exposed to stress earlier in their life which could be linked to the earlier start of weaning (due to shorter breastfeeding period). The combination of shorter breastfeeding and new agricultural food may have led to slightly higher occurrence of stress in the Neolithic children in the Danube Gorges compared to the Mesolithic.

By contrast, the process of Neolithisation seems to have strongly influenced the Neolithic human groups outside the Danube Gorges, and led to the frequent incidences of childhood stress. Although Neolithic baby food (possibly made of cereals and milk) ensured that children remained sated for a while, it lacked important vitamins and minerals. This could also have contributed to malnutrition and vitamin deficiency, leading to infectious diseases and, consequently, high occurrence of hypoplasia. The most affected in the transitional process were females living outside the Gorges; this may indicate that their living conditions during childhood were worse than those of males. On the other hand, in all of the three observed groups girls shows earlier onset of stress events. The higher frequency and the earlier onset of hypoplastic defects in females can be explained by multiple biological (e.g. earlier eruption of teeth in girls, genetics) and cultural (e.g. preferential care for boys) factors.

5.4. Body proportions

In this section the results of the analysis of body size, body mass and body mass index will be combined and interpreted, and they will be compared with the available data from other relevant studies from Early Neolithic Europe and the Near East. The results are discussed in relation to the Mesolithic-Neolithic transition in different regions of the central Balkans and are examined alongside other health and dietary parameters considered in this study. In addition, differences between the results for males and females are discussed in detail.

5.4.1. Stature and body mass

The results reveal a trend toward decrease in adult stature from the Mesolithic to the Neolithic period. The Mesolithic humans were tall, slim, with large body size, whilst both of the Neolithic groups studied in this thesis were shorter and smaller. The decrease in the stature is followed by a reduction in body mass through time, which corresponds to the reduction in body size.

A similar trend in stature reduction, often connected to the intensification of agricultural production, is observed in other European Mesolithic-Neolithic transitional populations (Angel 1984; Larsen 1984; Meiklejohn et al. 1984; Formicola and Giannecchini 1999; Piontek and Vančata 2002; Hermanussen 2003; Ehler and Vančata 2009; Papathanasiou 2011). Various studies have demonstrated that changes in the body proportions are linked to numerous factors such as the environment (Larsen 1995), dietary changes (Hauspie 2002; Hindmarsh 2002), overall health (Cohen and Armelagos 1984; Goodman et al. 1984; Kemkes-Grottenthaler 2005), physical activities (de Becdelièvre et al. 2015, 2016; Ruff et al. 2015), genetics (Ehler and Vančata 2009). These studies understand changes in the diet as a main determinant of the body proportions. As Larsen (1995) already stated, there is a growing body of data which suggest that, during periods of starvation or malnutrition stature reduces (Fogel et al. 1983, Yagi et al. 1989, cited in Larsen 1995), whilst good dietary balance results in the stature increase (Eveleth and Tanner 1990, cited in Larsen 1995).

Dietary changes could be one of the possible explanations for the differences in the body proportions between the Mesolithic and Neolithic human groups in the study areas. The research on the diet, including stable isotopes and starch grain analyses, showed that Mesolithic diet was rich in proteins derived from aquatic resources (Grupe et al. 2003; Borić et al. 2004; Nehlich et al. 2010; Jovanović et al. submitted), whilst in the Neolithic proteins from terrestrial sources and carbohydrates represent the dietary basis. The Mesolithic human groups were of relatively good overall health; the Neolithic people outside the Danube Gorges had slightly higher frequencies of non-specific stress markers, such as cribra orbitalia and enamel hypoplasia. Thus, dietary changes and the health decline (as evidenced by higher occurrence of non-specific stress indicators) could have contributed to the decrease in stature. Another important factor which could have resulted in the shorter body proportion may have been the shorter period of lactation and, consequently, earlier age at weaning and stress exposure in the Neolithic people.

Further, changes in the daily activities could have also negatively influenced the stature. A recent study by de Becdelièvre and colleagues (2015a, 2016) documents different mobility patterns between the Mesolithic and Neolithic human groups in the Danube Gorges. It shows a trend towards reduced daily mobility in the Neolithic (especially in females) connected to the semi-sedentary way of life, which could have had positive effects on the overall reduction in body proportions.

One should, however, be extremely careful when interpreting these data, concerning the Neolithic groups outside the Gorges as body proportions of their potential pre-agricultural ancestors are unknown. Thus, different genetic background should also been take into consideration. In sum, the observed decrease in the stature could have been impacted by a combination of various factors such as genetics, diet and mobility patterns that are different in the Mesolithic and Neolithic human groups.

5.4.1.1. Sex-related differences

Males and females from both periods show decrease in stature. It is interesting to note that, the Mesolithic and Neolithic males and females from the Danube Gorges were taller than most of the contemporary inhabitants of Europe. On the other hand, the females from outside the Gorges were of an average stature of 154 cm which compares well to the stature of other females in Early Neolithic Europe (Angel 1984; Formicola and Giannecchini 1999; Piontek and Vančata 2002; Hermanussen 2003; Ehler and Vančata 2009; Larsen et al. 2015) (Fig. 5.39).

Both Mesolithic males and females were taller than the Neolithic ones. Neolithic males from the Danube Gorges were very tall and were among the highest in Early Neolithic Europe and the Near East; they mostly resemble Xirolimni (Papathanasiou 2011) and Jericho males (Larsen et al. 2015) (Fig. 5.39). Their body mass is similar to that of the central European LBK communities. According to the available literature (Angel 1984; Formicola and Giannecchini 1999; Piontek and Vančata 2002; Hermanussen 2003; Ehler and Vančata 2009; Papathanasiou 2011; Larsen et al. 2015), the Danube Gorges Neolithic females were the tallest in Europe, but were of similar weight to the females in the rest of Europe (especially LBK females) (Fig. 5.40). Based on their height and weight, it may appear that they were more fit than other Early Neolithic females.

Following the Mesolithic-Neolithic transition in the Danube Gorges, the male stature decreased more (7cm on average) than the female (4cm on average). This indicates that there was no decrease in the female stature, as seen in other European

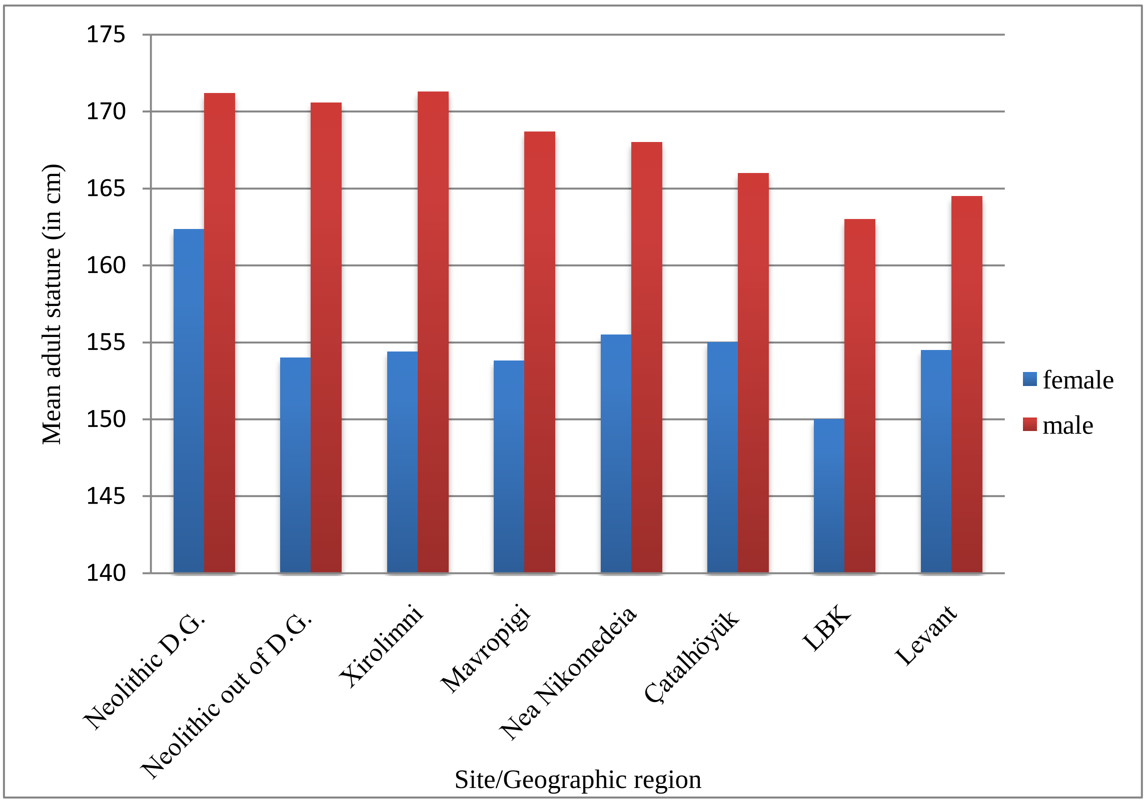


Fig.5.39. Estimated adult stature in cm in the Neolithic study regions and other Early Neolithic sites/regions[52]

Mesolithic-Neolithic transitional populations. This particular sex-specific trend pertinent to females is often explained by the observation that the changes brought about by the NDT deeply affected women, whose bodies had to cope with, and adjust to, higher fertility and/or who may have had a different diet to man (Wittwer-Backofen and Tomo 2008). In case of the Danube Gorges, the stable isotope results show that there was no sex-specific diet, whilst a recent paleodemography study suggests an increase in the female's fertility (de Becdelièvre et al. 2014). If the Danube Gorges women had higher fertility and shorter periods between birthing, they could have been more vulnerable and sensitive to general stress. However, it seems that the diet rich in aquatic resources could have had positive impact on female's physiological fitness.

In contrast, in the regions outside the Danube Gorges, females were very small; the data for male populations are limited and thus potential sex-specific trends could not

[52] The data for other Early Neolithic sites/regions were taken from: Hershkovitz and Gopher 2008; Papathanasiou 2011; Piontek and Vančata 2012; Larsen et al. 2015.

be discerned. There is a difference in the stature between the females in and outside the Gorges suggesting that the latter had a more pronounced reaction to the general stress situation during the NDT. Their different diet, rich in terrestrial food and carbohydrates and containing little or no aquatic proteins could have had negative effects on their overall health, including the reduction in stature. Furthermore, shorter breastfeeding could also have played a part in their stature decrease but does not seem to have influenced their weight. This could be explained by higher consumption of high-energy food such as that containing carbohydrates, and the reduced mobility. Caution is, however, needed when interpreting these data and one should bear in mind that the two studied Neolithic groups represent different populations; the origin of Neolithic groups outside the Gorges is unknown as are the body proportions of the people who they may have descended from and who may not have practiced agriculture.

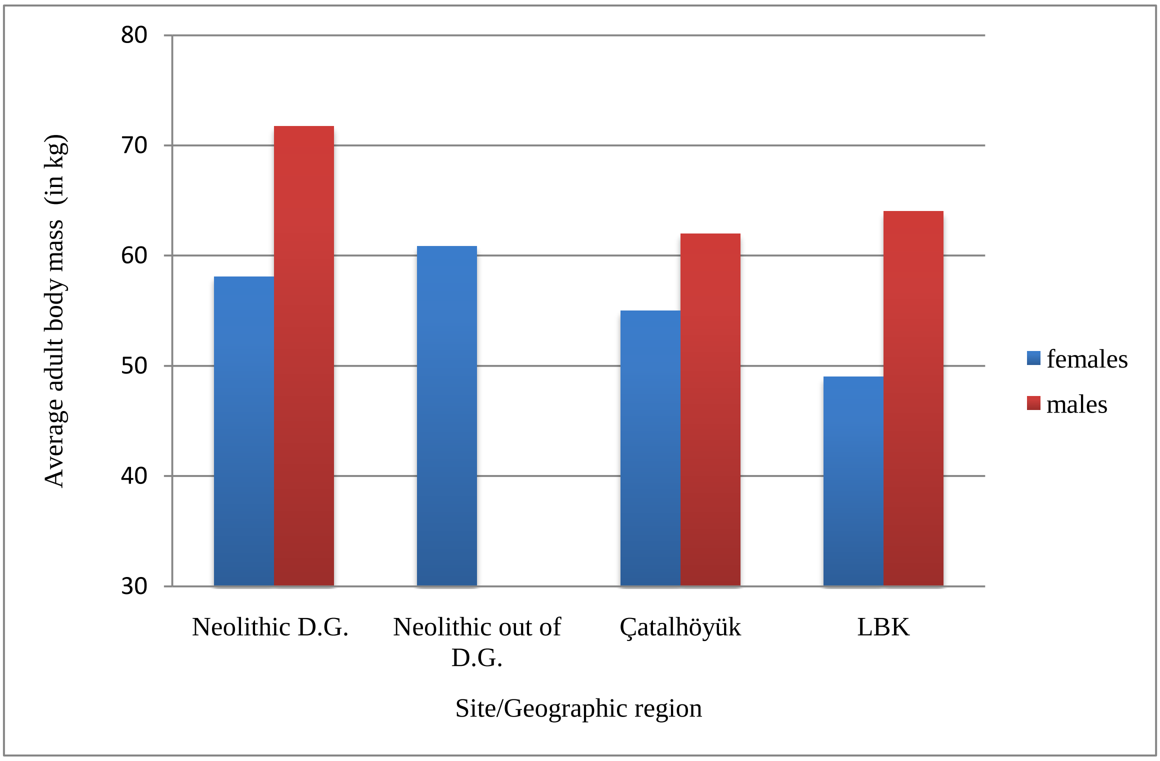


Fig. 5.40. Estimated adult body mass in the Neolithic study regions and other Early Neolithic sites/regions[53]

[53] The data for other Early Neolithic sites/regions were taken from: Piontek and Vančata 2012; Larsen et al. 2015.

Overall, the results reveal an important decrease in the average stature and body mass in the Neolithic human groups compared to the Mesolithic, and especially clear is the difference between females from in and outside the Danube Gorges. This manifestation of the relative growth decline through the Neolithic, especially among women, is a result of the higher occurrence of physiological stress, lower intake of animal proteins and a change in daily activities in comparison to the Mesolithic. It suggests that girls during childhood could have had a different status (e.g. limited access to resources) that made them more vulnerable to various stress conditions which, ultimately, affected their body proportions.

5.4.2. Body mass index

Body mass indices show that the normal body mass index was the generally sustained throughout the Mesolithic-Neolithic sequence. This indicates that people had mostly normal growth trajectories and regular access to necessary nutrients (e.g. enough proteins, vitamins, minerals). This is especially visible for the Mesolithic, where 90% of the individuals had a normal body mass index whilst the rest were overweight.

From the Mesolithic sequence in the Danube Gorges, three individuals from Vlasac were identified as being overweight. A non-local (Borić and Price 2013) female buried in grave 32 had aquatic diet and showed presence of healed porotic hyperostosis, enamel hypoplasia, and ante mortem tooth loss. Two other overweight individuals were males of local origin (Borić and Price 2013): the old male buried in Grave 60 (characterised by aquatic diet and healed cribra orbitalia) and the middle-aged male buried in grave 78 (characterised by aquatic diet, presence of dental calculus and porotic hyperostosis with mixed and healed lesions).

In the Neolithic there is a greater variability in body mass indices, with 60% of the individuals with normal body mass index.

The only underweight individual in the studied sample is a middle-aged female buried at Lepenski Vir (grave 32b). Interestingly, the preserved bones do not show any traces of pathologies[54]. The only element reflecting her health is the high degree of

[54]The skull is not present, only the mandible. The postcranial bones also show no traces of pathologies. The information on her diet based on the stable isotope analysis is limited due to the low/non-valid C/N ratio.

dental calculus. Further, a male buried at the same site (grave 7/I) was the only Neolithic individual from the Danube Gorges who was overweight. This old man had a predominantly terrestrial diet and the presence of starch grain was detected in the calculus on his teeth. In the regions outside the Danube Gorges, two females from the site of Golokut-Vizić show overweight body mass index. Noteworthy is that these middle-aged females displayed significant number of dental and skeletal pathological conditions (the woman from grave 2/1984 with mostly terrestrial diet had cribra orbitalia with mixed healed and non-healed lesions, presence of dental caries, enamel hypoplasia and ante mortem tooth loss; the woman from grave 3/1984 had very low protein intake, presence of starch grains, cribra orbitalia with mixed healed and non-healed lesions, presence of dental caries and enamel hypoplasia).

Given that all of the overweight individuals suffered from some health issues, it could be suggested that their dietary choices and mobility patterns resulted in high body mass indices.

Further, although slightly higher values of BMI are observed in the Neolithic (compared to the Mesolithic), the available sample from the regions outside the Danube Gorges is small and does not offer a sufficient basis for the discussion on variations in body mass indices.

5.4.3. Conclusion

The new, sedentary way of life characterised by various diseases, combined with shorter breastfeeding and the consumption of new, less nutritious food had multiple negative effects on the human health. This is, among other aspects, also evident in the decrease in the average stature and body mass in the Danube Gorges Neolithic human groups compared to the Mesolithic. For females outside the Danube Gorges it is impossible to assess whether they decreased in stature and weight since their genetic origin is indeterminate. However, these females were relatively small and short, which may have been a consequence of the high exposure to physiological stress as also indicated by the considered dietary/health parameters. Additionally, the higher number of pregnancies in the Neolithic could have had negative effects on their physiological fitness, leading to overall decrease in the body proportions.

In the Danube Gorges there was no significant reduction in the female stature from the Mesolithic to the Neolithic. Further, no female-specific trend was observed toward greater rate of stature decrease as seen in other European Mesolithic-Neolithic transitional populations. This indicates that, although Neolithic females were more affected by physiological stress and were less mobile than the males or the Mesolithic females, the diet rich in aquatic resources could have had a positive impact on their physiological fitness. Indeed, their height and weight suggest that they were more fit than Early Neolithic females in other regions. For instance, the females from outside the Gorges were less fit, as implied by the proportionately higher body mass and shorter body size. This may be explained by greater consumption of high energy food rich in carbohydrates and the limited mobility.

With respect to the females from outside the Gorges, the body proportions of their ancestors who, presumably, lived in the period before the transition to agriculture, cannot be determined and thus the interpretations of decrease in their stature remain tentative. On the other hand, for women in the Gorges, one can observe slight decrease in stature. However, the observed decrease in female stature in the Gorges could have been influenced by the arrival of non-local people with small stature whose genetic structure was different.

The most important consequence of the reduction in female's body size could be narrower pelvic bones; this, combined with the carbohydrate-rich female diet, which would have increased the size of the foetus head, may have impacted the childbirth process by making it riskier and painful than before.

5.5. CONCLUSION

The results obtained within this thesis represent a significant step toward better understanding of the process of Neolithisation and its consequences to human health and biology. They also provide a unique contribution to our knowledge of the first Balkans agro-pastoralist communities, especially those that occupied the regions outside the Danube Gorges. Importantly, the outcomes of this work confirm the hypotheses set out at the beginning and are in accordance with theory of the Neolithic Demographic Transition. The first European farmers in the Central Balkans outside the Gorges show significant decline in health, comparable to the decline seen in most of the contemporary communities from across Europe. In contrast, the Neolithic communities in the Danube Gorges did not experience serious decline in health. These marked differences are a result of multiple factors including different dietary pathways, environmental conditions, cultural habits and adherence to the Mesolithic traditions.

Finally, the effect of the process of Neolithisation in the Central Balkans is most visible in the females and children, and they show remarkable rate of health decline. The new, sedentary way of life characterised by the development of various diseases, more pregnancies and the consumption of new food had multiple negative consequences on the females' health and physiological fitness. Whilst the higher number of pregnancies led to 'boom' in world population, it also had negative effects to the most sensitive members of the society, i.e. children who suffered from poor immune system due to the reduced length of breastfeeding. This led to higher frequency of physiological stress in the Neolithic children. Furthermore, although the introduction of new food and preparation techniques provided novel type of baby weaning porridge and a stable food supply for the Neolithic communities, it also had negative consequences on children's health. To summarize, although the most important aspect of the Neolithic was the increase in the number of children, the Neolithic in the Central Balkans brought along profound health problems to those same children and their mothers.

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FIGURES

Fig. 4.19. The body mass index types in Mesolithic and Neolithic population in both studied regions

Fig. 5.1. Left: PCA 1a (n=84, humans), δ^{15}Ncoll, δ^{13}Ccoll, δ^{34}Scoll, with an oblimin rotation (components correlation: 0,501), associated correlation matrix and extracted communalities. KMO index: 0,681, Bartlett test significant ($p<0.05$ level).
Right: PCA 1b (n=42, humans), δ^{15}Ncoll, δ^{13}Ccoll, δ^{34}Scoll, δ^{13}Cap , with a varimax rotation (components correlation using an oblimin rotation: 0.057), associated correlation matrix and extracted communalities. KMO index: 0.522, Bartlett test significant ($p<0.05$ level) (from: Jovanović et al. submitted)

Fig. 5.2a and b. (5.2a - δ^{13}C and δ^{15}N values of human and animals from the Danube Gorges Mesolithic sites; 5.2b - δ^{34} S and δ^{15} N values of human and animals from the Danube Gorges Mesolithic sites.)(adapted from Jovanović et al. submitted)

Fig. 5.3a and b (5.3a - Comparison of δ^{13}C and δ^{15}N values of human and animals from the different Neolithic sites; 5.3b- Comparison of δ^{34} S and δ^{15} N values of human and animals from the different Neolithic sites) (adapted from Jovanović et al. submitted)

Fig. 5.4. Left: PCA 3a (n=20, humans), δ^{15}Ncoll, δ^{13}Ccoll, δ^{34}Scoll, with an oblimin rotation (components correlation: 0.490), associated correlation matrix and extracted communalities. KMO index: 0.633, Bartlett test significant ($p<0.05$ level).
Right: PCA 3b (n=20, humans), δ^{15}Ncoll, δ^{13}Ccoll, δ^{34}Scoll, δ^{13}Cap, with an oblimin rotation (components correlation: -0,342), associated correlation matrix and extracted communalities. KMO index: 0,659, Bartlett test significant ($p<0.05$ level)(from Jovanović et al. submitted)

Fig. 5.5ab (5.5a. δ^{13}C and δ^{15}N values of human and animals from the Danube Gorges Neolithic sites; 5.5b. δ^{34} S and δ^{15} N values of human and animals from the Danube Gorges Neolithic sites) (adapted from Jovanović et al. submitted)

Fig. 5.6. Left: PCA 2a (n=49, humans), δ^{15}Ncoll, δ^{13}Ccoll, δ^{34}Scoll with an oblimin rotation (components correlation: 0.613), associated correlation matrix and extracted communalities. KMO index: 0,704, Bartlett test significant ($p<0.05$ level).
Right: PCA 2b (n=23, humans), δ^{15}Ncoll, δ^{13}Ccoll, δ^{34}Scoll, δ^{13}Cap, with an oblimin rotation (components correlation: -0373), associated correlation matrix and extracted communalities. KMO index: 0,706 , Bartlett test significant ($p<0.05$ level) (from Jovanović et al. submitted)

Fig.5.36. The prevalence of enamel hypoplasia in the Neolithic study regions and other Early Neolithic sites/regions

Fig. 5.37. Linear enamel hypoplasia on maxillar teeth, Klisa, grave 8

Fig. 5.38. Linear enamel hypoplasia on maxillar teeth, Klisa, grave 8

Fig. 5.39. Estimated adult stature in cm in the Neolithic study regions and other Early Neolithic sites/regions

Fig. 5.40. Estimated adult body mass in the Neolithic study regions and other Early Neolithic sites/regions

TABLES

Table 4.50. Crosstabulation of period and degree of porotic hyperostosis among Mesolithic and Neolithic inhabitants of the Danube Gorges

Table 4.51. Crosstabulation of period and degree of porotic hyperostosis among Mesolithic and Neolithic females in the Danube Gorges

Table 4.52. Crosstabulation of period and degree of porotic hyperostosis among Mesolithic and Neolithic males in the Danube Gorges

Table 4.53. Crosstabulation of period and degree of porotic hyperostosis among Mesolithic and Neolithic children in the Danube Gorges

Table 4.54. Crosstabulation of period and activity types of porotic hyperostosis among Mesolithic and Neolithic inhabitants of the Danube Gorges

Table 4.55. Crosstabulation of period and activity types of porotic hyperostosis among Mesolithic and Neolithic females in the Danube Gorges

Table 4.56. Crosstabulation of period and activity types of porotic hyperostosis among Mesolithic and Neolithic males in the Danube Gorges

Table 4.57. Crosstabulation of period and activity types of porotic hyperostosis among Mesolithic and Neolithic children in the Danube Gorges

Table 4.58. Crosstabulation of period and presence of porotic hyperostosis among Mesolithic (D.G.) and Neolithic inhabitants outside the Danube Gorges

Table 4.59. Crosstabulation of period and presence of porotic hyperostosis among Mesolithic (D.G.) and Neolithic children outside the Danube Gorges

Table 4.60. Crosstabulation of period and degree of porotic hyperostosis among Mesolithic (D.G.) and Neolithic inhabitants outside the Danube Gorges

Table 4.61. Crosstabulation of period and presence of porotic hyperostosis among Mesolithic (D.G.) and Neolithic females outside the Danube Gorges

Table 4.62. Crosstabulation of period and activity type of porotic hyperostosis among Mesolithic (D.G.) and Neolithic inhabitants outside the Danube Gorges

Table 4.63. Crosstabulation of period and presence of porotic hyperostosis among Mesolithic (D.G.) and Neolithic females outside the Danube Gorges

BIBLIOGRAPHY

Al-Abassi, S. A. and Sarie, I. 1998. Neolithic collapse in the Levant viewed from dental enamel hypoplasia.*American Journal of Physical Anthropology, 26,* 62–63.

Almonaitiene, R., Balciuniene,I.and Tutkuviene, J. 2010. Factors influencing permanent teeth eruption. Part one, general factors. *Stomatologija, 12* (3), 67-72.

Allué, E., Filipović, D., Borić, D. 2015. *Wood charcoal and seed/fruit remains from Lepenski Vir*. MESO2015: The Ninth International Conference on the Mesolithic of Europe (14.-18.September, 2015.), *Book of abstracts*, pp. 117. Belgrade: Institute of Archaeology.

Allué, E., D. Filipović, and D. Borić. in press. Archaeobotanical Record from the Site of Vlasac in the Danube Gorges (Serbia), In Arias, P. (Ed), *Proceedings of the 10th Conferenceon the Mesolithic in Europe*. Oxford: Oxbow Books.

Ambrose, S. H. 1990. Preparation and characterisation of bone and tooth collagen for isotopic analysis, *Journal of Archaeological Science,17*, 431-451.

Ambrose, S.H., Norr, L. 1993. Experimental evidence for the relationship of the carbon isotope ratios of whole diet and dietary protein to those of bone collagen and carbonate. In Lambert, J.B., Grupe, G. (Eds.), *Prehistoric human bone Archaeology at the molecular level*(pp. 1-37). Berlin: Springer-Verlag.

Ambrose, S.H. 2000. Controlled diet and climate experiments on nitrogen isotope ratios of rats.In Ambrose,S.H. and Katzenberg, M.A. (Eds.),*Biogeochimical approaches to paleodietary analysis* (pp. 243-257).New York: Kluwer Academic/Plenum.

Ambrose, S.H., Buikstra, J., Krueger, H.W. 2003. Status and gender differences in diet at Mound 72 Cahokia revealed by isotopic analysis of bone. *Journal of Anthropological Archaeology*, *22*, 217-226.

Anderson, P. 1992. Experimental cultivation, harvest, and threshing of wild cereals and their relevance for interpreting the use of Epipalaeolithic and Neolithic artefacts. In Anderson, P. (Ed), *Préhistoire de l'agriculture: Nouvelles approches expérimentales et ethnographiques*(pp. 179-209). Monographie du Centre de Recherches Archéologiques No. 6, CNRS. Paris.

Angel, J.L.1966. Porotic hyperostosis, anemias, malarias and marshes in the prehistoric Eastern Mediterranean. *Science, 153*, 706-763.

Angel, J.L. 1971. *The People of Lerna: anaylsis of a prehistoric Aegean Population*. Washington: Smithsonian Institution Press.

Angel, J. L. 1984. Health as a crucial factor in the changes from hunting to developed farming in the eastern Mediterranean. In Cohen, M.N. and Armelagos, G.J. (Eds.),*Paleopathology and the origins of agriculture*(pp. 51-73). Orlando: Academic Press.

Antonović, D. 2003. *Neolitska industrija glačanog kamena u Srbiji*. Arheološki institut: Beograd.

Antonović, D. 2004. Predmeti od glačanog kamena. U:Bogdanović, M. (Ur.) *Grivac: naselje protostarčevačke I vinčanske kulture* (str.439- 464). Kragujevac: Centar za naučna istraživanja.

Антоновић, Д. 2005. Неолитско земљорадничко оруђе и његов значај у почецима пољопривреде на тлу Србије. У *Зборник народног музеја, XVIII* (1), 47-68. Београд: Народни Музеј Београд.

Antonović, D. 2006. *Stone tools from Lepenski Vir*. Beograd: Arheološki institut.

Antonović, D. 2008. The development of the ground stone industry in the Serbian part of the Iron Gates. In Bonsall,C., Boroneant,V. and Radovanović, I. (Eds.), *The Iron Gates in Prehistory, new perspectives* (pp.19-38). BAR international series, Oxford: Archaeopress.

Aranđelović-Garašanin, D. 1954. *Starčevačka kultura*. Ljubljana: Arheološki seminar Univerziteta u Ljubljani.

Arnold, E. R. and Greenfield H. J. 2006. The Origins of Transhumant Pastoralism in Temperate Southeastern Europe, *British Archaeological Reports International Series,1538*. Oxford: Archaeopress.

Ash, A., Francken, M., Pap, I., Tvrdý, Z., Wahl,J.and Pinhasi, R. 2016. Regional differences in health, diet and weaning patterns amongst the first Neolithic farmers of central Europe. *Scientific reports 6,* 29458; doi: 10.1038/srep29458 (2016).

Auerbach, B. M. and Ruff, C.B. 2004. Human Body Mass Estimation: A Comparison of “Morphometric” and “Mechanical” Methods *American Journal of Phyical Anthrology* 125:331–342.

Aufderheide, A.C. and Rodríguez-Martín, C. 1998. *The Cambridge Encyclopedia of Human Paleopathology*. Cambridge: Cambridge University Press.

Bailey, D.W. 2000. *Balkan Prehistory: Exclusion, Incorporation and Identity*. London: Routledge.

Bačkalov, A. 1979. *Predmeti od kosti i roga u predneolitu i neolitu Srbije*. Beograd: Savez arheoloških društava Jugoslavije.

Bar-Yosef, O. 2004. Guest editorial: East to west - agricultural origins and dispersal into Europe. *Current Anthropology, 45(S4),* S1–S3.

Bartosiewicz, L., Bonsall, C., Boroneanţ, V., Stallibrass, S., 1995. Schela Cladovei: a preliminary review of the prehistoric fauna. *Mesolithic Miscellany, 16*(2), 2–19.

Bartosiewicz, L., Boroneant, V., Bonsall, C., Stallibrass, S. 2001. New data on the prehistoric fauna of the Iron Gates: a case study from Schela Cladovei, Romania. In Kertész, R., Makkay, J. (Eds.), *From the Mesolithic to the Neolithic*. Proceedings of the International Archaeological Conference held in the Damjanich Museum of Szolnok (22.–27., September, 1996.) Budapest: Archaeolingua.

Bartosiewicz, L., Bonsall, C., Şişu, V. 2008. Sturgeon fishing along the Middle and Lower Danube.In Bonsall, C., Boroneanţ V. and Radovanović, I. (Eds.),*The Iron Gates in Prehistory: new perspectives* (pp. 39-54). BAR International Series 1893. Oxford: Archaeopress.

Beaumont, J., Gledhill, A., Lee-Thorp, J. and Montgomery, J. 2013. Childhood diet: A closer examination of the evidence from dental tissues using stable isotope analysis of segmental human dentine. *Archaeometry* 55 (2), 277-295.

Beaumont, J., Montgomery, J., Buckberry, J. and Jay, M. 2015. Infant mortality and isotopic complexity: New approaches to stress, maternal health and weaning. *American Journal of Physical Anthropology, 157* (3), 441-457.

Bender, R. L., Dufour, D. L., Valenzuela, L. O., Cerling, T. E., Sponheimer, M., Reina, J. C. and Ehleringer, J. R. 2014. Stable isotopes (carbon, nitrogen, sulfur), diet and anthropometry in urban Colombian women: Investigating socioeconomic differences. *American Journal of Human Biology, 27*, 207–218.

Bentley, R.A. 2006. Strontium Isotopes from the Earth to the Archaeological Skeleton: A Review. *J Archaeol Method Theory, 13*(3), 136-187.

Beldiman, C. 2005. 'Parures paléolithiques et épipaléolithiques de Roumanie (25000-10000 BP): typologie et technologie'. En Dujardin, V. (Éd.) *Industrie osseuse et parures du Solutréen au Magdalénien en Europe*. Table ronde sur le paléolithique supérieur récent, Angoulême (Charente), 28-30 mars 2003. Paris: Société préhistorique française: 39-71.

Belfer-Cohen, A. and Goring-Morris, N. 2009. For the First Time. *Current Anthropology, 50*(5), 669-672.

Biagi, P. and Spataro, M. 2005. New Observations on the Radiocarbon Chronology of the Starcevo-Cris and Koros Cultures.*Reports of prehistoric research projects*, 6 – 7, 35 – 40.

Bickle, P. et al. 2011. Roots of diversity in a Linearbandkeramik community: isotope evidence at Aiterhofen (Bavaria, Germany). *Antiquity, 85*, 1243–1258.

Blatt, S.H., Redmond, B.G., Cassman, V., Sciulli, P.W. 2011. Dirty teeth and ancient trade: evidence of cotton fibres in human dental calculus from Late Woodland, Ohio. *Int. J. Osteoarchaeol., 21*, 669–678. doi:10.1002/oa.1173

Blažić, S. 1985. Ostaci faune sa arheološkog nalazišta kod Vizića. *Rad Vojvođanskih Muzeja,29*, 33-36.

Blažić, S. 1992. Fauna Donje Branjevine: preliminarni rezultati. *Arheologija i Prirodne Nauke*, 65-67.

Блажић С. 1995. Остаци животињских врста са локалитета на аутопуту кроз Срем. *Археолошка истраживања дуж аутопута кроз Срем*, 331-346.

Blažić, S. 2005. The faunal assemblage. In Karmanski, S. (Ed.), *Donja Branjevina: a Neolithic settlement near Deronje in the Vojvodina (Serbia),* (74-78).Trieste: Societa per la Preistoria e Protostoria della Regione Friuli-Venezia Giulia.

Blakey, M. L., Leslie, T. E. and Reidy, J. P. 1994. Frequency and chronological distribution of dental enamel hypoplasia in enslaved AfricanAmericans: a test of the weaning hypothesis. *American. Journal of Physical Anthropolgy, 95*, 371–383.

Bocquet-Appel, J.P. 2008. Explaining the Neolithic Demographic Transition. In Bocquet-Appel, J.P. and Bar-Yosef, O. (Eds.) *The Neolithic Demographic Transition and its Consequences*. Publisher: Springer Netherlands; Springer Science +Business Media B.V.

Bocquet-Appel, J. P., Naji,S., Vander-Linden, M., Kozłowski, J. K. 2009. Detection of diffusion and contact zones of early farming in Europe from the space-time distributionof 14C dates. *Journal of Archaeological Science*, *36*, 807–820.

Bocquet-Appel, J. P. 2011. When the world's population took off: the springboard of the Neolithic Demographic Transition. *Science*, 333, 560–561.

Bocquet-Appe,l JP and Bar-Yosef, O. 2008. Prehistoric Demography in a Time of Globalization. In JP Bocquet-Appel and O Bar-Yosef (eds), *The Neolithic Demographic Transition and its Consequences*. Springer Netherlands : 1-12.

Bocherens, H. 1992. *Biogéochimieisotopique (13C,15N,18O) et paléontologie des vertébrés: application à l'étude des réseauxtrophiquesrévolus et des paléoenvironnements* (pp. 317). Thèse de doctorat, Paris: Université Paris VI.

Bocherens, H. 1997. Signature isotopique dans le collagène des os.*Comptes rendus de la Société de biologie,4*, 493-510.

Bocherens, H., Drucker, D. 2003. Trophic level isotopic enrichment of carbon and nitrogen in bone collagen: case studies from recent and ancient terrestrial ecosystems. *International Journal of Osteoarchaeology, 13*, 46-53.

Bogdanović, M. 2004. *Grivac, Naselja protostarčevačke i vinčanske kulture.* Kragujevac: Centar za naučna istraživanja Srpske akademije nauka i umetnosti, Univerziteta u Kragujevcu i Narodni muzej Kragujevac.

Bogosavljević-Petrović, V. 2004. Predmeti od okresanog kamena. U Bogdanović, M.,(Ur.), *Grivac-naselje protostarčevačke i vinčanske culture* (str. 379-411).Kragujevac: Centar za naučnaistraživanja SANU i Univerziteta u Kragujevcu.

Bökönyi, S. 1969. Kičmenjaci (prethodni izveštaj). U Srejović, D. (Ed.*), Lepenski Vir — Nova praistorijska kultura u Podunavlju* (pp. 224–228). Beograd: Srpska književna zadruga.

Bökönyi, S.1970. Animal remains from Lepenski Vir. *Science 167* (926). 1702-1704.

Bökönyi, S. 1972. The vertebrate fauna. In Srejović, D. (Ed.), *Europe's First Monumental Sculpture: New Discoveries at Lepenski Vir* (pp.186–189). London, Thames and Hudson.

Bökönyi, S. 1974. *History of Domestic Mammals in Central and Eastern Europe*. Budapest: Akademia Kiado.

Bökönyi, S.1975. Vlasac: an early site of dog domestication. In Clason, A.T. (Ed.) *Archaeological studies*. *Papers of the archaeological conference, 1974* (pp. 167-178). Groningen. Amsterdam: Elsevier.

Bökönyi, S. 1978. The vertebrate fauna of Vlasac, In Srejović, D. and Letica, Z. (Eds.), *Vlasac: a Mesolithic settlement in the Iron Gates* (pp. 35-65). Belgrade: Serbian Academy ofScience and Arts.

Bökönyi, S. 1984. Die fruneolitische Wirbeltierfauna von Nosa. *Acta Archaeologica Hungarica, 36,* 29-41.

Bökönyi, S. 1988. The Neolithic fauna of Divostin. In McPherron, A. and Srejović, D. (Eds.), *Divostin and the Neolithic of Central Serbia* (pp. 419-445). Pittsburgh: University of Pittsburgh.

Bökönyi, S. 1992. Animal remains of Mihajlovac-Knjepište; an early Neolithic settlement of the Iron Gate Gorge. *Balcanica, XXIII,* 77-87.

Bonsall, C., Lennon, R., McSweeney, K., Stewart, C., Harkness, D., Boroneanţ, V., Bartosiewicz, L., Payton, R. & Chapman, J. 1997. Mesolithic and Early Neolithic in the Iron Gates: A palaeodietary perspective. *Journal of European Archaeology, 5*(1), 50 – 92.

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

Bonsall, C., Macklin, M.G., Payton, R.W., Boroneant, A. 2002. Climate, floods and river gods: environmental change and the Meso–Neolithic transition in southeast Europe. *Before Farming, The Archaeology of Old World Hunter-Gatherers, 3-4* (2), 1-15.

Bonsall, C., Cook, G.T., Hedges, R.E.M., Higham, T.F.G., Pickard, C.,Radovanovic, I., 2004. Radiocarbon and Stable Isotope Evidence of Dietary Change from the Mesolithic to the Middle Ages in the Iron Gates: New Results from Lepenski Vir. *Radiocarbon, 46* (1), 293-300.

Bonsall, C., Radovanović, I., Roksandić, M., Cook, G., Higham, T. and Pickard, C. 2008. Dating burial practices and architecture at Lepenski Vir. In Bonsall, C., Boroneanţ, V. and Radovanović, I. (Eds.) *The Iron Gates in Prehistory: New perspectives* (pp. 175–204). BAR InternationalSeries 1893. Oxford: Archaeopress.

Bonsall, C., Vasić, R., Boroneant, A., Roksandić, M., Soficaru, A., McSweeney, K., Evatt, A., Aguraiuja,Ü., Pickard,C., Dimitrijević, V., Higham, T., Hamilton, D. and Cook, G. 2015a. New AMS ^{14}C dates for human remains from stone age sites in the Iron Gates reach of the Danube, Southeast Europe. *Radiocarbon* 57(1), 33-46.

Bonsall, C., Cook, G., Pickard, C., McSweeney, K., Sayle, K., Bartosiewicz, L., Radovanović, I., Higham, T., Soficaru, A., Boroneant, A. 2015b. Food for Thought: Re-Assessing Mesolithic Diets in the Iron Gates. *Radiocarbon, 57* (4), 2015, 1–11.

Borić, D. 1999. Places that created time in the Danube Gorges and beyond, c. 9000–5500 BC. *Documenta Praehistorica, 26*, 41–70.

Borić, D., 2001. Mesolithic and early Neolithic hunters and fishers in the Danube Gorges: an analysis of archaeozoological data. In Kertész, R., Makkay, J. (Eds.), *From the Mesolithic to the Neolithic* (pp. 101-124).Proceedings of the International Archaeological Conference held in the Damjanich Museum of Szolnok, (22–27, September, 1996.). Budapest: Archaeolingua.

Borić, D. 2002a. *Seasons, life cycles and memory in the Danube Gorges, c. 10000-5500 BC* (p. 358). Unpublished PhD thesis: Cambridge, UK: University of Cambridge.

Borić, D. 2002b. The Lepenski Vir conundrum: reinterpretation of the Mesolithic and Neolithic sequences in the Danube Gorges. *Antiquity,76*, (1026–1039). doi: 10.1017/s0003598x00091833

Borić, D. and Stefanović, S. 2004. Birth and death: Infant burials from Vlasac and Lepenski Vir. *Antiquity, 78* (301), 526–546.

Borić, D. and Miracle, P. 2004. Mesolithic and Neolithic (dis)continuities in the Danube Gorges: New AMS dates from Padina and Hajdučka Vodenica (Serbia). *Oxford Journal of Archaeology, 23* (4), 341–371.

Borić, D., Grupe, G., Peters, J., Mikić, Ž. 2004. Is the Mesolithic-Neolithic subsistence dichotomy real? New stable isotope evidence from the Danube Gorges. *European Journal of Archaeology,7* (3), 221-248.

Borić, D. 2005. Body metamorphosis and animality: Volatile bodies and boulder artworks from Lepenski Vir. *Cambridge Archaeological Journal, 15*(1), 35–69.

Borić, D. and Dimitrijević, V. 2005. Continuity of foraging strategies in Mesolithic-Neolithic transformations: Dating faunal patterns at Lepenski Vir (Serbia). *Atti della Società per la preistoria e protostoria della regione Friuli-Venezia Giulia XV (2004–2005),* 33–107.

Borić, D. 2006. New discoveries at the Mesolithic–Early Neolithic site of Vlasac: Preliminary notes. *Mesolithic Miscellany, 18* (1), 7–14.

Borić, D. and Dimitrijević, V. 2007. When did the 'Neolithic package' reach Lepenski Vir? Radiometric and faunal evidence. *Documenta Praehistorica, 34*, 53–72.

Borić, D. 2008. First households and 'house societies' in European prehistory. In Jones, A. (Ed.), *Prehistoric Europe* (pp. 109-142). Malden, MA: Blackwell Publishing.

Borić, D. 2009. Absolute dating of metallurgical innovations in the Vinča Culture of the Balkans. In Kienlin, T. K. and Roberts, B. W. (Eds.), *Metals and societies. Studies inhonour of Barbara S. Ottaway* (pp.191–245). Bonn: Habelt.

Borić, D. and Dimitrijević, V. 2009. Apsolutna hronologija i stratigrafija Lepenskog Vira (Absolute Chronology and Stratigraphy of Lepenski Vir). *Starinar, LVII*, 9 – 55. doi: 10.2298/sta0757009b

Borić, D., Raičević, J. and Stefanović, S. 2009. Mesolithic cremations as elements of secondary mortuary rites at Vlasac (Serbia). *Documenta Praehistorica, 36,* 247–282.

Borić, D. 2011. Adaptations and transformations of the Danube Gorges foragers c. 13,000-5500 cal. BC: An overview. In Krauß, R. (Ed.), *Beginnings – New Research inthe Appearance of the Neolithic between Northwest Anatolia and the Carpathian Basin* (pp.157-203). Rahden/Westf.: Verlag Marie Leidorf GmbH.

Borić, D. and Price, T. D. 2013. Strontium isotopes document greater human mobility at the start of the Balkan Neolithic. *Proceedings of the National Academy of Sciences, 110* (9), 3298 – 3303.

Borić, D. 2014. Mortuary Practices, Bodies and Persons in the Neolithic and Early–Middle Copper Age of Southeast Europe. In Fowler, C., Harding, J. and Hofmann, D. (Eds.), *The Oxford Handbook of Neolithic Europe* (pp. 1-23). Oxford University Press.

Borić, D., French, C.A.I., Stefanović, S., Dimitrijević, V., Cristiani, E., Gurova, M., Antonović, D., Allué, E.A. and Filipović, D. 2014. Late Mesolithic lifeways and deathways at Vlasac (Serbia). *Journal of Field Archaeology, 39* (1), 1-31.

Borić, D. and Cristiani, E. 2016. Social networks and connectvitiy among the Paleolitic and Mezolitic foragers of the Balkan and Italy. In Krauß, R. and Floss, H. (Eds.), *Southeast Europe before the Neolitization* (73 - 112). Proceedings of the workshop held in Tubingen, Germany. Rahden/Westfalen:Verlag Marie Leidorf Gmbh.

Boserup, E. 1965. *The conditions of agricultural growth; the economics of agrarian change under population pressure.* London: G. Allen & Unwin.

Bowen, W. H. and Pearson, S. K. 1993. Effect of milk on cariogenesis. *Caries Research, 27*, 461-466.

Brothwell, D. R. 1981. *Digging up Bones*. *Third edition.* London and Oxford:British Museum and Oxford University Press.

Брукнер, Б. 1960. Резултати заштитног ископавања локалитета „Баштине“ код села Обрежа. *Рад Војвођанских музеја, 9, 81-111.*

Brukner, B. 1960a. Rezultati zaštitnog iskopavanja lokaliteta ‘Baštine’ kod sela Obreža. *Rad Vojvođanskih muzeja* 9, 81–111.

Brukner, B. 1960b. Baštine - Obrež - Srem - Naselje. *Arheološki pregled, 2, 18-24.*

Brukner, B., Jovanović, B. and Tasić, N. 1974. *Rani neolit.PraistorijaVojvodine.* Novi Sad: Institut za izučavanje istorije Vojvodine, Savez arheoloških društavaJugoslavije.

Bruzek, J. 1991. *Fiabilité des procédés de determination du sexe à partir de l'oscoxal. Implication à l'étude du dimorphismesexuel de l'hommefossile* (p. 390). PhD thesis, Paris: Museum d'Histoire Naturelle, Institut de Paléontologie Humaine.

Bruzek, J. 2002. A method for visual determination of sex using the human hip bone. *American Journal of Physical Anthropology, 117,* 157-168.

Budd, C., Lillie, M. C., Roodenberg, A, S., Karul, N. and Pinhasi, R. 2013. Stable Isotope Analysis of Neolithic and Chalcolithic populations from Aktopraklık, northern Anatolia. *Journal of Archaeological Science, 40,* 860-67.

Buikstra, J.E., Ubelaker, D.H. 1994. *Standards for Data Collection from Human Skeletal Remains.* Arkansas: Archaeological Survey Research Series 44.

Burger, J., Kirchner, M., Bramanti, B. 2007. Absence of lactase persistence associated allele in early Neolithic Europeans. *Proceedings of the National Academy of Sciences, 104,* (3736-3741).

Burton, J., 2007. Bone Chemistry and Trace Element Analysis. In Katzenberg, M.A. and Saunders, S.R. (Eds.) *Biological Anthropology of the Human Skeleton*. Hoboken: John Wiley and Sons, 443–460.

Campbell, N.A. 1995. *Biologie*. Bruxelles: de Boeck.

Campbell, P.N. and Smith, A.D.2002. *La biochimie illustrée*. Paris: Maloine.

Cărciumaru, M. 1973. *Compte rendu de l'analyse pollinique des coprolithes d'Icoana – portes de fer. Actes du 4.* Congrès International des Sciences Prehistoriques et Protohistoriques, Beograd. 172–3. Beograd.

Cărciumaru, M. 1978. L'analyse pollinique des coprolithes da la station archéologique de Vlasac. U Srejović, D. i Letica, Z. (Ur.), *Vlasac, mezolitsko naselje u Đerdapu*, *tom II* (pp. 31 - 34). Beograd: Srpska akademija nauka i umetnosti.

Carvalho, A. and Petchey, F. 2013. Stable Isotope Evidence of Neolithic Palaeodiets in the Coastal Regions of Southern Portugal. *The Journal of Island and Coastal Archaeology*, *8*(3), 361-383.

Caselitz, P. 1998. Caries, ancient plague of humankind. In Alt, K.W., Rosing, F.W. and Teschler-Nicola, M. *Dental Anthropology: Fundamentals, Limits and Prospects* (pp. 203–226). Vienna: Springer.

Cate, A.R.T. 1994. *Oral histology: development, structure and function*. St Louis: Mosby.

Chapman, J. 1981. The Vinča culture of south-east Europe: Studies in chronology, economy and society (2 vols). *BAR International Series, 117.* Oxford: B.A.R.

Chapman, J. 1983. Meaning and Illusion in the Study of Burial in Balkan Prehistory. In Poulter A. G. (Eds.) *Ancient Bulgaria*(pp. 1–42). Papers presented to the international Symposium on the Ancient History and Archaeology of Bulgaria, University of Nottingham (1981).Nottingham: University of Nottingham.

Chapman, J. 1994. The living, the dead and the ancestors: Time, life cycles and the mortuary domain in Later European Prehistory. In Davies, J. (Ed.), *Ritual and remembrance: Responses to death in human societies* (pp. 40-85). Sheffield: Sheffield Academic Press.

Chapman, J. 2006. Why was the Vinča- Belo Brdo tell ocuupied for so long? InVorgić, B. and Brukner, B. (Eds.), *Current problems of the Transition periods from the Starčevo to the Vinča culture* (str.213-236). Zrenjanin.

Childe, V.G. 1936. *Man Makes Himself*. London: Watts and Co.

Chisholm, B.S., Nelson, D.E. and Schwarcz, H.P. 1982. Stable isotope ratios as a measure of marine versus terrestrial protein in ancient diet, *Science,216,* 1131-1132.

Choy, K., Jeon, O.R., Fuller, B.T., and Richards, M.P. 2010. Isotopic evidence of dietary variations and weaning practices in the Gaya cemetery at Yeanri, Gimhae, South Korea. *American Journal of Physical Anthropology*, *142* (1), 74–84.

Clason, A.T. 1980. Padina and Starčevo: game, fish and cattle. *Palaeohistoria, 22*, 142-173.

Clarke, N.G., Carey, S.E., Sirkandi, W.S., Hirsch, R.S. and Leppard, P.I. 1986. Periodontal disease in ancient populations. *American Journal of Physical Anthropology, 71*, 173–183.

Clarke, B. 2008. Normal bone anatomy and physiology. *Clinical Journal of the American Society of Nephrology, 3,*131–139.

Clayton, F., Sealy, J.C. and Pfeiffer, S. 2006. Weaning age among foragers at Matjes river rock shelter, South Africa, from stable nitrogen and carbon isotope analyses. *American Journal of Physical Anthropology*, 129 (2), 311–317.

Cohen, M. N. 1977. *The Food Crisis in Prehistory: Overpopulation and Origins of Agriculture*. New Haven: Yale University Press.

Cohen, M. N. and Armelagos,G. J. (Eds.) 1984. *Paleopathology at the Origins of Agriculture*. Orlando, FL: Academic Press.

Cohen, N. M. 1989. *Health and the Rise of Civilization.* New Haven, Connecticut: Yale University Press.

Cohen, M. N. 2008. Implications of the Neolithic Demographic Transition for World Wide Health and Mortality in Prehistory. In Bocquet-Appel, J. P. and Bar-Yosef, O. (Eds.), *The Neolithic Demographic Transition and its Consequences*, Springer Science + Business Media.

Cohen, M. N. 2009. Introduction: Rethinking the origins of agriculture. *Current Anthropology,50* (5), 591-595.

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

Cook, G., Bonsall, C., Pickard, C., McSweeney, K.,Bartosiewicz, L. and Boroneanţ, A. 2009. The Mesolithic-Neolithic transition in the Iron Gates, southeast Europe: Calibration and dietary issues. In Crombé, Ph.,Van Strydonck, M., Sergant, J., Boudin, M. and Bats, M. (Eds.) *Chronology and Evolution within the Mesolithic of north-west Europe* (pp. 497–515). Newcastle upon Tyne: Cambridge Scholars Publishing.

Cordain L. 1999. Cereal grains: humanity's double edged sword. *World Review of Nutrition and Dietetics, 84*, 19 –73.

Cordain, L., Boyd Eaton, S., Sebastian, A., Mann, N., Lindeberg, S., Watkins, B., O'Keefe, J., Brand-Miller, J. 2005. Origins and evolution of the Western diet: health implications for the 21st century. *American Journal of Clinical Nutrition, 81* (2), 341-354.

Craig, O.E. 1953. The geochemistry of stable carbon isotopes, *Geochimica et Cosmochimica Acta*, *3,* 59 – 92.

Craig, O. E., Chapman, J., Heron, C., Willis, L. H., Bartosiewicz, L. et. al. 2005. Did the first farmers of central and Eastern Europe produce dairy foods?. *Antiquity, 79,* 882–894.

Craig, O.E., Ross, R., Andersen, S.H., Milner, N., Bailey, G.N., 2006. Focus: sulphur isotope variation in archaeological marine fauna from northern Europe. *Journal of Archaeology Science 33,* (11)1642-1646.

Cristiani, E. and Borić, D. (in press). Technology of Osseous Artifacts in the Mesolithic Danube Gorges: The Evidence from Vlasac (Serbia). In Arias, P. (Eds.) *Proceedings of the 10th Conference on the Mesolithic in Europe*. Oxford: Oxbow.

Cummings, L.S., Magennis, A. 1997. *A phytolith and starch record of food and grit in Mayan human tooth tarta*r (pp. 211–218). Estado actual de los estudios de fitolitos en suelos y plantas Monografı´as del Centro de Ciencias Medioambientales 4.

Čuljković, B., Stefanović S. and Romac, S. 2008. DNA-based sex identification of the infant remains from Lepenski Vir. In Bonsall, C. Boroneanţ V. and Radovanović, I. (Eds.) *The Iron Gates in Prehistory: New perspectives* (pp. 171–174). BAR InternationalSeries 1893. Oxford: Archaeopress.

Danforth, M.E. 1999. Nutrition and Politics in Prehistory. *Annual Review of Anthropology,28,*125.

de Becdelievre, C., Jovanović, J., Stefanović, S. and Porčić, M. 2013a. *Female mobility during the Mesolithic and the Neolithic in the Danube Gorges (Balkans, 9500-5500 BC).*Conference on the 150th Anniversary of the discovery of the shell middens at Muge (21- 23, March, 2013).Muge: Portugal.

de Becdelievre, C., Jovanović,J., Porčić, M., Stefanović,S. 2013b. Paleodemography of the Danube Gorges Mesolithic-Neolithic: comparing skeletal evidence and summer radiocarbon probability distributions. The 19th European Association of archaeologists Annual Meeting (4-8, September,2013).Pilsen: CzechRepublic.

de Becdelievre, C., Jovanović, J., Le Roy, M., Goude, G., Stefanović, S., Herrscher, E. and Rottier, S. 2014. *Bioarchaeology of birth: new isotopic investigations of prehistoric neonates from Vlasac and Lepenski Vir* (Danube Gorges, 9500-5500 BC). The 20th European Association of Archaeologists Annual Meeting (10 -14, September, 2014). Turkey : Istanbul.

de Becdelievre, C., Porčić, M., Goude, G., Nešić, M., Jovanović, J., Stefanović, S. 2015a. *From individual mobility to population dynamics during the Mesolithic and Neolithic transformations in the Danube Gorges (Balkans, ca. 9500–5500 BC): Adaptations and interactions*. MESO 2015, The Ninth International Conference on the Mesolithic in Europe (14 - 18, September, 2015). Belgrade: Institute of Archeology.

de Becdelièvre, C.,Jovanović, J.,Goude, G., Le Roy, M.,Rottier, S. and Stefanović, S. 2015b. *Prehistoric Motherhood: diet from the pregnancy stage to the process of baby weaning in the Mesolithic-Neolithic Danube Gorges (Balkans, 9500-5500BC).* 84th Annual Meeting of the American Association of Physical Anthropologists. Saint-Louis, USA.

de Becdelièvre, C., Jovanović, J., Goude, G., Le Roy, M., Stefanović, S. 2015c.Pregnancy and breastfeeding during prehistory: Mothers' dietary strategies through the Mesolithic-Neolithic transformations in the Danube Gorges. MESO 2015, The Ninth International Conference on the Mesolithic in Europe. 14.-18.09.2015. Beograd.

de Becdelievre, C., Le Guen, M.A., Jovanović, J., Stefanović, S. 2016. *Adaptations comportementales - Adaptations morphologiques*. Les transformations du Mésolithique-Néolithique dans les Gorges du Danube, apport des cartographies morphométriques. Colloque annuel 1841èmes réunion scientifique, Société d' Anthropologie de Paris. Lyon: France.

de Becdelièvre, C. in preparation. Eco-ethology of prehistoric populations living in the Danube Gorges c. 9500-5500 BC.*Bioarchaeological perspectives on human habitual behavior and adaptive strategies during the Mesolithic and Neolithic transformations*. PhD Thesis, Faculty of Philosophy. University of Belgrade.

DeNiro, M.J. 1985. Post-mortem preservation and alteration of in vivo bone collagen isotope ratios on relation to palaeodietary reconstruction. *Nature, 317* (6032), 806-809.

DeNiro, M.J. and Epstein, S., 1981. Influence of diet on the distribution of nitrogen isotopes in animals. *Geochimica et CosmochimicaActa, 45*, 341-351.

Denham, T. 2009. A practice-centered method for charting the emergence and transformation of agriculture. *Current Anthropology, 50*, 661–667.

Delgado-Darias,T., Velasco-Vázquez, J., Arnay-de-la-Rosa, M., Martín-Rodríguez, E. and González-Reimers, E. 2006. Calculus, periodontal disease and tooth decay among the prehispanic population from Gran Canaria. *Journal of Archaeological Science, 33* (5), 663-670.

del Pilar Babot, M. 2003. Starch grain damage as an indicator of food processing. In Hart, D.M. and Wallis, L.A. (Eds.), *Phytolith and Starch Research in the Australian–Pacific–Asian regions: the state of the art* (pp. 69–81). Pandanus Press.

Dimitrijević, V. 2000. The Lepenski Vir fauna: bones in houses and between houses. *Documenta Praehistorica, 27,* 101–117.

Dimitrijević, V. 2008. Lepenski Vir animal bones: what was left in the houses?.In Bonsall, C., Boroneanţ, V., Radovanović, I. (Eds.), *The Iron Gates in Prehistory. New perspectives* (pp. 117-130).BAR InternationalSeries 1893. Oxford: Archaeopress.

Dimitrijević, V., Vuković, S., 2015. Was the Dog Locally Domesticated in the Danube Gorges? Morphometric Study of Dog Cranial Remains From Four Mesolithic–Early Neolithic Archaeological Sites by Comparison With Contemporary Wolves. *International Journal of Osteoarchaeology, 25,* 1-30.

Dimitrijević, V., Živaljević, I. and Stefanović, S. in press. Becoming sedentary? The seasonality of food resource exploitation in the Mesolithic-Neolithic Danube Gorges. *Documenta praehistorica 43*.

Dinu, A., Soficaru, A. and Miritoiu, A. 2007. The Mesolithic of the Danube's Iron Gates: newradiocarbon dates and old stratigraphies. *Documenta Praehistorica, 34,* 31-52.

Dinu, A. 2010. Mesolithic fish and fishermen of the lower Danube (Iron Gates). *Documenta Praehistorica, 37,* 299-310.

Duggal, M.S., Van Loveren, C. 2001. Dental considerations for dietary counselling. *International Dental Journal, 51,* 408–12.

Dupras, T.L. and Tocheri, M.W. 2007. Reconstructing infant weaning histories at Roman period Kellis, Egypt using stable isotope analysis of dentition. *American Journal of Physical Anthropology, 134* (1), 63–74.

Durrwachter, C., Craig, O.E., Collins, M.J., Burger, J., Alt, K.W., 2006. Beyond the grave: variability in Neolithic diets in Southern Germany? *Journal of Archaeological Science, 33* (1), 39 – 48.

Drucker, D.G., Bridault, A., Cupillard, C., Hujic, A. and Bocherens, H. 2011. Evolution of habitat and environment of red deer (Cervus elaphus) during the Late-glacial and early Holocene in eastern France (French Jura and the western Alps) using multi-isotope analysis (δ13C, δ15N, δ18O, δ34S) of archaeological remains. *Quaternary International, 245* (2), 268-278.

Duray, S.M. 1990. Deciduous enamel defects and caries susceptibility in a prehistoric Ohio population. *American Journal of Physical Anthropology, 81,* 27-34.

Ehrich, R.W. 1977. Starčevo Revisited. In Markotić, V. (Ed.)*Ancient Europe and the Mediterranean*.

Ellison, P.T. 1995. Breastfeeding, Fertility, and Maternal Condition. In Stuart-Macadam, P. and Dettwyler, K.A. (Eds.), *Breastfeeding: Biocultural Perspectives*(pp. 305–345). New York: Aldine de Gruyter.

El-Najjar, M.Y., Ryan, J.D., Turner, C.G. II and Lozoff, B. 1976. The etiology of porotic hyperostosis among the prehistoric and historic Anasazi Indians of southwestern United States. *American Journal of Physical Anthropology, 44*, 417-488.

Ehler, E. and Vančata, V. 2009. Neolithic transition in Europe: evolutionary anthropology study. *Anthropologie (Brno),*47 (3), 185-193.

Ehrich, R.W. 1977. Starčevo Revisited. In Markotić, V. (Ed.), *Ancient Europe and the Mediterranean*: *studied presented in honour of Hugh Hencken* (pp. 9-67). Warminster: Aris and Phillips Ltd.

Eriksson, G., Linderholm, A., Fornander, E., Kanstrup, M., Schoultz, P., Olofsson, H. and Liden, K. 2008. Same island, different diet: cultural evolution of food practice on Öland, Sweden, from Mesolithic to the Roman period. *Journal of Anthropological Archaeology, 27,* 520-543.

Eriksson, G. and Lidén, K. 2013. Dietary life histories in Stone Age Northern Europe. *Journal of Anthropological Archaeology*, *32,* 288-302.

Eveleth, P.B., Tanner, J.M. 1990. *World-Wide Variation in Human Growth*. Cambridge: Cambridge Ubiversity Press, 2nd edition.

Evershed, R. P., Payne, S., Sherratt, A. G., Copley, M. S., Coolidge, J., et al. 2008. Earliest date for milk use in the Near East and southeastern Europe linked to cattle herding. *Nature*, *455,* 528–531.

Fa, D.A. 2008. Effects of tidal amplitude on intertidal resource availability and dispersal pressure in prehistoric human coastal populations: the Mediterranean–Atlantic transition. Quaternary Science Reviews 27, 2194-2209.

Featherstone, J.D.B. 2004. The caries balance: the basis for caries management by risk assessment. *Oral Health & Preventive Dentistry,2*(Suppl 1), 259–264.

Ferraro, M. and Vieira, A.R. 2010. Explaining Gender Differences in Caries: A Multifactorial Approach to a Multifactorial Disease. *International Journal of Dentistry*. Volume 2010. 1-5.

Fewkes, V.J., Goldman, H. and Ehrich, R.W. 1933. Excavations at Starčevo, Yugoslavia, seasons 1931 and 1932, a preliminary report. BASPR 9 (1933) 33-54.

Filipović, D., Allué, E. A. and Borić, D. 2010. Integrated carpological and anthracological analysis of plant record from the Mesolithic site of Vlasac, Serbia. *Glasnik Srpskog arheološkog društva, 26*, 145–161.

Filipović, D. and Obradović, Dj. 2013. Archaeobotany at Neolithic Sites in Serbia: A Critical Overview of the Methods and Results. *Bioarheologija: bilans i perspective, 1*, 25-56.

Filipović, D., Živaljević, I. and Jovanović, J. 2015. *Human diet in the Mesolithic-Neolithic Danube Gorges.* Exhibition Bioarchaeology of the Danube Gorges, catalogue. Belgrade.

Filipović, D., de Becdelievre, C., Jovanović, J., Büdel, T., Penezić, K., Stefanović, S. 2016. *Exploring early farming diets and population dynamics in the Neolithic central Balkans.* Poster presented at the conference The Agricultural Origins of Urbanization: 'Intensification' in Late Prehistoric Western Eurasia and Beyond, (18.-20., March, 2016.), Oxford University.

Fogel, R.W., Engerman, S.L., Floud, R., Friedman, G., Margo, R.A., et al. 1983. Secular changes in American and British stature and nutrition. *Journal of Interdisciplinary History, 14*, 445-81.

Fogel, M.L., Tuross, N. and Owsley, D.W., 1989. *Nitrogen isotope tracers of human lactation in modern and archaeological populations.*Annual Report of the Director, Geophysical Laboratory, Carnegie Institute of Washington, 111–117.

Formicola, V. 1987. Neolithic transition and dental changes: the case of an Italian site, *Journal of Human Evolution,16,* 231-239.

Formicola, V. and Giannecchini, M.1999. Evolutionary trends of stature in upper Paleolithic and Meoslithic Europe. *Journal of Human Evolution, 36,* 319-333.

Fornander, E., Eriksson, G. and Lidén, K. 2008. Wild at heart: approaching Pitted Ware identity, economy and cosmology through stable isotopes in skeletal material from the Neolithic site Korsnäs in Eastern Central Sweden. *Journal of Anthropological Archaeology, 27*, 281-97.

Frémondeau, D., Cucchi, T., Casabianca, F., Ughetto-Monfrin, J., Horard-Herbin, M.P. and Balasse, M. 2012. Seasonality of birth and diet of pigs from stable isotope analyses of tooth enamel (δ18O, δ13C): a modern reference data set from Corsica, France. *Journal of Archaeological Science, 39* (7), 2023-2035.

Froment, A. and Ambrose, S.H.1995. Analyses tissulaires isotopiques et reconstruction du régime alimentaire en milieu tropical : implication pour l'archéologie, *Bulletins et Mémoires de la Sociétéd'Anthropologie de Paris,*7*,* 79-98.

Fuller, B. T., Fuller, J. L., Harris, D. A. and Hedges, R. E. M. 2006. Detection of Breastfeeding and Weaning in Modern Human Infants with Carbon and Nitrogen Stable Isotope Ratios.*American Journal of Physical Anthropology, 129,* 279-293.

Galović, R. 1967. Sahranivanje u starčevačkoj kulturi. *Starinar, XVIII,* 167–174.

Гарашанин, М. 1973. *Праисторија на тлу Србије*. Београд: Српска Књижевна Задруга.

Garašanin, M. 1979. Centralnobalkanska zona. U Benac, A. (Ur.) *Praistorija jugoslavenskih zemalja II* (str.79-212). Sarajevo: Akademija nauka i umjetnosti Bosne i Hercegovine – Svjetlost.

Garašanin, M. 1982. The Stone Age in the Central Balkan Area. *Cambridge Ancient History, 3,* Part 1. Cambridge University Press, 75–135.

Garašanin, D. 1984. Die Siedlung der Starčevo-Kultur. In Srejović, D., Stojanović, B., Tasić, N. and Krstic, D. (Ur.), *Vinča*, Beograd: Srpska Akademija Nauka i Umetnosti. 191-194.

Garašanin, M. and Radovanović, I. 2001. A pot in house 54 at Lepenski Vir I. *Antiquity, 75,* 118–125.

Гавела, Б. 1956-57. Енеолитска насеља у Гривцу. *Старинар н. с.,*VII-VIII, 237-268.

Gerbault, P., Roffet - Salque, M.,Evershed, R. P., Thomas, M. G. 2013.How long have adult humans been consuming milk? *IUBMB Life, 65* (12), 983–990.

Gimbutas, M. 1991. *The Civilization of the Goddess: The World of Old Europe*. San Francisco: Harper SanFrancisco.

Giorgi, F., Bartoli, F., Iacumin, P., Mallegni, F. 2005. Oligoelements and isotopic geochemistry: a multidisciplinary approach to the reconstruction of the palaeodiet. *Human Evolution, 20*, 55 - 82.

Giblin, J.I. 2011. *Isotope Analysis on the Great Hungarian Plain: An Exploration of Mobility and Subsistence Strategies from the Neolithic to the Copper Age*. PhD thesis,USA: The Ohio State University.

Gigov, A. 1969. Analiza polena. U Srejović D. (Ed.) *Lepenski vir* (pp. 203-206). Beograd: Srpska književna zadruga.

Goodman, A. H., Rose, J. C. and Armelagos, J. G.1980. Enamel Hypoplasias as Indicators of Stress in Three Prehistoric Populations from Illinois. *Human Biology, 52* (3), 515-528.

Goodman, A., Martin, D.L., Armelagos, G. J., Clark, G. 1984. Indications of stress from bone and teeth. In Cohen, N., Armelagos, G., (Eds.), *Paleopathology at the origins of agriculture* (pp. 13-49). Orlando: Academic Press.

Goodman, A. H. and Lindsay H. A., Hernandez, G.P., Amador, A., Arriola, V. L., Chavez, A. and Pelto, G.H. 1987. Prevalence and age at development of enamel hypoplasia in Mexican Journal. *AmericanJournal of Physical Anthropology, 72,* 7-19.

Goodman, A.H., Thomas, R.B., Swedlund, A.C., Armelagos, G.J. 1988. Biocultural perspectives on stress in prehistoric, historical and contemporary population research. *Yearbook of Physical Anthropology, 31*, 169-202.

Goodman, A.H. and Armelagos, G. J. 1989. Infant and childhood morbidity and mortality risks in archaeological populations. *World Archaeology, 21* (2), 225 - 43.

Goodman, A.H. and Rose, J.C. 1990. Assessment of Systemic Physiological Perturbations from Dental Enamel Hypoplasias and Associated Histological Structures. *Yearbook of Physical Anthropology, 33,* 59-110.

Goodman, A.H. and Rose, J.C. 1991. Dental enamel hypoplasias as indicators of nutritional status. In Kelley M. and Larsen, C. (Eds.) *Advances in dental anthropology,* (pp. 279- 294). New York: Wiley – Liss.

Goodman, A.H., Martinez, C. and Chavez, A.1991. Nutritional supplementation and the development of linear enamel hyopolasias in children from Tezonteopan, Mexico. *American Journal of Clinical Nutrition, 53*, 773-781.

Goodman, A. H. and Martin, D. L. 2002. *Reconstructing health profiles from skeletal remains. The Backbone of History.* Cambridge University Press.

Goude, G., 2007. Etude des modes de subsistancedes populations néolithiques (VIe-IVe millénaires av. J.-C.) dans le nord-ouest de la Méditerranée. Approche par l'utilisation des isotopes stables (13C et 15N) du collagène. PhD thesis. Université Bordeaux 1-Université de Leipzig, Talence-Leipzig.

Goude, G., Binder, D., del Lucchese, A. 2012-2013. Alimentation et modes de vie néolithiques en Ligurie. In Bernabo Brea, M., Maggi, R., Manfredini, A. (Eds.)*Il pienoNeolitico in Italia (8-10, Juin Finale Ligure 2009)* pp. 371 - 382). Instituto di studi liguri.

Goude, G., Fontugne, M., 2016. Carbon and nitrogen isotopic variability in bone collagen during the Neolithic period: Influence of environmental factors and diet, *Journal of Archaeological Science, 70*, 117-131.

Goude, G., Salazar-García, D. C., Power, R. C., Gourichon, L., Varalli, A., Rivollat, M., Deguilloux, M.F., André, G., Pruvost, S. and Binder, D. forthcoming. *Documenting diet and mobility at the onset of farming: multi-proxy analyses at the Les Bréguières site (6th-5th mill cal. BC, Southeastern France).* Réunion Scientifique de la Société d'Anthropologie de Paris. Paris.

Gremillion, K. J. 1997. *People, Plants, and Landscapes: Studies in Paleoethnobotany*. University of Alabama Press.

Greenfield, H. J. 1993. Faunal remains from the Early Neolithic Starčevo settlement at Bukovačka Česma. *Starinar, XLIII-XLIV*, 103-113.

Greenfield, H.J., 2008. The vertebrate fauna from Hajdučka Vodenica in the Danubian Iron Gates: subsistence and taphonomy from the Early Neolithic and Mesolithic. In Bonsall, C., Boroneant, V., Tadovanović, I. (Eds.), *The Iron Gates in Prehistory: New Perspectives* (pp. 205-226). Oxford: Archaeopress.

Grga, Đ. 1996. Karijes u humanoj populaciji kulture Lepenskog Vira. *Starinar, XLVII*, 177–185.

Grupe, G., H. Manhart, Mikić, Ž. and Peters, J. 2003. Vertebrate food webs and subsistence strategies of Meso - and Neolithic populations of central Europe. In Grupe G. and Peters J. (Eds.) *Documenta Archaeobiologiae 1. Yearbook of the State Collection of Anthropology and Palaeoanatomy* (pp. 193–213), München, Germany: Rahden/Westf.: Verlag M. Leidorf.

Guatelli-Steinberg, D. and Lukacs, J.R. 1999. Interpreting Sex Differences in Enamel Hypoplasia in Human and Non-Human Primates: Developmental, Environmental and Cultural Considerations. *Yearbook of PhysicalAnthropology, 42,* 73-126.

Han, Z.H., Palnitkar, S., Rao, D.S., Nelson, D.,Parfitt, A.M., 1997. Effects of Ethnicity and Age or Menopause on the Remodeling and Turnover of Iliac Bone: Implications for Mechanisms of Bone Loss. *Journal of Bone and Mineral Research 12,* (4), 498-508.

Hardy, K., Blakeney, T., Copeland, L., Kirkham, J., Wrangham, R., Collins, M. 2009. Starch granules, dental calculus and new perspectives on ancient diet. *Journal of Archaeological Science, 36*, 248–255. doi:10.1016/j. jas.2008.09.015

Hauspie, R.C. 2002. Adolescence: Somatic growth and sex differences. In Cameron, N. (Eds.), *Human growth and development* (45 - 64). San Diego, CA: Academic Press.

Heaton, T.H.E. 1986. Isotopic studies of nitrogen pollution in the hydrosphere and atmosphere: a review, *Chemical geology,59,* 87-102.

Hedges, R. E. M., Stevens, R. E. and Richards, M. P. 2004. Bone as a stable isotope archive for local climatic information. *Quaternary Science Reviews, 23,* 959–965.

Hedges, R.E.M., Clement, J.G., Thomas, C.D.L., O'Connell, T.C., 2007. Collagen turnover in the adult femoral mid-shaft: Modeled from anthropogenic radiocarbon tracer measurements. *American Journal of Physical Anthropology 133*, (2), 808-816.

Henry, A.G., Piperno, D.R. 2008. Using plant microfossils from dental calculus to recover human diet: a case study from Tell al-Raqa'i, Syria. Journal of Archaeological Science 35, 1943–1950.

Henry, A. G., Hudson, H. F., Piperno, D. R. 2009. Changes in starch grain morphologies from cooking. *Journal of Archaeological Science, 36,* 915–922.

Hermanussen, M. 2003. Stature of Early Europeans. *Hormones*, *2* (3), 175-178.

Herrscher, E. 2013. Détection isotopique des modalités d'allaitement et de sevrage à partir des ossements archéologiques. *Cahiers de Nutrition et de Diététique, 48* (2),75-85.

Herrscher E., Goude, G. and Metz, L. (accepted). *Composition isotopique (C, N) du lait maternel au cours des premiers mois d'allaitement : approche exploratoire et application en paléoalimentation infantile*. Symposium proceedings "Allaitement" (25-26, mars, 2014). Paris.

Hershkovitz, I. Gopher, A. 2008. Demographic, Biological and Cultural Aspects of the Neolithic Revolution: A view from the southern Levant. In Bocquet-Appel, J. P. and Bar-Yosef, O., (Eds.), *The Neolithic Demographic Transition and its Consequences*. Springer Science + Business Media.

Hillson S. W. 1979. Diet and dental disease. *World Archaeology, 11,* 147–62.

Hillson, S. 1996. *Dental Anthropology*. Cambridge: Cambridge University Press.

Hillson, S. 2001. Recording Dental Caries in Acheological Human Remains. *Internacional Journal of Osteoarchaeology, 11,* 249-289. DOI: 10.1002/oa.583

Hillson, S. 2005. *Teeth.* Cambridge: Cambridge University Press.

Hindmarsh, P.C. 2002. Endocrinology of growth. In Cameron, N. (Eds.), *Human growth and development* (85-102). San Diego, CA: Academic Press.

Hobson, K.A., Alisauskas, R.T., Clark, R.G., 1993. Stable nitrogen enrichment in avian tissues due to fasting and nutritional stress: implications for isotopic analyses of diet. *The Condor, 95,* 388-394.

Hobson, K.A., Gibbs, H.L. and Gloutney, M.L. 1997. Preservation of blood and tissue samples for stable-carbon and stable-nitrogen isotope analysis.*Canadian Journal of Zoology, 75,* 1720–1723.

Hoefs, J. 1997. *Stable isotope geochemistry*. Berlin: Springer Editions.

Horrocks, M. and Wozniak, J. A. 2008. Plant microfossil analysis reveals disturbed forest and a mixed-crop, dryland production system at Te Niu, Easter Island. *Journal of Archaeological Science,35*, 126-142.

Howcroft, R. 2013. *Weaned Upon A Time: Studies of the Infant Diet in Prehistory*. PhD thesis. Stockholm University.

Howcroft, R., Eriksson, G. and Lidén, K. 2014. Infant feeding practices at the Pitted Ware Culture site of Ajvide, Gotland.*Journal of Anthropological Archaeology, 34*, 42-53.

Howland, M.R., Corr, L.T., Young, S.M.M., Jones, V., Jim, S., van der Merwe, N.J., Mitchell, A.D. and Evershed, R.P. 2003. Expression of the dietary isotope signal in the compound-specific 13C values of pig bone lipids and amino acids. *International Journal of Osteoarchaeology*, *13* (1-2), 54–65.

Hu, Y., Shang, H., Tong, H., Nehlich, o., Liu, W., Zhao, C., Yu, J., Wang, C., Trinkaus, E. and Richards, M. 2009. Stable isotope dietary analysis of the Tianyuan 1 early modern human. *Proceedings of the National Academy of Sciences*, *2009 106*(27), 10971-10974.

Humphrey, L. T. 2010. Weaning behaviour in human evolution. *Seminars in Cell and Developmental Biology, 21,* 453-461.

Infante, P. and Gillespie, G.M. 1977. Enamel hypoplasia in relation to caries in Guatemalan children. *Journal of Dental Research, 56,* 493-498.

Itan, Y., Powell, A., Beaumont, M. A., Burger,J. and Thomas, M. G. 2009. The origins of lactase persistence in Europe. *PLoS Comput. Biol. 5,* e1000491.

Jarošova, I. and Dočkalova, M. 2008. Dental remains from the Neolithic settlements in Moravia, Czech Republic. *Anthropologie*, *46* (1), 77-101.

Jay, M., Fuller, B.T., Richards, M.P., Knüsel, C.J. and King, S.S. 2008. Iron Age breastfeeding practices in Britain: isotopic evidence from Wetwang Slack, East Yorkshire. *American Journal of Physical Anthropology*, *136* (3), 327–37.

Jim, S., Ambrose, S.H. and Evershed, R.P. 2004. Stable carbon isotopic evidence for differences in the biosynthetic origin of bone cholesterol, collagen and apatite: implications for their use in palaeodietary reconstruction. *Geochim Cosmochim Acta, 68,* 61– 72.

Jim, S., Jones, V., Ambrose, S.H. and Evershed, R.P. 2006. Quantifying dietary macronutrient sources of carbon for bone collagen biosynthesis using natural abundance stable carbon isotope analysis. *British Journal of Nutrition, 95,* 1055–1062.

Jose, A. and Joseph, M. R. 2003. Prevalence of dental health problems among school going children in rural Kerala. *Journal of the Indian Society of Pedodontics and Preventive Dentistry, 21*(4), 147–151.

Jovanović, B. 1968. Elements of the Early Neolithic Architecture in the Iron Gate Gorge and their Functions. *Archaeologia Iugoslavica,* 9, 1-19.

Jovanović, B., 1969. Chronological frames of the Iron Gate group of the Early Neolithic period. Archaeologica Iugoslavica 10. In Fowler, C., Harding, J., Hofmann, D. (Eds.) *Middle Copper Age of Southeast Europe* (pp. 1-23). The Oxford Handbook of Neolithic Europe. Oxford University Press.

Jovanović, B. 1974. Praistorija gornjeg Djerdapa. *Starinar, XII,* 1-22.

Јовановић, Б. 1984. Хајдучка Воденица, праисторијска некропола. *Старинар, XXXIII-XXXIV,* (1982-1983), 305-312.

Jovanović, B. 1987. Die Architektur und Keramik der Siedlung Padina B am Eisernen Tor, Jugoslawien. *Germania, 65*(1), 1–16.

Jovanović, B. 2008. Micro-regions of the Lepenski Vir culture Padina in the Upper Gorge and Hajdučka Vodenica in the Lower Gorge of the Danube. *Documenta Praehistorica, 35,* 289–324.

Jovanović, J., de Becdelièvre, C., Goude, G., Le Roy, M, Stefanović, S., Herrscher, E., Rottier, S., Starović, A. 2014. *Children feeding practices in the Danube Gorges at the advent of the Neolithic*. The 20th European Association of Archaeologists Annual Meeting (10 - 14,September, 2014), Turkey:Istanbul.

Јовановић, Ј., де Бекделиевр, К., Гуд, Г., Ле Руа, М., Ершер, Е. и Стефановић, С. 2015. Исхрана и здравствени статус деце у мезолиту и неолиту Ђердапа. *Архаика, 1,* Београд.

Jovanović, J., Le Roy, M., de Becdelièvre, C., Stefanović, S., Herrscher E. And Goude, G. 2015a. *Children's health status in the Danube Gorges Mesolithic Neolithic: a comparsion of macroscopical observations and stable isotope data.* Colloque du Groupe des Méthodes Pluridisciplinaires contribuant à l'Archéologie (27 – 30, April, 2015.). Besancon, France.

Jovanović, J., de Becdelievre, C., Goude, G., Stefanović, S. 2015b. *Stable isotope and dental evidence for dietary changes at the Mesolithic-Neolithic transition in Serbia.*MESO 2015: The Ninth International Conference on the Mesolithic in Europe (14.-18, September,2015.). Belgrade: Institute of Archeology.

Jovanović, J., Blagojević, T., de Becdelièvre, C. and Stefanović, S. 2016. *The stress of farming: bodies and health during the Mesolithic and the Neolithic Transition in Serbia.* "IUAES" - the International Union of Anthropological and Ethnological Sciences (4. - 9. May 2016). Dubrovnik, Croatia.

Jovanović, J., de Becdelièvre, C., Stefanović, S., Živaljević, I., Dimitrijević, V. and Goude, G. (submitted). *Last hunters-first farmers: new insight into subsistence strategies in the Central Balkans through multi-isotopic analysis.*

Juan-Tresserras, J., C. Lalueza, R. Albert and Calvo, M. 1997. Identification of phytoliths from prehistoric human dental remains from the Iberian Peninsula and the Balearic Islands. In Pinilla, A., Juan-Tresserras, J. and Machado, M. J. (Ed.) *Primer encuentro Europeo sobre el estudio de fitolitos* (pp. 197-203)Madrid: Gráficas Fersán.

Kaczanowska, M. and Kozlowski, J.K. 1984-5. Chipped stone industry from Golokut. *Рад Војвођанских музеја, 29,* 27-31.

Katzenberg, M.A., Saunders, S.R., and Fitzgerald, W.R., 1993. Age differences in stable carbon and nitrogen isotope ratios in a population of prehistoric maize horticulturists. *American Journal of Physical Anthropology, 90* (3), 267–81.

Karmanski, S. 2005. Donja Branjevina: A Neolithic settlement near Deronje in the Vojvodina (Serbia). In Biagi, P. (Eds.), *Società per la preistoria e protostoria della regione Friuli-Venezia Giulia,* Quaderno - 10. Trieste: Museo Civico di Storia Naturale.

Kaupova, S., Herrscher, E., Velemínský, P., Cabut, S., Poláček, L. and Bružek, J. 2014. Urban and rural infant-feeding practices and health in early medieval Central Europe (9th–10th Century, Czech Republic). *American Journal of Physical Anthropology,155*, 635 – 651.

Keenleyside, A., Schwarcz, H. and Panayotova, K. 2006. Stable isotopic evidence of diet in a Greek colonial population from the Black Sea. *Journal of Archaeological Science, 33,* 1205–1215.

Keenleyside, A., Schwarcz, H.P., Stirling, L. and Ben Lazreg, N. 2009. Stable isotopic evidence for diet in a Roman and Late Roman population from Leptiminus, Tunisia. *Journal of Archaeological Science, 36* (1), 51–63.

Kemkes-Grottenthaler, A. 2005. The short die young: The interrelationship between stature and longevity- evidence form skeletal remains. *American Journal of Physical Anthropology, 128,* 340- 347.

Kempster, B., Zanette, L., Longstaffe, F.J., MacDougall-Shackleton, S.A., Wingfield, J.C. and Clinchy, M. 2007. Do stable isotopes reflect nutritional stress? Results from a laboratory experiment on song sparrows. *Oecologia, 151,* 365-371.

Kennedy, G.E. 2005. From the Ape's Dilemma to the Weanling's Dilemma: Early Weaning and Its Evolutionary Context. *Journal of Human Evolution, 48*, 23-145.

Keys, A., Fidanza, F., Karvonen, M.J., Kimura, N. and Taylor, H.L. 1972. Indices of relative weight and adiposity. *J. Chronic Dis, 1972*(25), 329-343.

Klepinger, L.L. 1984. Nutritional assessment from bone, *Annual Review of Anthropology,* 13, 75-96.

Korošec, J. 1950. Grobovi u Vinči. *Arheološki vestnik, 1*, (1-2), 156-169.

Kozlowski, J. K. and Kozłowski, S. 1982. Lithic industries from the multi-layer Mesolithic site Vlasac in Yugoslavia. *Prace Archeologiczne, Vol. 32*, Krak6w.

Kozlowski, J. K. and Kozłowski, S. 1984. Chipped stone industries from Lepenski Vir. *Preistoria Alpina, 19,* 259–293.

Krauß, R. (Ed.), 2011. *Beginnings – New Research in the Appearance of the Neolithic Between Northwest Anatolia and the Carpathian Basin.* Germany: Verlag Marie Leidorf GmbH, Rahden/Westfalen.

Krenz-Niedbala, M. 2001. Biological and cultural consequences of the transition to agriculture in human population on Polish territories. *Variability and Evolution, 9,* 89–99.

Krouse, H.R. 1980. Sulphur Isotopes in our Environment. In Fritz, P., Fontes, J.C. (Eds.) *Handbook of environmental isotope geochemistry* (pp.435-471). Amsterdam: Elsevier B.V.

Krouse, H.R., 1989. Sulfur Isotope Studies of the Pedosphere and Biosphere. *Ecological Studies, 68*, 424-444.

Lallo, J.W., Armelagos, G.J. and Mensforth, R.P. 1977. The role of diet, disease, and physiology in the origin of porotic hyperostosis. *Human Biology, 49,* 471-483.

Lamb, J. and Loy, T. H. 2005. Seeing red: The use of Congo Red dye to identify cooked and damaged starch grains in archaeological residues. *Journal of Archaeological Science, 32,* 1433–1440.

Larsen, C.S. 1982. The anthropology of S.Catherine Island: 3. Prehistoric Human Biological Adaptation. *Anthropological Papers of the American Museum of Natural History, 57*, part 3.

Larsen, C.S. 1983. Behavioural implications of temporal change in cariogenesis. *Journal of Archaeological Science, 10*, 1-8.

Larsen, C.S. 1984. Health and disease in prehistoric Georgia: the transition to agriculture. In Cohen, M.N., and Armelagos, G.J., (Eds.) *Paleopathology at the Origins of Agriculture*(pp. 367-392). Orlando, Florida: Academic Press.

Larsen, C.S. 1987.Bioarchaeological interpretations of subsistence economy and behavior from human skeletal remains. In Schiffer, M.B. (Ed.) *Advances in Archaeological method and theory* (pp. 339- 445).San Diego: Academic Press.

Larsen, C.S. and Griffin, M.C. 1991. Dental caries evidence for dietary change: an archaeological context. In Kelley, M.A. and Larsen, C.S. (Eds.), *Advances in dental anthropology* (pp. 179-202). New York: Wiley- Liss.

Larsen C.S. 1995. Biological Changes in Human Populations with Agriculture. *Annual Review of Anthropology, 24,* 185-213.

Larsen, C.L. 1997. *Bioarchaeology: Interpreting behavior from the human skeleton*. Cambridge: Cambridge University Press.

Larsen, C. S. and Ruff, C. 2011. An External Agency of Considerable Importance: The Stresses of Agriculture in the Foraging-to-Farming Transition in Eastern North America. In Pinhasi, R. and Stock, J.T (Eds),*Human Bioarchaeology of the Transition to Agriculture*. Chichester: Wiley-Blackwell, 293-315.

Larsen, C. S., Hillson, S.W., Boz , B., Pilloud, M.A., Sadvari, J.W., Agarwal, S.C., Glencross, B., Beauchesne, P., Pearson, J., Ruff, C.B., Garofalo E.M., Hager, L.D., Haddow, S.D. and Knusel, C. J. 2015. Bioarchaeology of Neolithic Catalhoyuk: Livesand Lifestyles of an Early Farming Society in Transition.*Journal of World Prehistory,28,* 27–68.

Lazzarini, L. and Antonelli, F. 2003. Petrographic and Isotopic Characterization of The Marble Of The Island Of Tinos (Greece). *Archaeometry, 45,*541–552.

Leach, B.F., Quinn, C.J. and Lyon, G.L. 1996. A stochastic approach to the reconstruction of prehistoric human diet in the Pacific region from bone isotope signatures. *Tuhinga, Records of the Museum of New Zealand Te Papa Tongarewa, 8*, 1–54.

Leach, H.M. 2003. Human domestication reconsidered. *Current Anthropology, 44* (3), 349-368.

Le Bras-Goude, G., Binder, D., Formicola, V., Duday, H., Couture-Veschambre, C., Hublin, J. J., Richards, M. P., 2006. Strategies de subsistance et analyse culturelle de populations neolithiques de Ligurie : approche par l'etude isotopique (13C et 15N) des restes osseux. *Bull. Memoires Soc. d'Anthropol. Paris 18*, 45-55.

Le Bras-Goude, G., Binder, D., Zemour, A., Richards, M.P. 2010. New radiocarbon dates and isotope analysis of Neolithic human and animal bone from the Fontbrégoua Cave (Salernes, Var, France).*Journal of Anthropological sciences, 88*, 167-78.

Legrand, A. 2007. *Fabrication et utilisation de l'outillage en tmatieres osseuses du Neolithique de Chypre: Khirokitia et Cap-Andreas-Kastros.* BAR InternationalSeries 1893. Oxford: Archaeopress.

Leković, V. 1985. The Starčevo mortuary practicies-New perspectives. *Godišnjak centra za Balkanološka ispitivanja, 27*, 157–172.

Lelli, R., Allen R., Biondi, G., Calattini, M., Barbaro, C., Gorgoglione, M., Manfredini, A., Martinez-Labarga, C., Radina, F., Silvestrini, M., Tozzi, C., Rickards, O., Craig, O., 2012. Examining dietary variability of the earliest farmers of south-eastern Italy. *American Journal of Physical Anthropology, 149*, 380–390.

Letica, Z. 1968. Starčevo and Körös culture at Vinča, *Archaeologia Iugoslavica, 9*, 11–18.

Летица, З. 1970. Гроб Салкуца културе са Лепенског вира, *Старинар* (н.с.) XXI, 117–124.

Li, Y., Lee, S., Hujoel, P., Su, M., Zhang, W., Kim, J., Zhang, Y.P. and DeVizio, W., 2010. Prevalence and severity of gingivitis in American adults. *American Journal of Dentistry, 23*, 9–13.

Libby, W.F., Berger,R., Mead, J.F. and Alexander,G.V., 1964. Replacement rates for human tissue from atmospheric radiocarbon.*Science,146*, 1170-1172.

Lichter, C. 2001. *Untersuchungen zu den Bestattungssitten des südosteuropäischen Neolithikums und Chalkolithikums*. Mainz: Verlag Philipp von Zabern.

Lieverse, A. R. 1999. Diet and the aetiology of dental calculus. *International Journal Osteoarchaeology, 9*, 219–232.

Lieverse, A. R., Stock, J. T., Katzenberg, M. A. and Haverkort, C. M. 2011. The Bioarchaeology of Habitual Activity and Dietary Change in the Siberian Middle Holocene. In Pinhasi, R. and Stock, J. T. (Eds.), *Human Bioarchaeology of the Transition to Agriculture* (pp. 265-291). Chichester: Wiley-Blackwell.

Lightfoot, E., Boneva, B., Miracle, P.T., Šlaus, M. and O'Connell, T. C. 2011. Exploring the Mesolithic and Neolithic transition in Croatia through isotopic investigations. *Antiquity, 327* (85), 73–86.

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

Lillie, M. C. and Richards, M.P. 2000. Stable Isotope Analysis and Dental Evidence of Diet at the Mesolithic–Neolithic Transition in Ukraine. *Journal of Archaeological Science, 27*(10), 965-972.

Lillie, M.C., Richards, M.P. and Jacobs, K. 2003. Stable Isotope Analysis of Twentyone Individuals from the Epipalaeolithic Cemetery of Vasilyevka III, Dnieper Rapids region, Ukraine. *Journal of Archaeological Science, 30,* 743-52.

Linderholm, A., Andersson, K., Mörth, C.M., Grundberg, L., Hårding, B. and Lidén, K. 2008. An early Christian cemetery at Björned in northern Sweden: stable isotope analyses of skeletal material. *Fornvännen, 103,* 176-89.

Littleton, J. and Frohlich, B.1993. Fish eaters and farmers: dental pathology in the Arabian Gulf. *American Journal of physical Anthropology, 92,* 427-447.

Longin, R., 1971. New method of collagen extraction for radiocarbon dating. *Nature, 230*, 241-242.

Lowenstam, H.A. and Weiner, S. 1989. *On Biomineralization*. Oxford: Oxford University Press.

Lösch, S., Grupe, G., Peters, J., 2006. Stable isotopes and dietary adaptations in humans and animals at pre-pottery Neolithic Nevallı Çori, southeast Anatolia. *American Journal of Physical Anthropology, 131,* 181–193.

Lubbock, J. 1865. *Pre-historic Times*. London: Williams & Norgate.

Lukacs, J.R. 1989. Dental paleopathology: methods of reconstructing dietary patterns. In Iscan M.Y. and Kennedy, K.A.R. (Ed.). *Reconstruction of life from the skeleton* (pp.261-286). New York: Alan R. Liss.

Lukacs, J. R. and Largaespada, L. L. 2006. Explaining sex differences in dental caries prevalence: Saliva, hormones, and “life-history” etiologies. *American Journal of Human Biology,18,* 540–555.

Lukacs, J.R. 2008. Fertility and agriculture accentuate sex differences in dental caries rates, *Current Anthropology,49* (5), 901–914.

Lukacs,J.R. 2011. Sex differences in dental caries experience: clinical evidence, complex etiology. *Clinical Oral Investigations,15*(5), 649-656.

Malmström, H., Linderholm, A., Liden, K., Stora, J., Molnar, P., et al. 2010. High frequency of lactose intolerance in a prehistoric hunter-gatherer population in northern Europe. *BMC Evolutionary Biology,10,*89.

Marchi, D., Sparacello, V. and Shaw, C. 2011. Mobility and Lower Limb Robusticity of a Pastoralist Neolithic Population from North-Western Italy. In Pinhasi, R., and Stock, J.T. (Ed.) *Human Bioarchaeology of the Transition to Agriculture*(pp. 293-315). Chichester: Wiley-Blackwell.

Marinković, S. 1996. *Starčevačka kultura na tlu srednjeg Banata-katalog izložbe*. Zrenjanin.

Marinković, S. 2006. Starčevo culture in central Banat. In Vorgić, B. and Brukner, B. (Eds.), *Current problems of the transition period from the Starčevo to the Vinča culture* (pp. 63-79). Zrenjanin: National museum Zrenjanin.

Марковић, Н., Булатовић, Ј., Јовановић. Ј. и Катић, В. (у припреми). Биоархеолошка перспектва ранонеолитског налазишта Баташево.

Mariotti, A. 1983. Atmospheric nitrogen is a reliable standard for natural 15 N abundance measurements. *Nature, 303*, 685-687.

Marsh, P. D. and Bradshaw, D. J. 1995. Dental plaque as a biofilm. *Journal of Industrial Microbiology, 15*, 169–175.

Martin, R. 1928. *Lehrbuch der anthropologie, zweiter band: kraniologie, osteology.*Jena: Verlag Gustav Fischer.

Masson, M. 2014. The Osteological Evidence of Neolithic Populations from the Southern Great Plain of Hungary. Unpublished PhD Thesis, Faculty of Science and Informatics. University of Szeged.

May, R. I., Goodman, A. and Meindl, R.S. 1993. Responses of Bone and Enamel Formation to Nutritional Supplementation and Morbidity Amoung Malnourished Guatemalan Children. *American Journal of PhysicalAnthropology, 92*, 37-51.

Mays, S.A., Richards, M.P. and Fuller, B.T. 2002. Bone stable isotope evidence for infant feeding in mediaeval England. *Antiquity, 76*, 654–656.

Meiklejohn, C., Schentag, C., Venema, A. and Key, P. 1984. Socioeconomic change and patterns of pathology and variation in the Mesolithic and Neolithic of Western Europe: some suggestions. In Cohen, M.N. and Armelagos, G.J (Eds.). *Paleopathology at the Origins of Agriculture* (pp.75-100). Orlando: Academic Press.

Menghini, G., Steiner, M., Thomet, E., Roos, M. and Imfeld, T. 2008. Caries prevalence in 2 year old children in the city of Zurich. *Community Dental Health,25*(3), 154–160.

Mensforth, R.P., Lovejoy, C.O., Lallo, J.W. and Armelagos, G.J. 1978. The role of constitution factors, diet, and infectious disease in the etiology of porotic hyperostosis and periosteal reactions in prehistoric infants and children. *Medical Anthropology, 2*, 1-59.

Mickleburgh, H. and Pagán-Jiménez, J. R. 2012. New Insights Into the Consumption of Maize and Other Food Plants in the Pre-Columbian Caribbean from Starch Grains Trapped in Human Dental Calculus. *Journal of Archaeological Science, 39,*2468-2478.

Mikić, Ž. 1981. Djerdapska serija kao antropološki model neolitizacije. *GlasnikEtnografskog instituta SANU, XXX*,103-130.

Mikić, Ž. 1988a. Anthropological Remains from the Neolithic Sites in Serbia. In Srejović D. (Ed.), *Neolithic of Serbia: Archaeological Research 1948-1988* (pp. 20–23). Belgrade: The University of Belgrade, Faculty of Philosophy, Centre for Archaeological Research.

Mikić, Ž. 1988b. *Antropološka struktura stanovništva Srbije*. Etnoantropološki problemi, Monografije, knjiga 4. Beograd: Odeljenje za etnologiju Filozofskog fakulteta.

Микић, Ж. 1989. Прилог антрополошком упознавању неолита у Србији. *Гласник српског археолошког друштва, 5*, 18-26.

Mikić, Ž. 1989. Novi starčevački antropološki nalazi jugoslovenskog podunavlja. *Godišnjak centra za balkanološka ispitivanja, 27/25,* 79-90.

Mikić, Ž. 1995. Antropološki ostaci neolitskih ljudi sa nalazišta Zlatara (7) i Kudoš (20) u Sremu. *Arheološka istraživanja duž autoputa kroz Srem*. Novi Sad: Pokrajinski zavod za zaštitu spomenika kulture, 45-49.

Millard, A.R. 2000. A model for the effect of weaning on nitrogen isotope ratios in humans. In Goodfriend, G., Collins, M., Fogel, M., Macke, S. and Wehmiller, J. (Eds.)*Perspectives in Amino Acid and Protein Geochemistry*(pp. 51–59). New York: Oxford University Press.

Miles, A.E.W. 1963. Dentition in the Estimation of Age. *Journal of Dental Research,42*, 255–263.

Miles, A., Powers, N., Wroe-Brown, R., Walker, D. 2008. *St Marylebone Church and burial ground in the 18th to 19th centuries.* Museum of London Archaeology Service: London.

Minagawa, M. and Wada, E., 1984. Stepwise enrichment of 15N along food chains: Further evidence and the relation between 15N and animal age. *Geochimica et Cosmochimica Acta*, *48,* 1135–1140.

Minagawa, M. 1992. Reconstruction of human diet from13C and 15N in contemporary Japanese hair: astochastic method for estimating multi-source contribution by double isotopic tracers, *AppliedGeochemistry,*7, 145-158.

Minichreiter, K. 2006. Development of the Starčevo Culture in the Territory of Continental Croatia. In Tasić, N. and Grozdanov, C. (Hrsg.), *Homage to Milutin Garašanin* (str.79-97). Belgrade.

Minichreiter, K. 2007. The First Farmers of Northern Croatia, a Short Walk through the Balkans: The First Farmers of the Carpathian Basin and Adjace Regions.*Societa per la Preistoria e Protostoria della Regione Friuli- Venezia Giulia*, quaderno 12, Trieste, 171 – 183.

Minichreiter, K. and Botić, K. 2010. Early Neolithic burials of Starčevo culture at Galovo, Slavonski Brod (Northern Croatia). *Documenta Praehistorica*, *37,*105-124.

Mundorff-Shrestha, S. A., Featherstone, J. D. B., Eisenberg, A. D., Cowles, E., Curzon, M. E. J., Espeland, M. A. and Shields, C. P. 1994. Cariogenic potential of foods. II. Relationship of food composition, plaque microbial counts, and salivary parameters to caries in the rat model. *Caries Research,28,*106–15.

Murail, P., 1996. *Biologie et pratiques funéraires des populations d'époque historique: une demarche méthodologique appliquée à la nécropole gallo-romaine de Chantambre (Essonne, France).*Unpublished thesis, University Bordeaux 1.

Murail, P., Bruzek, J., Houët, F., Cunha, E., 2005. DSP: a probabilistic sex-diagnosis tool using world-wide variation of pelvic measurments. Bulletins et mémoires de la sociétéd' *Anthropologie de Paris 17,* 167-176.

Moffat, T. and Finnis, E. 2010. Dietary Diversity, Dietary Transitions and Childhood Nutrition in Nepal: Questions of Methodology and Practice. In Moffat,T. and Prowse, T. (Ed.) *Human diet and nutrition in biocultural perspective Past Meets Present* (pp.133-151). New York: Berghahn Books.

Moggi-Cecchi, J., Pacciani, E. and Pinto-Cisternas, J. 1994. Enamel hypoplasia and age at weaning in 19th century Florence. *Am. J. Phys. Anthrop., 93,* 299-306.

Moore, W.J. and Corbett, M.E. 1983. Dental and Alveolar Infection. In Hart, G. and Legg, N. *Disease in Ancient Man* (pp. 139-155). Toronto: Clarke Irwin.

Moorrees, C.F.A., Fanning, E.A. and Hunt, E.E. 1963a. Formation and resorption of three deciduous teeth in children. *American Journal of Physical Anthropology, 21,* 205-213.

Moorrees, C.F.A., Fanning, E.A. and Hunt, E.E. 1963b. Age variation of formation stages for ten permanent teeth. *Journal of Dental Research,* 42, 1490-1502.

Naito, Y.I., Chikaraishi, Y., Ohkouchi, N., Drucker, D., Bocherens, H., 2013. Nitrogen isotopic composition of collagen amino acids as an indicator of aquatic resource consumption: insights from Mesolithic and Epipalaeolithic archaeological sites in France. *World Archaeology, 45,* 338-359.

Nardoto, G. B., Godoy, P.B., de Ferraz, E. S., de Barros, O. Balbaud, J. P. H. and Martinelli, L. A. 2006. Stable carbon and nitrogen isotopic fractionation between diet and swine tissues. *Scientia Agricola*, *63*(6), 579-582.

Nehlich, O. and Richards, M.P., 2009. Establishing collagen quality criteria for sulphur isotope analysis of archaeological bone collagen. *Archaeological and Anthropological Sciences*, *1*(1), 59-75.

Nehlich, O., Borić, D., Stefanovic, S. and Richards, M.P., 2010. Sulphur isotope evidence for freshwater fish consumption: a case study from the Danube Gorges, SE Europe. *Journal of Archaeological Science*, *37*(5), 1131-1139.

Nehlich, O., Fuller, B.T., Jay, M., Mora, A., Nicholson, R.A., Smith, C.I., Richards, M.P., 2011. Application of sulphur isotope ratios to examine weaning patterns and freshwater fisconsumption in Roman Oxfordshire, UK. *Geochimica et Cosmochimica Acta*, *75* (17), 4963-4977.

Nehlich, O., 2015. The application of sulphur isotope analyses in archaeological research: A review. *Earth-Science Reviews*, *142*(0), 1-17.

Nehlich, O. and Borić, D. 2015. Response to Bonsall et al. Food for thought: reassessing Mesolithic diets in the Iron Gates. *Radiocarbon*, *57*(4), 701–3.

Nemeskéri, J. 1969. Stanovništvo Lepenskog Vira. U Srejović, D. *Lepenski Vir – Nova praistorijska kultura u Podunavlju* (str.239–257). Beograd: Srpska književna zadruga.

Nemeskéri, J., Szathmàry, L. 1978. Individual data of the Vlasac anthropological service. In Grašanin, M. (Ed.), Vlasac II (pp.285-426). Beograd: Serbian Academy.

Newbrun, E.1982. Sugar and dental caries: a review of human studies. *Science, 217,* 418-423.

Nicklisch, N., Ganslmeier, R., Siebert, A., Friedrich, S., Meller, H., Alt, K.W. 2016. Holes in teeth – Dental caries in Neolithic and Early Bronze Age populations in Central Germany. *Annals of Anatomy - Anatomischer Anzeiger, Volume 203,* 90–99.

Nielsen-Marsh, C., Gernaey, A., Turner-Walker, G., Hedges,R., Pike,A., Collins, M. 2000. The chemical degradation of bone.InCox, M. and Mays, S.A. (Eds) (pp. 439-

454). *Human osteology in archaeological and forensic science*.Londres: Greenwich Medical Media.

Nitsch, E.K., Humphrey, L.T. and Hedges, R.E.M. 2011. Using stable isotope analysis to examine the effect of economic change on breastfeeding practices in Spitalfields, London, UK. *American Journal of Physical Anthropology*, *146* (4), 619–628.

Nriagu, J.O., Coker, R.D. and Barrie, L.A. 1991. Origin of sulphur in Canadian Arctic haze from isotope measurements. *Nature*, *349* (6305), 142–45.

Nystrom, M., Kleemola-Kujala, E., Evalahti, M., Peck, L., Kataja, M. (2001). Emergence of permanent teeth and dental age in a series of Finns. *Acta Odontol Scand, 59, 49-56.*

O'Connell, T.C. and Hedges, R.E.M. 1999. Investigations into the effect of diet on modern human hair isotopic values.*American Journal of Physical Anthropology,108*, 409-425.

Ogrinc, N. and Budja, M. 2005. Paleodietary reconstruction of a Neolithic population in Slovenia: A stable isotope approach. *Chemical Geology*, 01.

Oelze, V. M. et al. 2011. Early Neolithic diet and animal husbandry: stable isotope evidence from three Linearbandkeramik (LBK) sites in Central Germany. *Journal of Archaeological science,38* (2), 270-279.

Ortner, D.J. 2003. *Identification of Pathological Conditions in Human Skeletal Remains*. New York: Academic Press.

Ortner, D.J. and Putschar WGJ. 1981. *Identification of Pathological Conditions in Human Skeletal Remains*. Washington DC: Smithsonian Institution Press.

Orton, D. 2008. Beyond hunting and herding, humans, animals, and the political economy of the Vinča period. Unpublished PhD dissertation. University of Cambridge.

Özbek, M. 1998. Human skeletal remains from Asikli, a Neolithic village near Aksaray, Turkey. In: Arsebuk G, Mellink MJ, Schirmer W, editors. Light on top of the black hill: Studies presented to Halet C¸ ambel. Istanbul: EGE Yayınları. pp. 567–573.

Özdogan, M. 2011. Archaeological evidence on the westward expansion of farming communities from eastern Anatolia to the Aegean and the Balkans. *Current Anthropology 52* (S4), 415–430.

Palubeckaite, Z. 2001. Patterns *of* linear enamel hypoplasia *in* Lithuanian Iron age population.*Variability and Evolution, 9*, 75-87.

Papathanasiou, A. 2003. Stable isotope analysis in Neolithic Greece and possible implications on human health. *International Journal of Osteoarchaeology, 13*(5), 314–324.

Papathanasiou, A. 2005. Health Status of the Neolithic Population of Alepotrypa Cave, Greece. *American Journal of Physcal Antropology 126*, 377–390.

Papathanasiou, A. 2011. Health, Diet and Social Implications in Neolithic Greece from the study of Human Osteological Material, In Pinhasi, R. and Stock, J. T. (Eds.), *Human Bioarchaeology of the Transition to Agriculture* (pp. 87-106), Chichester: Wiley-Blackwell.

Parkington, J. 1991. Approaches to dietary reconstruction in the western cape: are you what you have eaten?. *Journal of Archaeological Science,18*, 331-342.

Pearsall, D. M. 2008. *Paleoethnobotany: A Handbook of Procedures. 2nd ed*. UK: Emerald, Bingley.

Pearson, J.A., Hedges, R.E.M., 2007. Stable carbon and nitrogen isotope analysis and the evidence for diet at Ecsegfalva and beyond. In Whittle, A. (Ed.), *The Early Neolithic on the Great Hungarian Plain: investigations of the Körös culture site of Ecsegfalva 23*(pp. 37-43).Co. Bekes, TBA: TBA.

Pearson, J.A., Hedges, R.E.M., Molleson, T.I. and Özbek, M. 2010. Exploring the relationship between weaning and infant mortality: An isotope case study from Aşıklı Höyük and Çayönü Tepesi. *American Journal of Physical Anthropology, 143,* 448–457.

Pearson, J., Grove, M., Özbek, M. and Hongo, H. (2013). Food and social complexity at Çayönü Tepesi, southeastern Anatolia: Stable isotope evidence of differentiation in diet according to burial practice and sex in the early Neolithic. *Journal of Anthropological Archaeology, 32*(2), http://dx.doi.org/10.1016/j.jaa.2013.01.002

Pechenkina, E.A., Benfer Jr., R.A. and Zhijun, W. 2002. Diet and health changes at the end of the Chinese Neolithic: The Yangshao/Longshan transition in Shaanxi province. *American Journal of Physical Anthropology,117,* 15-36.

Penezić, K., Stefanović,S., Wittwer-Backofen, U., Urban, P. and Jovanović, J. 2016. *Female stress during the Neolithic Demographic Transition in the Balkans: evidences from tooth cementum*. 8th World Archaeological congress (28.08.-02.09.2016.). Kyoto: Japan.

Perić, S and Nikolić, D. 2006. On the issue of an ossuary – pit dwelling Z in the oldest horizon at Vinča. *Starinar*, *LVI,* 47-72.

Perry, G. H., Dominy, N. J., Claw, K. G., Lee, A. S., Fiegler, H., Redon, R., Werner, J., Vilanea F., Mountain J., Misra R., Carter, N., Lee, C., Stone, A. C. 2007. Diet and the evolution of human amylase gene copy number variation. *Nature Genetics*, *39*(10), 1256–1260.

Peterson, B.J. and Fry, B., 1987. Stable Isotopes in Ecosystem Studies. *Annual Review of Ecology and Systematics*, *18* (1), 293–320.

Petrović, J. 1976. Golokut, Vizić, Fruška gora - praistorijsko naselje. *Arheološki pregled, 18,* 11-12.

Petrović, J. 1978. Golokut, Vizić, Fruška gora - praistorijsko neolitsko naselje. *Arheološki pregled*, *20*, 12-14.

Петровић, J. 1984-5. Насеље старчевачке културе на Голокуту код Визића. Ископавања 1973. и 1976. године. *Рад Војвођанских музеја, 29,* 9-25.

Petrović, J. 1985.Golokut, Vizić, Neolitsko naselje. *Arheološki pregled, 49-50.*

Petrović, J. 1987. Zemunica u naselju starčevačke culture na Golokutu. *Рад Војвођанских музеја, 30, 13-27.*

Петровић, J.1990. Истраживања локалитета Голокут у 1988. години. *Гласник Српског археолошког друштва, 6,* 55-58.

Petrović, J. 1999-2000. Građevinski objekti u naselju starčevačke kulture na Golokutu. *Rad muzeja Vojvodine 41-42,(1999-2000).*7-10.

Phillips, D.L., Koch, P.L., 2002. Incorporating concentration dependence in stable isotope mixing models. *Oecologia, 130,* 114-125.

Pindborg, J. 1970. Pathology of the dental hard tissues. Philadelphia: W. B. Saunders.

Pindborg, J. 1982. Etiology of Developmental Enamel Defects Not Related to Fluorosis. *International Dental Journal, 32,* 123-124.

Pinhasi, R., Fort, J., Ammerman, A. J. 2005. Tracing the origin and spread of agriculture inEurope. *PLoS Biol3* (12), e410.

Pinhasi, R., Stefanović, S., Papathanasiou, A. and Stock, J. T.. 2011. Variability in long bone growth patterns and limb proportions within and among Mesolithic and Neolithic populations from southeast Europe. In Pinhasi, R. and Stock, J. T. (Eds.), *Human Bioarchaeology of the Transition to Agriculture* (pp.177-202), Chichester: Wiley-Blackwell.

Piontek, J. and Vančata, V. 2002. Transition to agriculture in Europe: evolutionary trends in body size and body shape. In Bennike, P., Bodzsar, E., Susanne, C. (Eds.) *Ecological aspects of past human settlements in Europe*(pp. 61-92). Budapest: Eötvös University Press.

Piperno, D.R., Dillehay, T.D. 2008. Starch grains on human teeth reveal early broad crop diet in northern Peru. *Proceedings of the National Academy of Sciences,* USA. 105, 19 622–19 627. doi:10.1073/pnas.0808752105

Pirie, M., Cooke, I., Linden, G. and Irwin, C. 2007. Dental manifestations of pregnancy. *The Obstetrician & Gynaecologist, 9*, 21–26.

Pop, E., Boscaiau, N., Lupsa, V., 1970. Anexa Nr 1. Analizä sporopolenicà' a sedi'entelor de l a Cuina Turcului-Cuina Turcului-Dobova. *SCIV, 21*, 31-34.

Porčić, M., de Becdelièvre, C., Le Roy, M., Jovanović, J., Stefanović, S., Thomas, M., Shennan, S., Timpson, A. *Investigating local demographic fluctuations during the Mesolithic and the Neolithic in the Danube Gorges : a review of radiocarbon, skeletal and settlement evidence*. The 20 th European Association of Archaeologists Annual Meeting (10 - 14, September, 2014). Istanbul, Turkey.

Porčić, M. and Nikolić M., 2016. The Approximate Bayesian Computation approach to reconstructing population dynamics and size from settlement data: demography of the Mesolithic-Neolithic transition at Lepenski Vir. *Archaeological and Anthropological Sciences*,1-18.

Porčić, M., Blagojević, T., Stefanović, S. 2016. Demography of the Early Neolithic Population in Central Balkans: Population Dynamics Reconstruction Using Summed Radiocarbon Probability Distributions. *PLoS ONE 11,* (8), e0160832.

Powell, M.L. 1985. The Analysis of Dental Wear and Caries for Dietary Reconstruction. In Gilbert, R.I. Jr. and Mielke, J. H., (Eds.), *The Analysis of Prehistoric Diets* (pp.307-338), Orlando: Academic Press.

Plantinga, T. S., Alonso, S., Izagirre, N.,Hervella, M., Fregel, R., et al. 2012. Low prevalence of lactase persistence in Neolithic South - West Europe. *European Journal of Human Genetics,20*, 778–782.

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

Privat, K.L., O'Connell, T.C. and Hedges, R.E.M. 2007. The distinction between freshwater- and terrestrial-based diets: methodological concerns and archaeological applications of sulphur stable isotope analysis. *Journal of Archaeological Science, 34*, 1197-1204.

Premk, A., Popović, P., Bjelajac, Lj. 1984. Vajuga-pesak, fouilles de sondage de 1980. *Đerdapske sveske II*, 118-124.

Prowse, T. 2001. Isotopic and Dental Evidence for Diet from the Necropolis of Isola Sacra (1st–3rd centuries AD), Italy. PhD thesis, McMaster University.

Pruvost, S., Binder, D., Duday, H., Goude, G., Durrenmath, G., Gourichon, L., de Castex, D., Delhon, C., Gentile, I., Vuillien, M. and Zemour, A. under review. Une sépulture collective à la transition des 6ème et 5ème millénaires BCE : Mougins – « Les Bréguières » 1 (Alpes-Maritimes, France), fouilles Maurice SECHTER 1966-1967. *Gallia Préhistoire submitted.*

Radišić, R. 1967. Batka, Perlez-neolitsko, eneolitsko i halštatsko nalazište. *Arheološki pregled, 9*. 44-45.

Radosavljević-Krunić, S. 1986. Resultats de l'etude anthropologique des squelettes provenant du site Ajmana (Rezultati antropološke obrade skeleta sa lokaliteta Ajmana). *Đerdapske sveske* III, 51–58.

Radovanović, I. 1981. *Ranoholocenska kremena industrija sa lokaliteta Padina u Djerdapu*. Beograd: Centar za arheološka istraţivanja.

Radovanović, I. 1992. *Mezolit Djerdapa.* Unpublished PhD thesis, Beogradski Univerzitet.

Radovanović, I. 1995. *Mesolithic and Early Neolithic in the Iron Gates Region, Settlements, Subsistence and Chronology.* Paper presented at the Épipaléolithique et mésolithique en Europe, Paléoenvironement, peuplement et systems culturels, 5ème Congres International U.I.S.P.P., Commision mèsolithique, Grenoble.

Radovanović, I. 1996. *The Iron Gates Mesolithic*. Ann Arbor, MI: International Monographs in Prehistory, Archaeological Series 11.

Radovanović, I. 1997. The Lepenski Vir culture: A contribution to interpretation of its ideological aspects. In *Antidoron Dragoslavo Srejović completis LXV annis ab amicis,collegis, discipulis oblatum* (pp. 85–93). Beograd: Centar za arheološka istraživanja, Filozofski fakultet.

Radovanović, I. 2006. Further Notes on Mesolithic-Neolithic contacts in the Iron Gates region and the Central Balkans. *Documenta Praehistorica XXXIII,* 107-124.

Radović, M. 2012. Ageing in the Danube Gorges population (9500–5500 bc) – tooth cementum annulation method. *Starinar, LXII,* 9-18.

Радовић, М. 2013. *Трагови немастикаторних активности на зубима становника Ђердапа у периоду од 9500 – 5500 г. прен.е.* Докторска теза: Универзитет у Београду, Филозофски факултет.

Radović, M. and Stefanović, S. 2013. The bioarchaeology of the Neolithic transition: evidence of dental pathologies at Lepenski Vir (Serbia). *Documenta Praehistorica, XL,* 75-83. DOI:10.4312\dp.40.7

Ramezani, G. H., Norozi, A. and Valael, N. 2003. The prevalence of nursing caries in 18 to 60 months old children in Qazvin. *Journal of the Indian Society of Pedodontics and Preventive Dentistry*, *21*(1), 19–26.

Reid, D. and Dean, C. 2006. Variation in modern human enamel formation times. *Journal of Human Evolution, 50,*329-346.

Rey, L., Goude, G. and Rottier, S. 2016. Comportements alimentaires au Néolithique: nouveaux résultats dans le Bassin parisien à partir de l'étude isotopique (δ13C, δ15N) de la nécropole de Gurgy « Les Noisats » (Yonne, Ve millénaire av. J.-C.). *Bulletins et Mémoires de la Société d'Anthropologie de Paris.*DOI 10.1007/s13219-016-0170-9

Richards, M.P., Fuller, B.T., Hedges, R.E.M. 2001. Sulphur isotopic variation in ancient bone collagen from Europe: implication for human palaeodiet residence mobility and modern pollutant studies. *Earth and Planetary Science Letters*, 185-190.

Richards, M.P. 2002. A brief review of the archaeological evidence for Paleolithic and Neolithic subsistence. *European Journal of Clinical Nutrition*, *56,* 1270-1278.

Richards, M. P., Schulting, R. and Hedges, R. 2003. Sharp schift in diet in onset of Neolithic. *Nature, 423*, 136-137.

Richards, M. P., Montgomery, J., Nehlich, O. and Grimes, V. 2008. Isotopic analysis of humans and animals from Vedrovice. *Anthropologie, XLVI* (2-3), 185-194.

Robling, A.G., Castillo, A.B. and Turner, C.H. 2006. Biomechanical and molecular regulation of bone remodeling. *Annual Review of Biomedical Engineering*, *8,* 455–498.

Rodney, J.D. 1983. The age related distribution of dental indicators of growth disturbance in ancient lower Nubia: an ethological model from the ethnographic record. *Journal of Human Evolution, 12*, 535-543.

Roksandić, M. 1999. *Transition from Mesolithic to Neolithic in the Iron Gates gorge: Physical anthropology perspective*. PhD thesis, Simon Fraser University.

Roksandić, M. 2000. Between foragers and farmers in the Iron Gates gorge: Physical
anthropology perspective. Djerdap population in transition from Mesolithic to Neolithic. *Documenta Praehistorica, 27,* 1–100.

Roksandić, M. 2004. Contextualizing the evidence of violent death in the Mesolithic: Burials associated with victims of violence in the Iron Gates Gorge. In Roksandić, M. (Eds.) *Evidence and meaning of violent interactions in Mesolithic Europe* (pp. 53-74). Oxford: Archaeopress.

Roksandić, M., Vlak, D., Schillaci, M.A. and Voicu, D. 2009. Technical note: Applicability of tooth cementum annulation to an archaeological population. *American Journal of Physical Anthropology,140,* 583–588.

Roosevelt, A.C. 1984. Population, health, and the evolution of subsistence: conclusions from the conference. In M.N. Cohen and G.J. Armelagos (Eds.), *Paleopathology at the Origins of Agriculture* (pp. 559-583), New York.

Rosan B, Lamont, R.J. 2000. Dental plaque formation. *Microbes and Infection, 2,* 1599–1607.

Rose, J.C., Armelagos, G.J., Lallo, J.W., 1978. Histological enamel indicator of childhood stress in prehistoric skeletal samples. *American Journal of Physical Anthropology, 49,* 511-516.

Ruff, C.B. 2008. Biomechanical analyses of archaeological human skeletal samples. In Katzenberg M.A. and Saunders S.R. (Eds.), *Biological Anthropology of the Human Skeleton, 2nd edition* (pp. 183-206), New York: John Wiley and Sons.

Ruff, C. B., Larsen, Clark Spencer., Hayes, Wilson C. 1984. Structural changes in the femur with the transition to agriculture on the Georgia coast. *American Journal of Physical Anthropology, 64* (2), 125–136.

Ruff, C. B., Scott, William W., Liu, Allie Y.C. 1991. Articular and diaphyseal remodeling of the proximal femur with changes in body mass in adults. *American Journal of Physical Anthropology, 86* (3), 397–413.

Ruff,C., Holt, B., Niskanen, M., Sladek, V., Berner, M., Garofalo, E., Garvin,H. M., Hora, M., Junno, J., Schuplerova, E., Vilkama, R., Whittey, Erin. 2015. Gradual decline in mobility with the adoption of food production in Europe. *PNAS,112,*(23), 7147–7152.

Rundić, Lj., Knežević, S., Kuzmić, V., and Kuzmić, P., 2012. New data on the geology of the archaeological site Vinča (Belgrade, Serbia). *Geološki anali Balkanskoga poluostrva, 73*, 21-30.

Russell, N. 1993. *Hunting, Herding and Feasting: human use of animals in Neolithic Southeast Europe.* Unpublished Doctoral Dissertation, University of California Berkeley

Samuel, D., 2000. Brewing and baking. In Nicholson, P.T., Shaw, I. (Eds.), *Ancient Egyptian Materials and Technology* (pp. 537–576). Cambridge University Press, Cambridge.

Saravanan, S., Anuradha, K. P. and Bhaskar, D. J. 2003. Prevalence of dental caries and treatment needs among school going children of Pondicherry, India. *Journal of the Indian Society of Pedodontics and Preventive Dentistry, 21*(1), 1–12.

Schaefer M., Black S., and Scheuer L. 2009. Juvenile Osteology: A Laboratory and Field Manual. Academic Press, London.

Scheuer, L. and Black, S., 2000. *Developmental Juvenile Osteology*. London: Elsevier.

Scheuer, L. and Black, S. 2004. *The Juvenile Skeleton.*London: Elsevier Academic Press.

Schmitt, A. 2002. Estimation de l'âge au décès des sujets adultes à partir du squelette: des raisons d'espérer.*Bulletins et Mémoires de la Société d'Anthropologie de Paris,14*, 51-73.

Schmitt, A. 2005. Une nouvelle méthode pour estimer l'âge au décès des adultes à partir de la surface sacro-pelvienne iliaque.*Bulletins et Mémoires de la Société d'Anthropologie de Paris,17,* 89-101.

Schneider, K.N. 1986. Dental caries, enamel composition, and subsistence among prehistoric American Indians of Ohio. *American Journal of Physical Anthropology, 71*, 95 -102.

Schoeninger, M.J. and DeNiro, M.J. 1984. Nitrogen and carbon isotopic composition of bone collagen from marine and terrestrial animals. *Geochimica et Cosmochimica Acta*, *48* (4), 625–639.

Schoeller, D., 1999. Isotope Fractionation: Why aren't we what we eat? *Journal of Archaeological Science*, *26* (6), 667–673.

Schurr, M. R. 1998. Using stable nitrogen-isotopes to study weaning behaviour in past populations. *World Archaeology*, *30* (2), 327–342.

Schurr, M. R.., Powell M. L. 2005. The Role of Changing Childhood Diets in the Prehistoric- Evolution of Food Production: An Isotopic Assessment. *American Journal of Physical Anthropology, 126,* 278–294.

Schulting, R. 2011. Mesolithic-Neolithic Transition: An Isotopic Tour through Europe, In Pinhasi, R. and Stock, J. T. (Eds.), *Human Bioarchaeology of the Transition to Agriculture* (pp. 17-43), Chichester: Wiley-Blackwell.

Schultz, M. 2001. Paleohistopathology of Bone: A New Approach to the Study of Ancient Diseases. *Yearbook of Physical Anthropology, 44,*106–47.

Schwarcz, H. P. and Schoeninger, M. J. 1991. Stable Isotope Analyses in Human Nutritional Ecology. *Yearbook of Physical Anthropology, 34*, 283-321.

Schwarcz, H.P., Dupras, T.L. and Fairgrieve, S.I. 1999. 15N enrichment in the Sahara: In search of a global relationship. *Journal of Archaeological Science, 26,* 629-636.

Schwidetzky, I. 1971-1972. Menschliche Skelettreste von Vinca. *Glasnik antropoloskog drustva Jugoslavije, 8-9,*101-112.

Seibel, M.J. 2005. Biochemical markers of bone turnover: part I: biochemistry and variability. *The Clinical Biochemist Reviews, 26* (4), 97–122.

Swellen, D. W. 2001. Comparison of Infant Feeding Patterns Reported for Nonindustrial Populations with Current Recommendations. *Community and International Nutrition,131*, 2707-2715.

Swellen, D.W. and Smay, D.B. 2001. Relationship between subsistence and age at weaning in "preindustrial" societis. *Human Nature, 12,* (1), 47-87.

Shell-Duncan, B. 1997. Evaluation of infection and nutritional status as determinants of cellular immunosuppression. *American Journal of Biology, 9,* 381–390.

Smith, B.H. 1984. Patterns of molar wear in hunter-gatherers and agriculturalists. *American Journal of Physical Anthropology, 63*, 39–55.

Smith, B.N. and Epstein, S. 1971. Two categories of 13C/12C ratios for higher plants. *Plant Physiology, 47* (3), 380– 384.

Smith, P., Bar-Yosef, O., Sillen, A. 1984. Archaeological and skeletal evidence for dietary change during the late Pleistocene/earlyHolocene in the Levant. In Cohen, M.N., Armelagos, G.J. (Eds.), *Paleopathology at the origins of agriculture* (pp. 101–136). Orlando: Academic Press.

Smits, E., Millard, A.R., Nowell, G., Graham Pearson, D. 2010. Isotopic investigation of diet and residential mobility in the Neolithic of the lower Rhine basin. *European Journal of Archaeology, 13*, 5–31.

Solomons, N.W. and Keusch, G.T. 1981. Nutritional Implications of Parasitic Infections. *Nutrition Reviews, 39,* 149-161.

Sponheimer, M., Robinson, T., Roeder, B., Passey, B., Ayliffe, L., Cerling, T., Dear-ing, M., and Ehleringer, J. 2003. An experimental study of nitrogen flux in lla-mas: is 14N preferentially excreted? *Journal of Archaeological Science*, *30* (12), 1649–1655.

Srejović, D. 1969. *Lepenski Vir — Nova praistorijska kultura u Podunavlju*. Beograd: Srpska književna zadruga.

Srejović, D.1971. Die Lepenski Vir-Kultur und der Beginn der Jungsteinzeit and der mittleren Donau. In Schwabedissen, H. (Ed.) *Die Anfänge des Neolithikums vom Orient bis Nordeuropa, Teil 2: Östliches Mitteleuropa* (pp. 1–19). Köln/Wien: Fundamenta, Monographien zur Urgeschichte, Reihe A, Band 3.

Srejović, D. 1972. *Europe’s First Monumental Sculpture: New Discoveries at Lepenski Vir*. London: Thames & Hudson.

Srejović, D. and Letica, Z. 1978. *Vlasac: Mezolitsko naselje u Djerdapu, vol. 1 arheologija*. Beograd: Srpska akademija nauka i umetnosti.

Srejović, D. 1981. *Lepenski Vir: Menschenbilder einer frühen europäischen Kultur*. Mainz am Rhein: von Zabern.

Stalio, B. 1986. Le site prehitorique à Ajmana Mala Vrbica. *Djerdapske sveske, 3,* 28-50.

Stalio, B. 1992. Grupno sahranjivanje na Ajmani – Mala Vrbica. *Zbornik Narodnog muzeja, 14*(1), (65–76). Beograd: Univerzitet u Beogradu, Filozofski fakultet, Odsek Arheologija.

Stanković, S. 1986. Localite Knjepište – une station du grupe de Starčevo. Fouilles de 1982-1983. *Đerdapske sveske,III*, 447-452.

Станковић, С. 1990. Гривац - вишеслојно насеље (ископавања 1989. године).*Гласник Српског археолошког друштва,6,*60-64.

Stanković, S. 1992. *Sakralna mesta i predmeti u starije neolitskim kulturama centralno balkanskog područja*. PhD Thesis. Beograd: Univerzitet u Beogradu, Filozofski fakultet.

Stefanović, S. and Borić, D. 2008. The newborn infant burials from Lepenski Vir: In pursuit of contextual meanings. In Bonsall, C., Radovanović, I. and Boroneanţ, V. (Eds*), The Iron Gates in prehistory: New perspectives* (pp.131–169). BAR International Series 1893, Oxford: Archaeopress.

Stefanović, S. and Porčić, M. 2009. Muscles in transition: *Changing bodily activities from the Mesolithic to the Neolithic in the Danube Gorges?* Paper presented at: Body Histories, conference sponsored by the Leverhulme Research Programme "Changing Beliefs of the Human Body" (11 – 13, September, 2009). Cambridge: McDonald Institute for Archaeological Research.

Стефановић, С. 2012. *Сифилис контроверза трепонематозне инфекције у европској праисторији.* Београд: Филозофски факултет.

Стефановић, С. и Порчић, М. 2015. Старчевачки гробови на Јаричишту – антрополошка анализа. *Архаика 03*/2015, 68-88.

Стефановић, С., Јовановић,Ј., Миљевић,М., Живановић, С. 2016. Старчевачка групна гробница на Винчи или место неолитског злочина? XXXVIII скуп српског археолошког друштва, Књига апстраката.

Stefanović, S. (in press). Ljudi Lepenskog Vira: bioantropološka analiza ljudskih ostataka Belgrade: Faculty of Philosophy.

Stefanović, S., Penezić, K., Filipović, D., Jovanović, J., Dimitrijević, V., Živaljević, I., Porčić, M., Blagojević, T., Starović, A. in preparation. Bone spoons for prehistoric babies: new weaning practices in the Early Neolithic Balkans.

Stinson, S. 1985. Sex Differences in Environmental Sensitivity during Growth and Development. *Yearbook of Physical Anthropology, 28*, 123 - 148.

Stloukal, M. and Hanakova, H. 1978. Die Länge der Längsknochen altslavischer Bevölkerungen-Unterbesonderer Berücksichtigung von Wachstumsfragen. *Homo, 29*, 53-69.

Stock, J.T., Pinhasi, R. 2011.Changing paradigms in our understanding of the transition to agriculture: Human bioarchaeology, behaviour and adaptation. In Pinhasi, R., Stock, J. (Eds). *The Bioarchaeology of the transition to Agriculture* (pp.1-16). New York: Wiley-Liss.

Stock, J.T., O'Neill, M.C., Ruff, C.B., Zabecki, M., Shackelford, L., Rose, J.C. 2011. Body Size, Skeletal Biomechanics, Mobility and Habitual Activity from the Late Palaeolithic to the Mid-Dynastic Nile Valley. In Pinhasi, R. and Stock, J.T. *Human Bioarchaeology of the Transition to Agriculture* (pp.293-315). Chichester: Wiley-Blackwell.

Stuart–Macadam, P. 1985. Porotic hyperostosis: representative of a childhood condition, *American Journal of Physical Anthropology, 66*, 391–398.

Stuart-Macadam, P.L. 1987. A radiographic study of porotic hyperostosis. *American Journal of Physical Anthropology, 74*, 511-520.

Stuart-Macadam P. 1989. Nutritional deficiency diseases: a survey of scurvy, rickets and iron deficiency anemia. In Iscan, M. Y. and Kennedy, K.A.R. (Eds.), *Reconstruction of life from the skeleton* (pp. 201-22). New York: Alan Liss.

Stuart-Macadam, P.L.1992. Porotic hyperostosis: a new perspective. *American Journal of Physical Anthropology, 87*, 39-47.

Stuart-Macadam, P., Dettwyler, K.A. (Eds.) 1995. *Breastfeeding: Biocultural Perspectives*. New York: Aldine de Gruyter.

Šarić, J. 2014. *Artefakti od okresanog kamena u starijem i srednjem neolitu na tlu Srbije*. Beograd: Arheološki institut.

Tasić, N., Srejović, D., Stojanović, B. 1990. *Vinča: Centre of the Neolithic culture of the Danubian region*. Belgrade: Cultura.

Tasić, N. N. 1997. *Hronologija starčevačke culture.* Unpublished PhD, Beograd: Univerzitet u Beogradu, Filozofski fakultet.

Тасић, Н.Н. 1998. Рудник код Србице. Насеље старчевачке културе. У *Архео-лошко благо Косова и Метохије, од неолита до раног средњег века*. Каталог. Приштина: Српска академије наука и уметности и Музеј у Приштини.

Tasić, N. N. 2007. Neolit u senci - još jedan osvrt na starčevačka naselja u Bosni.*Godišnjak centra za balkanološka ispitivanja, 34*, Sarajevo.

Tasić, N. N. 2008. Vinča - metropola kasnog neolita. In Nikolić, D. (Ed.), *Vinča - Praistorijska metropola* (str.15-37), Istraživanja 1908-2008, Beograd.

Tasić, N.N. 2014. *Interdisciplinary approach to salvation of the site of Vinča – Belo Brdo*. Asociatia ArheoVest Nr II. Timisoara. Szeged: Jate Press Kiadó.

Tasić, N. N., Marić, M., Ramsey, C. B., Kromer, B., Barclay, A., Bayliss, A., Beavan, N., Gaydarska, B., Whittle, A., 2015. Vinča – Belo brdo, Serbia: The times of tell. In *Germania* (pp.1-76). Heidelberg Research Data Repository, University of Heidelberg.

Tasić, N. N., Marić, M., Filipović, D., Penezić, K., Dunbar, E., Reimer, P., Barclay, A., Bayliss, A., Gaydarska, B. and Whittle, A., 2016. Interwoven Strands for refining the Chronology of the Neolithic tell of Vinča-Belo Brdo, Serbia. *Radiocarbon, 58* (4), 795-831.

Tafuri, M. A., Robb, J., Belcastro, M. G., Mariotti, V., Iacumin, P., Di Matteo, A., O'Connell, T., 2014. Herding Practices in the Ditched Villages of the Neolithic Tavoliere (Apulia, South east Italy). A Vicious Circle? The isotopic Evidence.In Whittle, A., Bicke, P. (Eds.) *Early Farmers*. Published by British Academy.

Tauber, H. 1981. ^{13}C evidence for dietary habits of prehistoric man in Denmark.*Nature*, *292*, 332 – 333.

Teegen, W.R., Schultz, M. 1997. Transverse linear enamel hypoplasia in the PPNB population of Nevali Cori (Turkey). *American Journal of Physical Anthropology*,*24*, 226–227.

Teegen, W.R., Schultz, M. 1998. Teeth as tools in the Late PPNB population from Nevali Cory (Turkey). *American Journal of Physical Anthropology*,*26*, 217.

Tieszen, L.L., Boutton, T.W., Tesdahl, K.G., Slade, N.A. 1983. Fractionation and turnover of stable carbon isotopes in animal tissues: implication for 13C analysis of diet.*Oecologia*,57, 32-37.

Touger-Decker, R. and Van Loveren, C. 2003. Sugars and dental caries. *American Journal of Clinical Nutrition*78, 881S–92S.

Trajković, Č. 1988. Topola-Bač. In Srejović, D. (Ed.), *The Neolithic of Serbia.Archaeologicalresearch 1948–1988* (pp. 99–101). Beograd: Centar za arheološkaistraživanja Filozofskog fakulteta.

Tringham, R. 1971. *Hunters, Fishers and Farmers of Eastern Europe(6000-3000 B.C.)*. London: Hutchinson University Library.

Tringham, R. 2000. Southeastern Europe in the transition to agriculture in Europe: bridge, buffer or mosaic (pp. 19–56). In Price, T.D. (Ed.), *Europe's first farmers*, Cambridge: Cambridge University Press.

Trotter, M., Gleser, G. C., 1958. A re-evaluation of estimation of stature based on measurements of stature taken during life and of long-bones after death.*American Journal of Physical Anthropology, 16*(1), 79–123.

Tromp, M., 2012. *Large-scale Analysis of Microfossils Extracted from Human Rapanui Dental Calculus: a Dual-Method Approach Using SEM-EDS and Light Microscopy to Address Ancient Dietary Hypotheses*. Unpublished M.Sc. thesis, USA: Idaho State University, Pocatello.

Tsutaya, T., Ishida, H. and Yoneda, M. 2015. Weaning age in an expanding population: stable carbon and nitrogen isotope analysis of infant feeding practices in the Okhotsk culture (5th–13th centuries AD) in Northern Japan. *American Journal of Physical Anthropology, 157,* 544–555. doi: 10.1002/ajpa.22740

Turner, C.G. 1979. Dental anthropological indications of agriculture among the Jomon people of Central Japan. *American Journal of Physical Anthropology, 51*, 619-636.

Ubelaker, D. H. 1989. *Human skeletal remains: Excavation, Analyses, Interpretation Second edition.* Washington D.C.: Taraxacum.

van Gerven, D. P., Beck, R. and Hummert, J.R. 1990. Patterns of Enamel Hypoplasia in Two Medieval Populations from Nubia.s Batn El Hajar. *American Journal of Physical Anthropology, 82,* 413 -420.

van Klinken, G.J., 1999. Bone collagen quality indicators for palaeodietary and radiocarbon measurements. *Journal of Archaeological Science, 26,* 687-695.

van Klinken, G.J., van der Plicht, H., Hedges, R.E.M. 1994. Bone 13C/12C ratios reflect (palaeo)climatic variations. *Geophysical Research Letters,21,*445-448.

van Klinken, G.J., Richards, M.P. and Hedges, R.E.M. 2000. An overview of causes for stable isotopic variations in past European human populations: environmental ecophysiological and cultural effects.In Ambrose, S.H. and Katzenberg, M.A. (Eds.), *Biogeochimical approaches to paleodietary analysis*(pp. 39-58). New York: Kluwer Academic/Plenum Publischers.

Vasić, M. M., 1910. Die Hauptergebnisse der prähistorischen Ausgrabung in Vinča im Jahre 1908, *Prähistorische Zeitschrift II* (1), 23-39.

Васић, M. 1932. *Преисториска Винча. 1, Индустрија цинабарита и козметика у Винчи: увод у проучавање Винче: са додацима: I. Везано божанство у преисториској религији. II. Винча и хиперборејски мит.* Београд: Државне штампарије Краљевине Југославије.

Vasić, M. 1936. *Preistoriska Vinča 2*, Beograd: Izdanje i štampa: Državne štamparije Kraljevine Jugoslavije.

Vasić, R. 2008. Velesnica and the Lepenski Vir culture. In Bonsall, C., Boroneanţ, V. and Radovanović, I. (Eds.), *The Iron Gates in prehistory: New perspectives* (pp. 227–241). BAR InternationalSeries 1893. Oxford: Archaeopress.

Valentin, J. 2003. Basic Anatomical and Physiological Data for Use in Radiological Protection: Reference Values. *ICRP Publication 89, 32*(3–4), 1 – 277.

Viguet – Carrin, S., Garnero, P.and Delmas, P.D.D. 2006. The role of collagen in bone strength. *Osteoporos Int. 17* (3), 319 – 336. doi 10.1007/s00198-005-2035-9

Vika, E. 2009. Strangers in the grave? Investigating local provenance in a Greek Bronze Age mass burial using δ34S analysis.*Journal of Archaeological Science, 36*, 2024- 28.

Vitzthum, V.J. 1994. Comparative study of breastfeeding structure and its relation to human reproductive ecology. *American Journal of Physical Anthropology*, *37,* 307–349.

Vitezović, S. 2010. Koštana industrija u starijem i srednjem neolitu centralnog Balkana. Unpublished PhD Thesis, Faculty of Philosophy. University of Belgrade.

Vitezović, S. 2011a. Early and Middle Neolithic bone industry in northern Serbia. *Acta Archaeologica Carpathica, XLVI,* 19 – 60.

Vitezović, S. 2011b. The Mesolithic bone industry from Kula, eastern Serbia. *Before farming*. DOI: 10.3828/bfarm.2011.3.2

Vitezović, S. 2013. The prehistoric bone tool assemblage from Grivac (central Serbia). *Glasnik srpskog arheološkog društva*, 209-232.

Vogel, J.C. and van der Merwe, N.J., 1977. Evidence for Early Maize Cultivation in New York State. *American Antiquity, 42* (2), 238–242.

Vörös, I. 1980. Zoological and palaeoeconoical investigations of the Early Neolithic Körös culture. *Folia Archaeologica, 31*, 3-64.

Zeder, M.A., Smith, B.D. 2009. A conversation on agricultural origins: Taking past each other in a crowded room. *Current Anthropology*, *50*(5), 681-691.

Zhou, L. 1995. Dental Enamel Defects Related to Famine Stress in Contemporary Chinese Populations: a Bioanthropological Study. *Paleopathology Newsletter, 99,* 20.

Zoffmann, Z. 1976. Anthropologische Kenntnisse über die Bevölkerung der Körös–Starčevo–Cris-Kultur. *Arheologiai Ertesitö, 103*/2.

Zoffman, Z. 1980. Das anthropologische Material des bronzezeitlichen Bestattung von Vizić-Golokut (Syrmien). *Rad Vojvođanskih Muzeja, 26*, 65-68.

Zoffmann, Z. 1983. Prehistorical skeletal remains from Lepenski Vir. *Homo 34*,(3/4). 129 –148.

Zoffmann, Z. 1982-1983. Neolitische Anthropologische Funde aus der Umgebung von Odzaci (Bačka, Jugoslawien). *Rad vojvođanskih muzeja, 28*, 35-38.

Zoffmann, Z. 1986-1987. Antropološka obrada starčevačkog skeleta sa lokaliteta Golokut, *Rad Vojvođanskih muzeja, 30.*

Zoffmann, Z. 1988. Human skeletal remains from Divostin. In McPherron, A. and Srejović, D. (Eds.), *Divostin and the Neolithic of Central Serbia* (pp. 447–455). Pittsburgh: University of Pittsburgh.

Zoffmann, Z. 1999-2000. Drugi antropološki nalaz Starčevačke kulture sa lokaliteta Vizić-Golokut u Sremu. *Rad vojvođanskih muzeja, 41-42*, 11-13.

Zoffmann, Z. 2004. Antropološki pregled populacije Starčevačke kulture (Najnoviji osteološki nalazi sa lokaliteta Vizić-Golokut). *Rad vojvođanskih muzeja, 46*, 143-149.

Zvelebil, M. 1998. Agricultural frontiers, Neolithic origins, and the transition to farming in the Baltic Basin. In Zvelebil, M., Domańska, L. and Dennell, R. (Eds.). *Harvesting the Sea, Framing the Forest: The Emergence of Neolithic Societies in the Baltic Region* (pp. 9 - 28). Sheffileld: Sheffield Academic Press.

Zvelebil, M. 2000. The contex of the agricultural transition in Europe. In C.Renfrew and K. Boyle /eds), Archaeogenetics: DNA and the population prehistory of Europe, 57-79. Cambridge: McDonald Institute for Archaeological Research.

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

Zvelebil, M. and Weber, W. A. 2013. Human bioarchaeology: Group identity and individual life histories – Introduction, *Journal of Anthropological Archaeology*, 32 (3),275-279.

Živaljević, I. (submitted PhD thesis). *Ribolov na Đerdapu u ranom holocenu (10. – 6. milenijum pre n. e.*). Belgrade: University of Belgrade.

Živaljević, I., 2012. 'Big Fish Hunting: Interpretations of stone clubs from Lepenski Vir' in Vasić, N. (Ed.), Harmony of Nature and Spirituality in Stones (Proceedings of the 2nd International Conference in Kragujevac, Serbia, March 15-16, 2012), Stone Audio Association: Belgrade, pp. 195-206.

Živaljević, I., Popović, D., Snoj, A., Marić, S. (submitted). *Ancient DNA analysis of cyprinid remains from the Mesolithic-Neolithic Danube Gorges reveals an extirpated fish species Rutilus frisii(Nordmann, 1840*).

Živanović, S. 1975a. Mesolitic Population in Djerdap Region. *Balcanica, VI,* 1-9.

Živanović, S. 1975b. A note on the Anthropological Characteristic of the Padina Population. *Zeitschrift für Morphologie und Anthropologie, 66,* (2) 161-175.

Živanović, S. 1975c. Prvo saopštenje o rezultatima antropološkog proučavanja skeletnih ostataka sa Padine u Djredapu. *Starinar N.S., XXIV-XXV,* 139-153.

Živanović, S. 1976a. Cromagnon in the Iron Gate Gorge of the Danube. *Nature, 260*, 518.

Živanović, S 1976b. Ostaci ljudskih skeleta iz praistorijskog nalazišta na Hajdučkoj vodenici. *Starinar, XXVI,* 124–129.

Živanović, S. 1979. Apsolutna starost skeletnih ostataka kromanjonaca sa Padine u Djerdapu. *Balcanica, X,* 26-30.

Živanović, S. 1988. The Temporal Region and the Supramastoid Ridge in Mesolitic Skulls from Padina in the Iron Gate Gorge of Danube. *Human Evolution.* Volume 3, Issue 5, 329–334.

Живковић, М. 2008. Заштитна истраживања археолошког налазишта Град - Старчево 2003. и 2004. године. *Археолошки преглед, н. с. 2/3, 2004/5*, 11.

Živković, M., Medović., I., Jovanov, J. 2011. Okresano i glačano kameno oruđe sa zaštitnih arheoloških iskopavanja naselja Starčevo-Grad u periodu od 2003. do 2008. godine. *Rad vojvođanskih muzeja 53*, 23-43.

Waldron, T., 2009. *Palaeopathology*.Cambridge: Cambridge University Press.

Walker, P.L. and Hewlwtt, B.S. 1990. Dental health diet and social status among Central African Foragers and Farmers. *Am. Anthropol. 92,* 383-98.

Walker, P.L., Barthurst, R. R., Richman, R., Gjedrum, T. and Andrushko, V. A. 2009. The Causes of Porotic Hyperostosis and Cribra Orbitalia: A Reappraisal of the Iron-Deficiency-Anemia Hypothesis. *American Journal of Physical Anthropology, 139*, 109-125.

Wapler, U., Crubézy, E. and Schultz, M. 2004. Is cribra orbitalia synonymous with anemia? Analysis andinterpretation of cranial pathology.In Sudan, *American Journal of Physical Anthropology*, *123*, 333-339.

Waters-Rist, A. L., Bazaliiskii, V. I., Weber, A. and Katzenberg, M. A. 2011. Infant and Child Diet in Neolithic Hunter-Fisher-Gatherers from Cis-Baikal. *Siberia: Intra-Long Bone Stable Nitrogen and Carbon Isotope Ratios 146*, (2), 225-241.

Weiner, S. 2010. *Microarchaeology: Beyond the Visible Archaeological Record*. Cambridge: Cambridge University Press.

White,T. and Folkens, P. 2005. *Human Bone Manual*. Academic press.

Whittle, A., Basrtosiewicz, L., Borić, D., Pettitt, P. and Richards, M. 2002. In the beginning: new radiocarbon dates for the Early Neolithic in northern Serbia and south-east Hungary. *Antaeus*, *25*, 63–117.

Whittle, A. and Bickle, P. 2013. *The First Farmers of Central Europe: Diversity in LBK Lifeways.* Oxbow Books.

Williams, P.L., Bannister, L.H., Berry, M.M., Collins, P., Dussek, J.E. and Ferguson, M.W.J. 1995. *Gray's anatomy*. New York: Churchill Livingstone.

Williams, J.S., White, C.D. and Longstaffe, F.J. 2005. Trophic level and macronutrient shift effects associated with the weaning process in the Postclassic Maya. *American Journal of Physical Anthropology*, *128* (4), 781–790.

Williams, J.S., White, C.D. and Longstaffe, F.J. 2006. Trophic level and macronutrient shift effects associated with the weaning process in Postclassic Maya. *American Journal of Physical Anthropology, 128,*781–790.

Wilson, P.J. 1988. *The Domestication of the Human species*. New Haven: Yale University Press.

Wittwer-Backofen, U. and Tomo, N. 2008. From Health to Civilization Stress? In Search for Traces of a Health Transition During the Early Neolithic in Europe. In Bocquet –Appel, J. and Bar - Josef, O. (Ed.),*The Neolithic Demographic Transition and its Consequences* (pp.501-538).Springer Netherlands.

Wood, J.W., Milner, G.R., Harpending, H.C., Weiss, K.M. 1992. The osteological paradox: problems in inferring prehistoric health from skeletal samples. *Current Anthropology, 33,* 343-358.

Wood, J. 1994. Dynamics of Human Reproduction. Biology, Biometry, Demography.New York: Transactions Publishers, New Brunswick.

Wright, L.E. and Schwarcz, H.P. 1999. Correspondence Beetwen Stable Carbon, Oxygen and Nitrogen Isotopes in Human Tooth Enamel and Dentine: Infant Diets at Kaminaljuyú. *Journal of Archaeological Science*, 26 (9), 1159–1170.

Yagi, T., Takebe, Y., Itoh, M. 1989. Secular trends in physique and physical fitness in Japanese students during the last 20 years. *American Journal of Human Biology, 1*, 581-587.

Quetelet, A. 1832. *Recherches sur le poids de l'homme aux different âges.* Nouveaux Memoire de l'Academie Royale des Sciences et Belles-Lettres de Bruxelles, p. V

APPENDIX 1.

The catalogue of analyzed Early Neolithic individuals outside the Danube Gorges region

In this appendix a catalogue of all analyzed individuals outside the Danube Gorges region will be presented. It contains: name of the site, burial number, the exact place where deceased was found, detail description of buried individual, its position, orientation, grave goods, relative and absolute chronology, preserved bones, information on sex and age, dental analysis, pathological analysis, metric analysis, stature, body weight, body mass index, stable isotope values, information on starch grain analysis and other observations.

First, the human skeletal remains derived from the sites located in southern part of the Great Hungarian Plain (Golokut-Vizić, Klisa, Sremski Karlovci, Perlez-Batka, Obrež-Baštine, Starčevo) will be presented, and then from the sites situated in the regions of Šumadija (Vinča, Grivac) and Kosovo (Rudnik Kosovski).

GOLOKUT-VIZIĆ

Grave 2/1984

Female, 40-50 years

<u>Description:</u> The grave was found in 1984, in the trench 25-25a, on the upper level of the niche in the north-eastern part of the pit-dwelling next to the entrance. Because of the burial, the niche was subsequently widened, such that part of the skeleton lay in subsoil and the greater part was on a level of ashes (Petrović 1985). The individual was lying on its right side oriented northwest-southeast, with the face toward west. The maximum length of skeleton was 0.90 m. On its left hand a complete auroch skull with horncores was found. At a distance of 0.40 m south from the leg bones (knee) a scapula of an auroch was found, probably as a grave good. A vessel without a base in the shape of an amphora was found at the distance of 0.50 cm from the legs of the body. The skeleton was placed near the entrance, bellow vaulted ceiling, most likely after the dwelling was abandoned and no longer used for living (Petrović 1985; Petrović 1987). The individual was barely wedged into the wall of the dwelling and the place for the

skull was afterwards expanded (Petrović 1985). In front and partly bellow the skeleton was thick layer of ashes with burnt clay, which is probably part of destroyed hearth. The burial was placed in the pit-dwelling only when it had ceased to be in use as a residence and had been partially covered with soil and fragments of house daub and hearth material.

Relative chronology: Starčevo culture, Early-Middle Neolithic

Absolute chronology: OxA-8694 (human bone): 6520±50 BP: 5560-5360 BC (89.05%) (Whittle et al. 2002); OxA-8695 (fragment of skull, *Bos primigenius*): 6520±50 BP: 5560-5360 BC (89.00%) (Whittle et al. 2002)

Preserved bones: The skeleton is fragmented. Present cranial bones: frontal, left and right parietal, occipital, left and right temporal, fragmented sphenoid, right zygomatic, right maxilla, mandible without left ramus. Postcranial bones: the left humerus without upper third of the bone, right humerus with fragmented lateral part of the proximal and distal end, left ulna without distal third of the bone, right ulna, left radius, distal third of the right radius, left scaphoid, left lunate, left triquetral, left and right hamate, left first metacarpal, left first proximal phalanx, left clavicle with fragmented body, right clavicle, the coracoid process and one fragment of the body of left scapula, the scapular spine, part of the body and glenoid fossa of right scapula, sternum without xiphoid process, 5 cervical and 11 fragmented thoracic vertebrae, 16 vertebral and 5 sternal ends of the ribs, as well as, 23 fragments of the body of ribs, left and right fragmented pelvic bones, sacrum, the upper half of left and right femur (fragmented), fragmented left tibia, right tibia without proximal end, left fibula without proximal end, and right fibula. All left and right tarsal bones are present (only left navicular is fragmented), left and right metatarsals, 6 proximal foot phalanges and left and right first distal phalanx.

Sex: Morphological features on the skull (nuchal crest, mastoid process, supraorbital margin, glabela and mental eminence on mandible are barely pronounced and indicate female, as well as morphological and metric features on the pelvic bones.

Age: The degree of all sutures closure indicates age around 40, while tooth abrasion shows younger age, between 25-35 years. Based on characteristics of the pelvic bones (auricular surface and pubic symphysis), estimated age is between 40-50 years.

Dental analysis: Teeth 13 and 14 were found inside alveolar sockets, while 46, 47 and 48 were found outside. Teeth 15, 16 and 17 were lost ante-mortem. Abrasion of the 1st

degree (in enamel) was noted on tooth 48; of the 2nd degree (exposed dentin) on teeth 22 and 44; and of the 4th degree (pulp exposure) on teeth 13 and 14. Presence of caries was noted on the following teeth: 46 (mesial side, interproximal surface and root-cemento enamel junction), 47 (distal side and interproximal surface and root-cemento enamel junction) and 48 (mesial side, interproximal surface and root-cemento enamel junction). Supragingival calculus is moderately pronounced on the teeth 13 (bucal side, degree score 2) and 14 (bucal side, degree score 2).

Pathology: Cribra orbitalia was noted on the roof of right orbit with degree score 3 (porosity with coalescence of foramina) and activity score 3 (mixture of active and healed lesions at time of death). Porotic hyperostosis was present on frontal (degree score 2, activity score 1) and both parietal bones (degree score 2, activity score 1) as well as on the occipital bone (degree score 1, activity score 2). Osteoarthritis (OA) was noted on all cervical vertebrae and two of them are totally fused. On thoracic and lumbal vertebrae there are no traces of OA. Osteoarthritic changes were also noticed on joint surfaces of sternum, as well as, on the iliac tuberosity of the coxal bone. On the whole diaphysis of both left and right tibia traces of light periosteal reaction were detected.

Metric analysis: All measurements and calculated indices are presented in Table 1ab.

Stature: According to the maximal length of right humerus (27.3cm) stature is 149.69 cm and left tibia (32.8cm) 156.65, which gives an average stature of 154.17cm.

Body mass: According to the maximal diameter of right femur head (4.26cm), body mass is 60.11 kg.

Stable isotope analysis: Isotopic values of $\delta^{13}C$, $\delta^{15}N$ indicate mostly terrestrial diet.

Starch grain analysis: Inside dental calculus starch grains were not detected.

Other observations: On the lateral side of the left tibia, near nutrient foramen there is a mild trace of cutting (1.07x0.5mm). A shallow depression (9.6x8.1mm) was noted on the anterior side of the head of right humerus. On the posterior side of left femur diaphysis, in proximal part, a mild thickening was detected. On the distal foot phalanx, just below the proximal end there is a shallow depression (4.3x2.2mm).

Grave 3/1984

Female, 30-39

Description: The grave was found in the south-eastern part of the pit in the trench 30. The individual was in an extended position, lying on its back, oriented northwest-southeast, with the head toward northwest. The right arm was placed above the chest with the palm on the left side. The hand of the right arm is placed just next to the elbow of left arm. The head was bent toward the left shoulder and lining on the left hand. The legs are extended next to each other. On the right side of the skull, one knife made from obsidian was found, but probably does not represent is not part of the grave goods. The maximum length of skeleton is 1.58 m[1]. The excavators of the site think that based on the position skeleton is not belonging to Starčevo culture. Namely, their opinion is that skeleton was subsequently buried in the pit with ceramic fragments belonging to Starčevo culture.

Relative chronology: Starčevo culture, Early-Middle Neolithic

Absolute chronology: OxA-8505 (human bone): 6550±55 BP: 5620-5460 BC (81.5%) (Whittle et al. 2002)

Preserved bones: The skull is well preserved, while postcranial skeleton is fragmented. Almost all cranial bones are present, and only mandible is fragmented and without both condyloid processes. Postcranial bones: left humerus with fragmented lateral part of distal end, right humerus partially fragmented, both ulnas, both radius, left scaphoid, left lunate, left triquetral, left pisiform, left trapezium, left capitate, 6 metacarpals, 7 proximal, 3 medial and 2 distal phalanges, left clavicle, right clavicle without sternal end, coracoid process, glenoid fossa and acromion of both left and right left scapula, coracoid process of left scapula, fragmented body of sternum, 5 fragmented cervical, 10 fragmented thoracic and 5 fragmented lumbal vertebrae, 4 vertebral and 5 sternal ends of the ribs as well as 20 fragments of the body parts of the ribs; left and right fragmented pelvic bones, left femur with fragmented proximal end, right femur with fragmented proximal end and part of diaphysis, partially fragmented right tibia, proximal end of right fibula, right talus, right navicular, right medial cuneiform, 4 left metatarsals, 1 proximal and 1 distal foot phalanx.

[1] Field diary, Archive of the Museum of Vojvodina.

Sex: Morphological features on the skull (nuchal crest, mastoid process, supraorbital margin, glabela and mental eminence on mandible are not pronounced and indicate female, as well as morphological features on the pelvic bones.
Age: The degree of all sutures closure indicates age around 40, while tooth abrasion shows younger age, between 25-35 years. Based on characteristics of the pelvic bones (auricular surface and pubic symphysis), estimated age is between 30-39 years.
Dental analysis: All teeth are present and found inside alveolar sockets, except 22, 31 and 41 which were lost post-mortem. Abrasion of the 2nd degree (exposed dentin) was noted on teeth 13, 14, 15, 16, 17, 18, 25, 26, 27, 28, 32, 33, 34, 35, 36, 37, 38, 42, 43, 44, 45, 46, 47, 48; of the 3rd degree (to the bottom of the fissure) on teeth 11, 23, 24 and of the 4th degree (pulp exposure) on the 12 and 21.
Hypoplasia was noted on the teeth: 13 (type linear, 1 line), 17 (type pit and linear, 1 line), 18 (pit type), 27 (type pit and linear, 1 line) and 28 (pit type). Presence of caries was noted on the following teeth: 26 and 27. Supragingival calculus is pronounced in small amount (degree score 1) on the following teeth: 27 and 28 (bucal side), 32-38 and 42-48 (buco-lingual side). On all other present teeth calculus was not detected.
Pathology: Cribra orbitalia was noted on the roof of the right orbit with degree score 1 (barely discernible porosity) and activity score 2 (healed at time of death) as well as on the left orbit with degree score 2 (porosity only) and activity score 3 (mixture of active and healed at time of death). Porotic hyperostosis was present on frontal (degree score 1, activity score 2), both parietal bones (degree score 2, activity score 2) and on the occipital bone (degree score 2, activity score 3). Traces of light periosteal reaction were detected on the whole diaphysis of right tibia.
Metric analysis: All measurements and calculated indices are presented in Table 1ab.
Stable isotope analysis: Isotopic values of $\delta^{13}C$, $\delta^{15}N$ indicate mostly terrestrial diet (Whittle et al. 2002).
Starch grain analysis: Inside the dental calculus two starch grains were found.
Stature: According to the maximal length of left humerus (32.0 cm) stature is 165.49 cm and left femur (43.6 cm) 161.79, which gives an average stature of 163.64 cm.
Body mass: According to the maximal diameter of left femur head (4.6 cm), body mass is 68.84 kg.

Other observations: During the anthropological analysis few animal bones were detected among human remains: one lower incisor of cattle, calcaneus of sheep/goat and two medial phalanges of deer.

Grave 1/2003

Child, 7-9 years

Description: The grave was found in the trench 72, on the upper level of pit-dwelling 27 in the course of new excavations in 2003. The individual was oriented southeast-northwest, with the head toward southeast. Burial position is flexed. Around the skeleton a vast number of animal bones were found. The maximum length of skeleton was 0.85m, measured from the skull to the end of the legs[2].

Relative chronology: Starčevo culture, Early-Middle Neolithic

Preserved bones: The skeleton is poorly preserved. Cranial bones are represented with few fragments of cranial vault and fragmented right half of mandible without condyloid process. Postcranial bones: fragmented diaphysis of left and right humeri, both left and right ulnas and radius, fragment of lateral border of scapula, fragment of vertebral arch, 30 fragments of the body parts of the ribs, three fragments of iliac bone (auricular surface and parts of the wing), left femur without distal end and with fragmented proximal end, fragments of diaphysis of right femur, fragments of diaphysis of left and right tibias and fibulas (with present distal end of the right fibula), left proximal foot phalanx.

Age: According to the degree of formation and teeth eruption, estimate age is 9 years ±3. According to the reconstructed maximal length of left femur (22.6 cm) estimate age is 7 years.

Dental analysis: Teeth 46, 84 and 85 are in alveolar sockets, while 14, 47, 55 and 83 are found outside. Teeth 43, 44 and 48 are still in the crypt. Abrasion of the 1st degree (in enamel) was noted on teeth 14, 46, 47, and of the 2nd degree (exposed dentin) on teeth 55, 83, 84 and 85. Hypoplasia was noted on the teeth 14 (type linear, 1 line). Presence of caries was noted on the teeth 55.

Stable isotope analysis: Isotopic ratios of $\delta^{13}C$, $\delta^{15}N$ indicate mostly terrestrial diet, with low protein intake.

[2] Field diary, Archive of the Museum of Vojvodina.

Other observations: Since all bones were covered by black colour it was not possible to observe external surfaces and pathological changes.

Grave 2/2003

Juvenile, 16-17

Description: The grave was found in the trench 72, in the northern part of pit-dwelling 27. The skeleton was poorly preserved with strong decomposition of bones. Around the skeleton, in the pit, a vast number of animal bones, fragments of pottery and house daub were found[3].

Relative chronology: Starčevo culture, Early-Middle Neolithic

Preserved bones: Cranial bones: fragment of frontal squama, fragment of right orbital part of the frontal bone, fragmented half of the left and right parietal bone and fragment of occipital squama. Postcranial bones: right capitate, right hamate, II and III right metacarpals, fragment of distal epiphyses of one metacarpal, 4 proximal, 1 medial and 1 distal phalanges, 4 sternal ends as well as 11 body fragments of the ribs, fragmented head and diaphysis of the femur (probably right), half of distal end of right tibia, fragment of left talus, right talus and right navicular.

Sex: Since skeleton was poorly preserved sex could not be determinate.

Age: The only criteria to estimate age is epiphyses- diaphyses fusion. On the distal ends of metacarpals and proximal hand phalanges epiphyses are not fused, while on four proximal phalanges epiphyseal lines are still visible. Based on this, estimate age for this individual is 16-17 years.

Dental analysis: Only tooth 23 was present. It has abrasion of the 1st degree (in enamel). Presence of caries, calculus and hypoplasia was not detected.

Pathology: Cribra orbitalia was noted on the roof of the right orbit with degree score 3 (porosity with coalescence of foramina) and activity score 3 (mixture of active and healed at time of death). Porotic hyperostosis was present on both parietal bones (degree score 1, activity score 1).

Stable isotope analysis: Isotopic values of $\delta^{13}C$, $\delta^{15}N$ indicate mostly terrestrial diet, with low protein intake.

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[3] Field diary, Archive of the Museum of Vojvodina.

Grave 3/2003

Juvenile, 15-18

Description: The grave was found in the trench 72, in the north-western part of the pit-dwelling 27. The individual was in semi-extended position, lying on its back, oriented southwest-northeast, with the head toward southwest and face toward north. The right arm was placed just next to the body, while left arm was contracted. Left leg was also contracted with a right leg above it. Since feet bones were not found, the maximum length of skeleton was 1.23 m[4].

Relative chronology: Starčevo culture, Early-Middle Neolithic

Preserved bones: Present cranial bones: left half of frontal bone, left parietal, 1/5 of right parietal, left half of squama occipitalis, fragmented left and right temporal bones, fragment of greater wings of sphenoid bone, fragment of alveolar part of left maxilla, alveolar part of right maxilla, fragment of left ramus of mandible without condyloid process, right half of mandible without condyloid process. Postcranial bones: both humeri (proximal epiphyses not fused), both ulnas (epiphyseal line visible on proximal ends, distal epiphyses not fused), both radii (proximal and distal epiphyses not fused, except distal one on left radius which is partially fused), left scaphoid, left lunate, left triquetral, left capitate, left hamate, right triquetral, right trapezium, right trapezoid, 9 fragmented metacarpals (distal ends not fused), 6 proximal, 3 medial and 2 distal phalanges (on proximal phalanges proximal ends not fused); medial half of the left clavicle, right clavicle without sternal end, lateral border of both left and right scapula, glenoid fossa and fragmented acromion of right scapula, two fragments of the body of scapula, 6 cervical, 10 thoracic and 5 lumbal fragmented vertebrae, 13 vertebral and 4 sternal ends of the ribs as well as 20 body fragments of the ribs, left iliac bone, fragmented left ischium and pubic bone, fragmented right iliac, right pubic, fragmented sacrum on lateral parts, both femurs with fragmented epiphyses (proximal epiphyses are partially fused while distal epiphyses are not fused), left tibia with fragmented epiphyses (epiphyses not fused), right tibia without distal epiphyses, left patella, left fibula, right fibula without distal epiphyses (proximal not fused).

Sex: Since sex based morphological characteristics are not fully developed at this age, sex could not be determinate.

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[4] Field diary, Archive of the Museum of Vojvodina.

Age: The only criteria to estimate age is epiphyses- diaphyses fusion and tooth eruption. Tempo-sphenoid suture is not fused, which indicates age under 19 years. Since roots of third molars are not completely formed, estimate age is between 15-18 years which is also in accordance with epiphysis-diaphysis fusion on postcranial skeleton: on both humeri proximal epiphyses are not fused; on both ulnas epiphyseal line is visible on the proximal ends and distal epiphyses are not fused, on both radii proximal and distal epiphyses are not fused, except distal one on left radius which is partially fused, on metacarpals distal ends are not fused, on proximal hand phalanges proximal ends are not fused; pelvic bones are not completely fused; on both femurs proximal epiphyses are partially fused while distal epiphyses are not fused, on tibia proximal epiphyses are not fused; on fibula proximal epiphyses are not fused. Auricular surface and pubic symphysis also indicate age under 18 years.

Dental analysis: Teeth 13, 14, 16, 17, 18, 26, 27, 28, 31, 32, 33, 34, 36, 37, 41, 42, 43, 44, 45, 46, 47, 48 are inside alveolar sockets, while 11, 12, 15, 21, 22, 24, 25, 35 and 38 are outside. Abrasion of the 1st degree (in enamel) was noted on 12, 13, 14, 15, 16, 17, 18, 24, 25, 27, 28, 33, 34, 35, 37, 38, 42, 43, 44, 45, 47, 48 and of the 2nd degree (exposed dentin) on teeth 11, 21, 22, 26, 31, 32, 36, 41 and 46. Presence of caries was noted on the tooth 46 (bucal side, gros-gros). Supragingival calculus is in small amount (degree score 1) present on the following teeth: on the teeth 13, 14, 15, 16 (buco-lingual side), 31, 32, 41, 42 (bucal and lingual side), 33 (lingual side), 35 (distal side), 36 (mesial side). Chipping was detected on teeth 18 (lingual side) and 48 (buco-mesial side). Discoloration was noted on following teeth: 16, 17, 18, 26, 27, 28, 36 and 47.

Pathology: Cribra orbitalia was noted on the roof of the left orbit with degree score 4 (coalescing foramina with increased thickness) and activity score 1 (active at the time of the death). Porotic hyperostosis was present on both parietal bones (degree score 3, activity score 1), whilst on frontal it was not detected (degree score 0). Increased porosity is present on the internal surface of left parietal bone. On the left humerus, above nutrient foramen a small thickening (1.0x0.1 cm) was detected.

Metric analysis: All measurements and calculated indices are presented in Table 1ab.

Stable isotope analysis: Isotopic values of $\delta^{13}C$, $\delta^{15}N$ and $\delta^{34}S$ indicate mostly terrestrial diet.

Grave 4/2003

Juveniles, 12-15 years

Description: The grave was found in the trench 78, in the northern part of pit-dwelling 31. Inside the dwelling a small pit (oval in shape with diameter 1.30m) was discovered filled with fragments of the hearth, ashes and chars. This place was probably first used as a hearth. In the ruins of this hearth, on the western edge, a human skull was discovered. The skull was lying on its right side, turn toward east. Approximately 0.40 m north from the skull three animal jaws, one horn and few large animal bones were discovered[5].

Preserved bones: Only cranium is preserved: partially fragmented frontal bone, left and right parietal, partially fragmented occipital bone, left and right temporal bones, sphenoid bone, ethmoid bone, left and right zygomatic, left nasal bone, fragment of alveolar part of left maxilla, alveolar part of right maxilla with a fragment of frontal process, fragment of left ramus of mandible without condyloid process, right half of mandible without condyloid process. Postcranial bones were not present.

Sex: Since sex based morphological characteristics are not fully developed at this age, sex could not be determinate.

Age: Tempo-sphenoid suture is not fused, which indicate age under 19 years. According to the degree of formation and teeth eruption, estimate age is 12 years ±3.

Dental analysis: Teeth 16, 17, 26, 27 are found inside alveolar sockets. Teeth 18 and 28 are still in the crypt. Teeth 11, 12, 13, 14, 15, 21, 22, 23, 24 and 25 were lost post mortem. Abrasion of the 1st degree (in enamel) was noted on 17, 27, and of the 2nd degree (exposed dentin) on teeth 16 and 26. Supragingival calculus is present in small amount (degree score 1) only on the tooth 26 (buco-mesial side). Chipping was detected on teeth 16 and 26 (buco-mesial side) and 17 (buco-distal side). Discoloration was noted on teeth 16 and 17.

Pathology: Cribra orbitalia was noted on the roof of the left orbit with degree score 1 (barely discernible porosity) and activity score 2 (healed at time of death). Porotic hyperostosis was present on both parietal bones (degree score 1, activity score 1), occipital bone (degree score 1, activity score 1) while on frontal it was not detected (degree score 0).

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[5] Field diary, Archive of the Museum of Vojvodina.

Metric analysis: All measurements and calculated indices are presented in Table 1ab.

Stable isotope analysis: Isotopic values of $\delta^{13}C$, $\delta^{15}N$ and $\delta^{34}S$ indicate mostly terrestrial diet, with small input of aquatic resources.

Other observations: Two fragments of burned bones (part of acetabulum?) were also found.

Grave ?/2003

Child, 1-3 years

During the anthropological analysis several bones of a child have been observed in one bag marked as "grave?", Pit 31, Trench 78, but they are not mentioned in the field diary.

Relative chronology: Starčevo culture, Early-Middle Neolithic

Preserved bones: The skeleton is poorly preserved. Only few bones are present: two bodies of vertebrae (one probably thoracic and one lumbal), two fragments of vertebral arches, one fragment of proximal end of the left femur (head and neck), left tibia without proximal end, one metatarsal bone without distal end, and one proximal foot phalanx.

Age: The bodies of vertebrae are not fused with the arches and epiphyses are not fused with diaphysis which indicates age less than 3 years.

Stable isotope analysis: Isotopic values of $\delta^{13}C$ and $\delta^{15}N$ indicate mostly terrestrial diet.

KLISA

At this site three graves have been found very close to each other. They are marked as 6, 8 and 10.

Grave 6

Child, 4-5 years

Description:.The skeleton was buried in flexed position, lying on its left side, with orientation west-east. It was found in excavation layer with lot of Starčevo culture material. Around skeleton a vast number of animal bones, bivalves (*Unio* sp.), fragments of Starčevo pottery, and flint knives[6] were found.

Relative chronology: Starčevo culture, Early-Middle Neolithic

[6] Field diary, Archive of the Provincial Institute for the Protection of Cultural Monuments

Preserved bones: fragmented squama of frontal bone, partially fragmented left parietal, ½ of right parietal, partially fragmented squama of occipital bone, fragmented squama and auditory fossa of left temporal bone, right temporal without squama, left zygomatic bone, fragmented maxilla without frontal processus, mandible without left ramus. Postcranial bones: diaphysis of left and right humerii, upper half of left ulnae, 2/3 of diaphysis of left radius, diaphysis of metacarpal bone, 1 proximal and 1 medial phalanx, left clavicle without lateral end, one half of atlas, 7 fragments of vertebral processus, 1 body of lumbal vertebrae?, 1 vertebral end of the ribs as well as 20 body fragments of the ribs, right fragmented iliac bone, ¼ of diaphysis of left femur, right femur diaphysis, diaphysis of left tibia distally fragmented, fragmented right tibia, left fibula without proximal end, 1/3 of diaphysis of right fibula.

Age: According to the degree of formation and teeth eruption, estimate age is 4 years ±1. According to the reconstructed maximal length of left humerus (14.3 cm) and reconstructed left tibia (15.2 cm) estimate age is 4 years and according to the reconstructed maximal length of right femur (17.5 cm) age is 5 years.

Dental analysis: Teeth 53, 54, 55, 62, 63, 64, 65, 71, 72, 73, 74, 75, 81, 82, 84 and 85 are in alveolar sockets. Teeth 16, 26, 36 and 46 are erupting, while teeth 42, 43 (found out of the alveolar socket) are still in the crypt. Teeth 51, 52, 61 and 83 were lost postmortem. Abrasion of the 1st degree (in enamel) was noted on teeth 54, 55, 62, 63, 64, 65, 73, 74, 75, and of the 2nd degree (exposed dentin) on teeth 53, 71, 72, 81, 82, 84 and 85. Hypoplasia was noted on the tooth 81 (type linear, 1 line). Caries and calculus were not detected.

Pathology: Presence of porotic hyperostosis was not detected.

Stable isotope analysis: Isotopic values of $\delta^{13}C$, $\delta^{15}N$ and $\delta^{34}S$ indicate mostly terrestrial diet. This child exhibited high $\delta^{15}N$ values of tooth crowns (both m1 and M1) indicating that it was possibly breastfed until around 2 years of age. After this time, the bone isotope values show a decrease in $\delta^{15}N$, which implies that weaning food, was introduced. Because of the faster remodelling of bones in children which, in the case of Klisa child (4-5 years old), is approximately 56% per year (Valentin, 2003), this signal actually reflects average diet between the age of 2.5-4.5 years. Subsequently, $\delta^{15}N$ value increased again, just prior to death, possibly as a consequence of disease or a nutritional stress.

Other observations: During the anthropological analysis few animal bones were detected among human remains: humerus of Bos sp., maxilla of Bos taurus, central tarsal bone of sheep/goat, tooth root of Bos sp., fragmented tibia of dog, femur of sheep/goat and few fragments of skull and long bones.

Grave 8

Female, 15-18 years

Description:The skeleton was buried in flexed position, lying on its left side, with orientation south-north. Around skeleton a vast number of animal bones, bivalves (*Unio* sp.), fragments of Starčevo pottery, and flint knives[7] were found.

Relative chronology: Starčevo culture, Early-Middle Neolithic

Preserved bones: The skeleton is well preserved. Present cranial bones: frontal, left and right parietal, occipital without right lateral and basilar part, left and right temporal, left zygomatic, left great wings of sphenoid bones, left maxilla without frontal end, mandible. Postcranial bones: left humerus with fragmented proximal epiphysis, right humerus with fragmented distal end, diaphysis of left ulna, upper ½ of right ulna without proximal epiphysis, upper ½ of left radius, diaphysis of right radius, right scaphoid, right trapezium, right trapezoid, right first meatcarpal, right third metacarpal without distal end, diaphysis of right fifth metacarpal, one proximal and one distal phalanx, diaphysis of left clavicle, one fragmented cervical vertebrae, two fragments of vertebrae, 4 body fragments of the ribs, left and right iliac bones fragmented, upper parts of left and right ischial bones, left femur, right femur partially fragmented, left patella, left and right tibia partially fragmented, distal half of left fibula, right fibula, left talus, left calcaneus, right calcaneus without distal half, right navicular, left cuboid, right first and second cuneiform, I, III, IV and V right metatarsal, I left metatarsal without distal end and first proximal phalanx.

Sex: Although individual is very young, it has pronounced sexual dimorphism. On the skull slightly delimited glabella, small processus mastoideus, slightly arched traces of nuchal lines on relief of the nuchal plane, smooth arcus superciliaris, small mentum and medium mandibular angle suggest female sex. On pelvic bone, great sciatic notch is

[7] Field diary, Archive of the Provincial Institute for the Protection of Cultural Monuments

broad and U shaped, preauricular sulcus is missing, composite arch is double curve, iliac crest is flat and S formed and fossa iliaca is low and broad.

Age: The only criteria to estimate age is epiphyses-diaphyses fusion and eruption of third molars. Since third molars are in eruption, estimate age is between 15-18 years which is also in accordance with epiphyses-diaphysis fusion on postcranial skeleton: on both humeri proximal epiphyses are not fused, on left radius proximal epiphyses is not fused, on metacarpals distal ends are not fused, on hand phalanges epiphyses are not fused, pelvic bones are not completely fused, on both femurs proximal and distal epiphyses are not fused, on both tibia proximal and distal epiphyses are not fused. Auricular surface also point to age under 18 years. Calcaneus is not fused, while on metatarsals epiphysis lines are still visible. Based on this, estimate age for this individual is 15-16 years.

Dental analysis: Present teeth are 22 - 28, 31 - 38 and 41 – 48, all found inside alveolar sockets. Tooth 21 was lost post-mortem. Abrasion of the 1st degree (in enamel) was noted on teeth 22, 24, 25, 28, 34, 35, 38, 44, 46 and 48, of the 2nd degree (exposed dentin) on teeth 23, 26, 27, 31, 32, 33, 36, 37, 41, 42, 43, 45 and 47. Supragingival calculus is moderately pronounced on the teeth 22, 23, 31, 41 and 42 (bucal side, degree score 2) and 14 (bucal side, degree score 2). Hypoplasia was noted on the teeth: 22 (type linear, 1 line), 23 (type linear, 1 line), 24 (type linear, 1 line), 34 (type linear, 2 lines) 35 (type linear, 1 line), 41(type linear, 1 line) 42 (type linear, 2 lines), 43 (type linear, 1 line) and 44 (type linear, 1 line). Caries was not detected.

Pathology: Cribra orbitalia and porotic hyperostosis were not detected.

Metric analysis: All measurements and calculated indices are presented in Table 2ab.

Stable isotope analysis: Isotopic values of $\delta^{13}C$, $\delta^{15}N$ and $\delta^{34}S$ indicate mostly terrestrial diet, with small input of aquatic resources.

Other observations: During the anthropological analysis few animal bones were detected among human remains: pig molar, fragmented scapula of deer or cattle, calcaneus of cattle, mandible of young sheep/goat, calcaneus of sheep/goat, patella of sheep/goat, precaudal vertebrae of catfish, fragmented tibia of Bos.sp and few fragments of long bones of medium sized mammal.

Grave 10a

Male, more than 40 years

Description:In contrast to graves 6 and 8, this skeleton was found inside the grave pit. The skeleton was buried in flexed position, lying on its right side, with orientation northwest-southeast. Around skeleton a vast number of animal bones, bivalves (*Unio* sp.), fragments of Starčevo pottery, and flint knives[8] were found.

Relative chronology: Starčevo culture, Early-Middle Neolithic

Preserved bones: frontal, left and right parietal, occipital, left and right temporal, fragment of left great wing of sphenoid bone, fragment of body and right great wing, left and right zygomatic, fragment of right maxilla, left ramus and fragment of right ramus of mandible. Postcranial bones: upper 1/3 of left humerus, right humerus without distal 1/3, right ulna without proximal end, right radius without proximal end, right scaphoid, left and right lunate, right trapezium, right hamate, fragment of one carpal, right I-V metacarpal, right second and third medial phalanx, one distal phalanx, left clavicle without lateral end, right clavicle, manubrium sternum, fragment of upper part of sternums body, lateral border of right scapula, fragment of coracoid process of right scapula, 5 fragmented cervical, 7 fragmented thoracic and 5 fragmented lumbal vertebrae, 2 vertebral and 2 sternal ends of the ribs as well as 4 body fragments of the ribs, auricular surface and part of fossa ilaca of left iliac bone, great sciatic notch of left iliac bone, auricular surface of right iliac bone with acetabular part, fragmented right ischiadic bone, upper half of sacrum, fragmented upper half of right femur, right patella, fragmented proximal end of right tibia.

Sex: Morphological features on the pelvic bones and skull indicate male. On the skull prominent glabella, robust processus mastoideus, strong traces of nuchal lines on relief of the nuchal plane, very prominent arcus superciliaris suggest male sex. On pelvic bone, great sciatic notch is narrow and V shaped, preauricular surface have smooth relief, without grooves, composite arch is single curved which all point to male sex.

Age:The degree of coronal and sagittal suture closure indicates age around 50, while tooth abrasion shows younger age, between 25-35 years.

Dental analysis: Teeth 17, 18, 37, 38, 45, 46, 47 and 48 are found inside alveolar sockets. Teeth 16, 36, 44 were lost postmortem. Abrasion of the 1st degree (in enamel)

[8] Field diary, Archive of the Provincial Institute for the Protection of Cultural Monuments

was noted on tooth 18, while all other teeth have 2nd degree (exposed dentin) of abrasion.

Pathology: Porotic hyperostosis was present on frontal (degree score 1, activity score 2) and both parietal bones (degree score 1, activity score 2). At the junction between frontal and right parietal bone, above the great wings of sphenoid bone, the lesion (2.6x1.1cm) has been detected. On the left parietal bone near the occipital suture the lesion (2.9x3.1 cm) has been detected. The same lesion (1.9x1.7 cm) is also noticed on sagittal suture near the occipital suture. On the right lateral side of mandible, bellow the tooth 47 there is a mild thickening circular in shape (0.8x0.9 cm), as well as on the medial part bellow the tooth 48. On the palmar side of third right hand medial phalanx, bellow the proximal end there are exostoses and a small lesion.

Osteoarthritis (OA) was noted on the superior surface of third and forth lumbal vertebrae. On the inferior surface of one thoracic vertebra there is a shallow depression-Schmorl's node

Metric analysis: All measurements and calculated indices are presented in Table 2ab.

Stature: According to the reconstructed maximal length of right humerus (32.0 cm) stature is 170.58 cm.

Stable isotope analysis: Isotopic values of $\delta^{13}C$, $\delta^{15}N$ and $\delta^{34}S$ indicate mostly terrestrial diet, with small input of aquatic resources.

Other observations: On the right pelvic bone and right femur there are traces of burning. During the anthropological analysis few animal bones were detected among human remains: two mandibles of sheep/goat, fragmented bone of Bos taurus, sacrum of Bos sp., metatarsal bone of Bos sp., humerus of sheep/goat, tibia of sheep/goat, tibia of sheep, caudal vertebrae of catfish, few cyprinid pharyngeal teeth (from Tench species), rib of medium sized mammal and fragment of skull of large sized mammal.

SREMSKI KARLOVCI[9]

Grave 1

Female, 35-50 years

Description: The grave, marked as a grave 1, was damaged due to the works and the skull was dislocated. The skeleton was found in trench 1, inside the object. The individual is oriented southeast-northwest, with the head on the southeast. Burial position is flexed. Above the skeleton one retouched blade was found, while bellow the skeleton chipped stone tool, little fish vertebrae and several fragments of pottery were found[10].

Relative chronology: Starčevo culture, Early-Middle Neolithic

Preserved bones: partially fragmented frontal bone, left and right parietal, occipital bone, fragmented sphenoid bone, left and right temporal, left and right nasal bones, left and right zygomatic bone, ½ of vomer, frontal process and zygomatic process of left maxilla, right maxilla, mandible. Postcranial bones: diaphysis of left humerus with ½ of medial epiphysis, right humerus, ½ of diaphysis of right radius, left II and III metacarpals, left first, second and third proximal phalanges; left and right clavicle, manubrium and body of sternum, 1/3 of left scapula, 1/3 of right scapula; 5 fragmented cervical and 12 thoracic vertebrae, 2 ribs, 10 vertebral and 6 sternal rib ends, as well as, 18 body fragments of the ribs; left patella, distal end of left femur, distal 1/3 of right femur, fragment of proximal end of right tibia.

Sex: Morphological features on the skull (nuchal crest, mastoid process, supraorbital margin, glabela and mental eminence on mandible are barely pronounced and indicate female.

Age: The degree of all sutures closure indicates age around 40-50 years, while tooth abrasion also point to similar age, between 25-35 years.

Dental analysis: Teeth 24, 25, 26, 27, 28, 33, 34, 35, 36, 37, 38, 42, 43, 44, 45, 46, 47 and 48 are present and find inside alveolar sockets. Teeth 21, 22, 23, 31, 32, 41 were

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[9] Although two Starčevo graves were found at this site, only one was available for anthropological analysis. This grave is marked as grave 2. It was found in trench 1. It is poorly preserved with just a few ribs and 7 vertebrae. The individual is lying on its back, oriented southeast-northwest, with the head on the south. Pottery fragments and lot of mollusc shells have been found next to the skeleton. Bellow spine there was a big fragment of pottery and 2 chipped stone tools (Field diary, Archive of the City Museum of Novi Sad).

[10] Field diary, Archive of the City Museum of Novi Sad

lost post-mortem. Abrasion of the 1st degree (in enamel) was noted on the tooth 28 and 48; of the 2nd degree (exposed dentin) on teeth 27, 33, 34, 35, 36, 37, 42, 43, 44, 45, 46, 47; and of the 3rd degree (to the bottom of the fissure) on teeth 24, 25 and 26. Supragingival calculus is moderately pronounced on the teeth 26, 27, 35, 42, 43, 47 (bucal side, degree score 2), while subgingival is present on teeth 34, 35, 44 and 45 (bucal side, degree score 2).

Pathology: Porotic hyperostosis was present on frontal (degree score 2, activity score 1) and both parietal bones (degree score 2, activity score 1) as well as on the occipital bone (degree score 3, activity score 1). On the manubrium of the sternum and around foramen magnum exostoses are present. Osteoarthritis was noted on glenoid fossa of left scapula, as well as, on the manubrium near joint surfaces for the first rib. In inferior part the body of sternum, there is a curvature toward anterior-posterior side. Spinous process of 2nd and 5th cervical vertebra is slightly deformed.

Metric analysis: All measurements and calculated indices are presented in Table 3ab.

Stature: According to the maximal length of right humerus (27.5cm) stature is 150.37 cm.

Stable isotope analysis: Isotopic values of $\delta^{13}C$ and $\delta^{15}N$ indicate mostly terrestrial diet.

Other observations: During the anthropological analysis few animal bones were detected among human remains: metatarsal bone of sheep/goat, fragment of mandible of medium sized mammal and mollusc shell Unio sp.

PERLEZ-BATKA

site C, Grave 1

Female, more than 30 years

Description: The grave was found in the trench II[11]. Individual was lying in flexed position.

Relative chronology: Starčevo culture, Early-Middle Neolithic

Absolute chronology: OxA-8605 (human tibia): 7145±50 BP: 6090-5880 BC (91.2%) (Whittle et al. 2002).

[11] Field diary, Archive of the Museum of Zrenjanin.

Preserved bones: The skeleton is fragmented. Present cranial bones: right half of frontal bone, 1/3 of left parietal bone, partially fragmented right parietal bone, squamous part of the occipital bone, right temporal bone without squama, frontal process of the right maxilla, left half of mandibular body and one fragment of the right side of mandibular body. Postcranial bones: left humerus without proximal end, with fragmented distal end, diaphysis of right humerus, 1/5 of upper part of left dyaphysis of ulna, right ulna, right radius with partially fragmented proximal and distal end, right proximal 2nd or 3rd phalanx, sternal end of left clavicle, glenoid fossa, a fragment of scapular spine, acromion and fragments of body of left scapula, 5 fragmented thoracic vertebrae, 6 vertebral and 2 sternal ends of the ribs, as well as 5 fragments of the body of ribs, 1/3 of left iliac bone, 1/3 of right acetabulum; fragment of greater sciatic notch, fragmented left and right upper pubic ramus, one fragment of the right pubic symphysis, diaphysis of right femur with one fragment of femurs neck and part of condyles, diaphysis of left tibia, diaphysis of right tibia, left fibula without proximal end, proximal end of right fibula, left talus, medial ½ of right talus, left calcaneus without 1/3 of lateral part, partially fragmented right calcaneus, left and right navicular bones, left first cuneiform; left I, IV and V metatarsal, left 2nd proximal phalanx.

Sex: Morphological features on the skull (nuchal crest, mastoid process, supraorbital margin, glabela and mental eminence on mandible are barely pronounced and indicate female. All postcranial bones are very gracile which also point to female.

Age: The degree of all sutures closure indicates age between 20-30 years. Sternal end of clavicle points to age above 30.

Dental analysis: None of the teeth is preserved. Teeth 36, 44 and probably 45 were lost ante- mortem, while teeth 31, 32, 33, 34, 35, 37, 38, 41, 42 and 43 were lost post-mortem.

Pathology: Porotic hyperostosis was present on both parietal bones and occipital bone (degree score 1, activity score 1). Cribra orbitalia was not detected. Osteoarthritis (OA) was noted on joint surfaces of both calcanei, tali, naviculars, left first cuneiform, left I, IV and V metatarsal bone. Right calcaneus is slightly curved toward latero-medial direction.

Metric analysis: All measurements and calculated indices are presented in Table 4ab.

Stature: According to the maximal length of right femur (35.0cm) stature is 140.55 cm and right tibia (30.5cm) 149.98, which gives an average stature of 145.26 cm.

Stable isotope analysis: Isotopic values of $\delta^{13}C$ and $\delta^{15}N$ indicate mostly terrestrial diet.

Other observations: During the anthropological analysis several animal bones were recovered: fragmented tibia of sheep/goat, fragment of occipital bone of Bos.sp, fragmented scapula of foetus pig, third lower molar of sheep/goat, upper 1st or 2nd molar of sheep/goat and a vertebrae of young specimen of large mammals (deer or Bos sp.). On the linea aspera of right femur, 2.3 cm bellow nutritional foramen there are possible traces of gnawing (in the length of 3.2cm). Similar traces are also noticed on lateral and medial side of right tibia diaphysis. On the posterior side of right tibia there are also two slight traces of cutting (1.00x0.05cm).

site B, Grave ?

Juveniles, 14 years

Description: The grave was found in the trench XI in 1972[12].

Relative chronology: Starčevo culture, Early-Middle Neolithic.

Preserved bones: The skeleton is poorly preserved. Present cranial bones: basilar part of occipital bone, with left lateral part and left ramus of mandible, without coronoid processes. Postcranial bones: ½ of diaphysis of left humerus, 2/3 of diaphysis of right humerus, diaphysis of left and right ulnae, partially fragmented left radius without distal end, partially fragmented right radius without proximal end, diaphysis of the left clavicle, 1/3 of left scapula (glenoid fossa, lateral border, part of scapular spine, acromion), 1/3 of right scapula (glenoid fossa, lateral border, part of spina scapulae, acromion), 2 fragmented thoracic vertebrae, 1 fragmented lumbal vertebrae, left iliac bone, partially fragmented right iliac bone, 2/3 of diaphysis of left femur, right femur without proximal end, diaphysis of left and right tibia, 2/3 of diaphysis of left fibula, right fibula without epiphysis.

Sex: Since skeleton is poorly preserved and sex based morphological characteristics are not fully developed at this age, sex could not be determinate.

Age: Basilar part of occipital bone is not fused, which indicate age under 19 years. Epiphyses are not fused with diaphysis, which gives age under 14. According to the

[12] Field diary, Archive of the Museum of Zrenjanin.

reconstructed maximal length of right humerus (24.0 cm), left radius (18.8 cm), right femur (34.3 cm) and right tibia (27.5 cm) estimate age is 14 years.

Metric analysis: All measurements and calculated indices are presented in Table 4ab.

Stable isotope analysis: Isotopic values of $\delta^{13}C$ and $\delta^{15}N$ indicate mostly terrestrial diet, with small input of aquatic resources.

Other observations: The periosteum is damaged on all bones. Upper half's of both ulnas are slightly curved toward medial direction. During the anthropological analysis several animal bones were recovered: pelvis of female cattle, fragmented proximal epiphysis of humerus of cattle, 1/3 of distal tibia of roe deer.

OBREŽ-BAŠTINE

Grave 1,

Child, 4-6 years

Description: The grave was found in the eastern part of trench I, above pit 1. The child was lying on its right side oriented northwest-southeast, with the face toward southwest. Burial position is flexed with the arms bent at the elbows and crossed above the chest. Legs are bent at the knees, close to the chest. Grave goods were not present.

Relative chronology: Starčevo culture, Early-Middle Neolithic

Preserved bones: The skeleton is poorly preserved. Present cranial bones: frontal squama with fragmented right orbit, half of left parietal, right parietal, fragmented squama of the occipital bone, fragmented squama and petrous part of the left temporal bone, fragment of petrous part of right temporal bone, fragmented left part of greater wings of left sphenoid, right zygomatic, fragment of right palatine, fragmented right maxilla, and mandible without condylus and mentum. Postcranial bones: left humerus without proximal end, one thoracic vertebra, left femur with distal epyphisis (not fused) and left tibia.

Age: According to the degree of formation and teeth eruption, estimate age is 6 years ±2. According to the maximal length of humerus (14.0 cm) estimate age is 4 years, and according to femur (20.2 cm) and tibia (17.1 cm) age was 5 years.

Dental analysis: Teeth 11, 16, 34, 36, 54, 55, 75, 84 and 85 are in alveolar sockets, while 32, 46, 53 and 64 are found outside. Teeth 16, 36 and 46 are in eruption, while teeth 11, 32 and 34 are still in the crypt. Abrasion of the 1st degree (in enamel) was noted on teeth 16, 36, 46, 53, and of the 2nd degree (exposed dentin) on teeth 54, 55, 64, 75, 84 and 85. Supragingival calculus is moderately pronounced on the tooth 46 (lingual side, degree score 2). Caries was not detected.

Pathology: Cribra orbitalia was noted on the roof of the right orbit with degree score 1 (barely discernible porosity) and activity score 2 (healed at time of death). Porotic hyperostosis was not present on frontal, both parietal bones and on occipital bone (degree score 0). There is a trace of cutting (0.8 x 0.4cm), on the posterior side, just above distal end of the left tibia made with some sharp tool. Around it periosteal reaction was detected. Periosteal reaction is also present on 1/3 of medial side of tibia

Stable isotope analysis: The isotopic bone values of $\delta^{13}C$ and $\delta^{15}N$ reflect a generally terrestrial dietary pattern, while $\delta^{34}S$ suggests little input of aquatic food resources. Isotope signature of the crown of deciduous first molar shows that, during the first six month of life the child was breastfed. The later signal (the bone value), which reflects the diet from approximately between 3-5 years of age (due to the rapid bone remodelling) shows a decrease in $\delta^{15}N$, suggesting that the child was not breastfed at the age of 3. Since the dietary signal for the period between 6 month and 3 years of age is lacking, it is hard to estimate until what age this child was exclusively breastfed. Thus one can only conclude that, at the age of 3 this child was not exclusively breastfed.

Other observations: Behind the coronal suture a shallow depression was detected. It is present along all length of the suture. It could be caused by the fact that this child was wearing something on the head, connected to everyday habits or cultural traditions.

STARČEVO

Grave 1/2004

Description: In 2004 two human skeletal remains (marked as grave 1) were found at the bottom of the pit dwelling in trench 5/2004 (Živković 2008). Inside the dwelling fragments of pottery and animal remains were also detected. The first individual (marked as Skeleton 1) was buried in flexed position, with orientation south-north. No grave goods were found. At the distance 0.6 m northeast from the Skeleton 1, on the same level, remains of another younger individual were detected and marked as

Skeleton 2. Beside these two individuals, in trench 3, in XI excavation layer, a human diaphysis of left femur has been discovered in the pit that can be associated with Starčevo culture. At the middle of the shaft, on posterior side there are traces of injury (three cuts, dimensions (1.2 cm x 0. 6 cm), probably caused by sharp edge tool.

Individual 1

Female, 55-60 years

Relative chronology: Starčevo culture, Early-Middle Neolithic

Preserved bones: Present cranial bones: partially fragmented frontal bone, left parietal bone, right parietal bone, occipital squama, both temporal bones, fragment of greater wings of sphenoid bone. Postcranial bones: diaphyses of both humeri, diaphyses of both left and right ulnas, fragmented proximal end of the left ulna; fragmented 2nd right metacarpal bone; fragment of the body of scapula, fragment of scapular spine; 4 fragments of thoracic vertebrae; 2 fragments of lumbal vertebrae; 3 vertebral rib ends, 4 body fragments of the ribs; partially fragmented left iliac bone; upper half of left ischiadic bone, ½ of right iliac bone, acetabular part of right ischiadic bone, one vertebrae of sacrum; left femur with fragmented distal end, fragmented right femur; fragmented left tibia without distal end, diaphysis of right tibia; ½ of diaphysis of left fibule; fragment of metatarsal bone.

Sex: On the skull slightly delimited glabella, small processus mastoideus, slightly arched traces of nuchal lines on relief of the nuchal plane, smooth arcus superciliaris suggest female sex. On pelvic bone, great sciatic notch is broad and U shaped, preauricular sulcus is present, composite arch is double curve, iliac crest is flat and S formed which also point to female.

Age: The degree of all sutures closure indicates age between 50-60 years, while tooth abrasion points to younger age, around 45 years.

Dental analysis: Teeth 32, 33, 34, 35, and 37 are inside alveolar sockets. Tooth 31is lost post-mortem, while teeth 36 and 38 were lost antemortem. All teeth have 2nd degree of abrasion, except 35 which has 4th degree. Supragingival calculus is moderately pronounced on the tooth 37, (lingual side, degree score 2), while subgingival is present on teeth 32, 33 have small amount (mesial and distal side, degree score 2). Tooth 34 has high amount of calculus (lingual side, degree score 3). Caries was not detected. Hypoplasia was noted on the teeth 32 (linear 2 lines) and 33 (linear 2 lines).

Pathology: Cribra orbitalia was not detected. Porotic hyperostosis was present on both parietal bones (degree score 1, activity score 2) and occipital bone (degree score 3, activity score 3).

Metric analysis: All measurements and calculated indices are presented in Table 5ab.

Other observations: On the lower part of left side of occipital squama there is a lump (18.76mm x 19.95mm), which can be consequence of injury or palliative treatment. On the upper part around the bulge two shallow depressions were detected (4.53 mm), which can be caused by some tool. OA changes were detected in all preserved vertebrae. During the anthropological analysis several animal bones were recovered: *pig axis*, cattle os malleolus, distal femur of large mammal (cattle?) and fragmented diaphysis of humerus (cattle?).

Individual 2

Child, 5-7 years

Preserved bones: The skeleton is poorly preserved. Cranial bones were not present. Postcranial bones: diaphysis of both humeri, right ulna, right radius, distal ¼ of left radius, two fragmented metacarpal bones and one fragmented proximal phalanx; fragment of acromion process of right scapula and part of lateral border with glenoid fossa; body of one thoracic and lumbal vertebrae; two vertebral and sterna ends of ribs as well as 20 body fragments of ribs; both iliac bones, left ischiadic bone, one sacral vertebra, fragment of sacral promontory; partially fragmented right femur, distal half of right tibia, proximal 1/3 of left fibula, right fibula without proximal end; first cuneiform bone and one metatarsal bone.

Age: According to the degree of formation and teeth eruption, estimate age is 7 years ±2. Based on maximal length of right femur (21.3 cm) and maximal length of right radius (11.2 cm) estimate age is 5 years.

Dental analysis: Teeth 54, 55, 84, 85 and 46 are inside alveolar sockets, while tooth 16 is out. Calculus, caries and hypoplasia were not detected.

Other observations: During the anthropological analysis several animal bones were recovered: fragment of metapodial bone and fragment of scapula of large size mammal, as well as a fragment of probably coxal bone of large size mammal.

VINČA BELO-BRDO

First anthropological analysis of human skeletal remains found in this pit was conducted by I. Schwidetzky in 1937. Since the skeletons were heavily damaged after bombing of Belgrade in the II World War Schwidetzky did revision anthropological analysis in 1957 and 1971/72. During the revised analysis it has been determined that all skulls were much damaged, and their remains were identified with the help of previous marks on them. They are marked from I-IX. Postcranial bones were pretty damaged after bombing and only few fragments have been preserved and mixed, so it was impossible to know to which individual they belong.

Material was stored in the box with each bag containing the remains of single individual[13]. However, during the anthropological analysis several bones were found outside of their respective bags, and consequently could not be associated with particular individual. Those bones are: two fragments of parietal bone, fragment of frontal bone; distal half of left humerus, right humerus[14], proximal part of left radius, right clavicle[15], two fragments of ribs (body), one fragmented cervical and two lumbal vertebrae, first fragmented vertebrae of sacrum; distal half of the left femur[16], as well as fragmented head of the femur, distal ½ half of the right tibia, distal part of the right fibula and two right tali. Beside this, there are also six fragmented zygomatic bones and two fragmented mandibles which were found in bag without any mark. Since all those bones could belong to any of analyzed individuals, they were excluded from analysis in this thesis.

A re-analysis of these human skeletal remains done for the purpose of this thesis showed that the minimal number of individuals was 12, not 9 like previously observed.

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[13] During the anthropological anaylsis it was determined that in several bags there are remains of more than one individual.

[14] Measurements : maximal length 28.2 cm, maximal AP diameter of the shaft 1.7 cm, minimal diameter of the shaft 1.8 cm, maximal head diameter 4.0 cm, minimal shaft diameter 6.0 cm, biepicondylar width 5.7 cm, articular width 2.6 mm.

[15] Measurements: maximum length 12.6 cm; shaft diameter 4.5 cm.

[16] Measurements: bicondylar length 5.8 cm, bicondylar width 7.4 cm.

It also shows that 2 females, one male and 9 individuals for which sex could not be determined due to poor preservation were buried here. The youngest individual was 15-18 years old, while all others are in the range between 20-40 years old. A study by Tasić and colleagues (2015)[17] shows that although some of the deceased were buried almost at the same time it is however clear that the burial of these 12 individuals does not represent one single event.

In order to investigate what does this feature present, in a recent study Stefanović and her colleagues (2016) examined digital photo documentation as well as field diaries.

Seven individuals were buried in extended position and only one is buried on the side but not in flexed position. All this suggest that this feature with skeletons was not place for burying the deceased. Furthermore, some of the skeletons (II, III, IX) were placed with a face and chest toward the ground which is commonly associated with expression of rejection and taking away dignity of the deceased. One of the alternative scenarios is that maybe those individuals died during sleep due to the suffocation which resulted from fire. However, this scenario is questionable since there are no traces of burning, except on the skeleton I. For this skeleton Vasić also noticed that skull has traces of burning and he is also mentioning a charred beam. During the anthropological analysis additional traces of burning were also noticed on skull I and one vertebra. All those traces look like they occurred post-mortem.

However, other evidences point that Starčevo group burial could be a „crime scene". Namely, traces of violence were detected on skull II, VI and VIII. On the skull VI there is a trace of blunt force trauma on left parietal bone, which was not detected during the first anthropological analysis by I. Schwidetzky. Since today skull II is not preserved as it was during the first anthropological analysis, by analysing photo documentation a small fracture on the occipital bone was detected. The secure evidences of violence are evidenced on individual VIII. This deceased was placed with the chest toward the ground and its left leg placed on the back, which was not possible without dismembering the leg. Right leg was contracted with a broken femur. Furthermore, its skull was dislocated. These three individuals with traces of violence

[17] Tasić et al. 2015

suggest this was maybe a place of Neolithic crime scene. Nevertheless, weather it was the crime scene or not, this new study showed this was not typical Starčevo burial place.

However, due to high fragmentation rates it was not possible to more precisely reconstruct positions of individuals numbered I, IV, V, VI and VII.

Vinča I,

Adult, 30 years

Preserved bones: Since bones and teeth are partially burned they were excluded from further analysis. Fragmented frontal bone, fragmented left and right parietal bones, two fragments of squama of occipital bone, alveolar part of the right maxilla, fragmented mandible.

Sex: Due to poor preservation of material and since only gracile mental eminence was present, sex could not be determined.

Age: The degree of sagittal suture closure indicates age around 30 years.

Dental analysis: Teeth 14, 15, 36, 37, 43, 44, 45, 46, 47 and 48 are in alveolar sockets. Due to traces of burning tooth abrasion could not be observed.

Other observations: In the box, marked as Vinča I tooth 11 was also found, and doesn't belong to this individual.

Vinča II,

Adult 30-35 years

Absolute chronology: 5515-5380 cal BC (Tasić et al. 2015)

Preserved bones: ¼ of both left and right parietal bones, fragmented maxilla, and mandible.

Sex: Due to poor preservation of material and since only mental eminence was present, sex could not be determined.

Age: The degree of sagittal suture closure indicates age between 30-40 years, while tooth abrasion points to younger age, between 20-30 years.

Dental analysis: Tooth 14, 15, 16, 23, 24, 25, 27, 36, 43, 44, 45, 46 are present and found inside alveolar sockets. Tooth 11 was lost antemortem, while teeth 12, 13, 17, 21, 22, 24, 31-37, 41-43, 47 are lost postmortem. Abrasion of the 1st degree (in enamel) was noted on teeth 27, 45; and of the 2nd degree (exposed dentin) on teeth 14, 15, 16, 23, 24, 25, 36, 43, 44, 46. On the teeth 14, 15, 16, 25, 26, 27, 36 and 45, supragingival and subgingival calculus were detected (bucal, mesial, lingual and distal side, degree score 1). Teeth 43, 44, and 46 also show presence od supragingival and subgingival calculus with degree score 2.

Pathology: Porotic hyperostosis was detected on parietal bones (degree score 1, activity score 2).

Metric analysis: All measurements and calculated indices are presented in Table 6.

Stable isotope analysis: Isotopic values of $\delta^{13}C$, $\delta^{15}N$ and $\delta^{34}S$ indicate mostly terrestrial diet, with small input of aquatic resources (Nehlich et al. 2010).

Starch grain analysis: Six starch grains have been found inside the dental calculus.

Vinča III,

Adult 30-40 years

Absolute chronology: 5570-5475 cal BC (Tasić et al. 2015)

Preserved bones: left parietal bone, right temporal bone with mastoid process without squama, fragmented mandible without right condyle.

Sex: Due to poor preservation of material and since only robust mastoid process and gracile mental eminence were present, sex could not be determined.

Age: The degree of coronal and sagittal suture closure indicates age between 30-40 years.

Dental analysis: None of the teeth was preserved. Teeth 31, 32, 34, 35, 36, 37, 38, 45, 46, 47, 48 were lost antemortem, and 33, 41, 42, 43 postmortem. Due to high number of antemortem teeth loss, mandible is deformed.

Pathology: Porotic hyperostosis was detected on parietal bones (degree score 1, activity score 3).

Metric analysis: All measurements and calculated indices are presented in Table 6.

Vinča IV,

Adult, 20-30 years

Absolute chronology: 5620-55485 cal BC (Tasić et al. 2015)

Preserved bones: ½ of the frontal bone, fragmented left parietal bone, great wings of the sphenoid bone, squama of the left temporal bone, fragmented maxilla and fragmented mandible.

Sex: Due to poor preservation of material and since only gracile mental eminence was present, sex could not be determined.

Age: The degree of coronal and sagittal suture closure indicates age between 20-30 years. Tooth abrasion indicates similar age, between17-25.

Dental analysis: Teeth 11, 12, 13, 16, 18, 21, 26, 27, 28, 31, 36, 38, 41, 42, 43, 46 are present and found inside alveolar sockets. Teeth 11, 12, 18, 21, 27, 28, 31, 38, 41, 42 were lost postmortem. All teeth have the 1st degree of abrasion, except 13, 16, 26, 36, 43, 46 which have 2nd degree. Caries was not detected. Linear enamel hypoplasia was noted on the teeth 14 (1 line), 15 (1 line), 23 (2 lines), 25 (1 line). Dental calculus, mostly supragingival, was detected on the following teeth: 13-17, 23, 25, 26, 33, 34, 35, 36, 37, 44, 45, 46, 47, and 48.

Pathology: Porotic hyperostosis was detected on parietal bones (degree score 1, activity score 2).

Metric analysis: All measurements and calculated indices are presented in Table 6.

Stable isotope analysis: Isotopic values of $\delta^{13}C$, $\delta^{15}N$ and $\delta^{34}S$ indicate mostly terrestrial diet, with small input of aquatic resources (Nehlich et al. 2010).

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Vinča V,

Adult, 20-30 years

Absolute chronology:5565-5470 cal BC (Tasić et al. 2015)

Preserved bones: two fragments of the frontal bone, two fragments of parietal bones, two fragments of occipital bone, fragmented great wings of sphenoid bone, fragmented petrous part of the temporal bone, left zygomatic bone, and mandible with fragmented right ramus.

Sex: Due to poor preservation of material and since only gracile mastoid process and medium pronounced mental eminence were present, sex could not be determined.

Age: Based on tooth abrasion estimated age is between 25-35 years.

Dental analysis: All teeth in mandible are present (except tooth 47, which was lost postmortem), and found inside alveolar sockets, and they have 2nd degree of abrasion. Caries was not detected. Hypoplasia was noted on the teeth 33, (pit and vertical), 36 (linear, 1 line), 43 (pit and vertical), 44 (linear, 1 line), 45 (linear, 1 line) and 46 (linear, 2 lines). Supragingival and subgingival dental calculus of degree 1 was detected on teeth 31, 32, 33, 34, 35, 37, 41, 43, 45, 46, 47, while teeth 36, 42 and 44 have degree 2.
Metric analysis: All measurements and calculated indices are presented in Table 6.
Stable isotope analysis: Isotopic values of $\delta^{13}C$, $\delta^{15}N$ and $\delta^{34}S$ indicate mostly terrestrial diet, with small input of aquatic resources (Nehlich et al. 2010).
Starch grain analysis: Five starch grains have been found inside the dental calculus.

Vinča VI?,

Adult, 20-30 years

Preserved bones: Fragmented maxilla, mandible.
Sex: On the skull slightly delimited glabela, supraorbital margin, and mental eminence suggest female sex.
Age: The degree of coronal and sagittal sutures closure indicates age between 20-30 years, and tooth abrasion points to similar age, between 17-25 years.
Dental analysis: Teeth 14, 15, 16-18, 36, 37, 43-48 are present and found inside alveolar sockets. Teeth 11, 12, 13, 16, 17, 18, 21, 22, 23, 24, 25, 31-35, 38, 41 and 42 were lost post-mortem. All teeth have the 1st degree of abrasion, except 26, 36, and 46, which have 2nd degree. Caries was not detected. Linear enamel hypoplasia was detected on tooth 37 (1 line). Supragingival and subgingival dental calculus of degree 1 was detected on teeth 15, 16, 28, 37, 43, 45, 46 and 47, while teeth 26, 27, 36, 44 have degree score 2.
Metric analysis: All measurements and calculated indices are presented in Table 6.
Stable isotope analysis: Isotopic values of $\delta^{13}C$, $\delta^{15}N$ and $\delta^{34}S$ indicate mostly terrestrial diet, with small input of aquatic resources (Nehlich et al. 2010).
Starch grain analysis: starch grains are not detected.

Vinča VI b?

Adult, 30-40 years

Preserved bones: 1/3 of frontal bone, ½ of left parietal bone and fragments of right parietal bone, two fragmented parts of occipital bone, fragmented right and left temporal bone with fragmented zygomatic processes.

Sex: Due to poor preservation of skeletal material sex could not be determined.

Age: The degree of sagittal and lambdoid sutures closure indicates age between 30-40 years.

Pathology: Cribra orbitalia was detected on orbital roof (degree score 1, activity score 2). Porotic hyperostosis was detected on parietal bones (degree score 2, activity score 3).

Other observations: In material there are two mastoid processes with totally different morphology, it is possible that one of them belongs to other individual and not to Vinča VIb.

Vinča VII,

Female, 15-18 years

Absolute chronology: 5565-5470 cal BC (Tasić et al. 2015)

Preserved bones: fragmented frontal bone, fragmented left and right parietal bones, right temporal bone, ½ of squama of occipital bone, maxilla, and partially fragmented mandible.

Sex: Morphological features on the skull (nuchal crest, mastoid process, supraorbital margin, glabela and mental eminence on mandible are not pronounced and indicate female.

Age: The degree of all sutures closure indicates age around 20, and tooth abrasion shows also, similar age, between 17-25 years. Since third molar is in eruption, estimated age is between 15-18.

Dental analysis: Teeth 14, 15, 16, 17, 26, 27, 28, 33, 36, 37, 46, 47 are present and found in their alveolar sockets. Teeth 11, 12, 13, 21, 22, 23, 24, 25, 31, 32, 34, 41, 42, 44, 45 and 48 were lost postmortem. All of them have the 1st degree of abrasion, except 16, 26, 36 and 46. On the tooth 47 precarious lesion hase been detected. Hypoplasia was detected on teeth 27 (linear, 2 lines) and 43 (pit). Supraginigval and subgingival dental calculus of degree 1, were noted on teeth 15-17, 26, 27, 33, 35, 36 and 43, while teeth 37, 46 and 47 have degree 2.

Pathology: Cribra orbitalia was detected on the right orbital roof (degree score 1, activity score 3). Porotic hyperostosis was detected on frontal (degree score 1, activity score 2), parietal (degree score 1, activity score 2) and occipital (degree score 1, activity score 2) bones.

Metric analysis: All measurements and calculated indices are presented in Table 6.

Stable isotope analysis: Isotopic values of $\delta^{13}C$, $\delta^{15}N$ and $\delta^{34}S$ indicate mostly terrestrial diet, with small input of aquatic resources (Nehlich et al. 2010).

Starch grain analysis: twenty three starch grains have been found inside the dental calculus.

Vinča VIII,

Male, 30-40 years

Preserved bones: fragmented frontal bone, right zygomatic bone, fragmented ½ of left and ½ of right parietal bone and fragmented ½ of squama of occipital bone, left temporal bone without squama, fragmented mandible.

Sex: On the skull prominent glabella, supraorbital margin, robust processus mastoideus, traces of nuchal lines on relief of the nuchal plane, prominent mental eminence suggest male sex.

Age: The degree of coronal suture closure indicates age between 30-40, while tooth abrasion shows younger age, between 25-35 years.

Dental analysis: Tooth 11 was lost postmortem. Only tooth 35 and 36 were present and they have 2nd degree of abrasion. Caries and hypoplasia was not detected. Both teeth show presence of supragingival calculs (degree score 1).

Pathology: Cribra orbitalia was detected on the orbital roofs (degree score 1, activity score 3). Porotic hyperostosis was detected on frontal (degree score 2, activity score 3), parietal (degree score 2, activity score 3) and occipital (degree score 3, activity score 3) bones.

Metric analysis: All measurements and calculated indices are presented in Table 6.

Stable isotope analysis: Isotopic values of $\delta^{13}C$, $\delta^{15}N$ and $\delta^{34}S$ indicate mostly terrestrial diet (Nehlich et al. 2010).

Starch grain analysis: one starch grains have been found inside the dental calculus.

Other observations: During anthropological analysis, inside the box marked as Vinča VIII, left half of the dog mandible and fragment of frontal bone of domesticated cattle, were found.

Vinča IX,

Female, 25-30 years

Absolute chronology:5660-5555 cal BC (Tasić et al. 2015)

Preserved bones: fragmented frontal bone, partially fragmented left and right parietal bones, squama of occipital bone, fragment of left maxilla, fragment of right maxilla and partially fragmented mandible.

Sex: On the skull slightly delimited glabela, supraorbital margin, mental eminence indicate female, although nuchal crest is very pronounced.

Age: The degree of all sutures closure indicates age between 20-30 years, and tooth abrasion points to similar age, between 25-30 years.

Dental analysis: Teeth 12, 13, 14, 15, 17, 18, 23, 34, 35, 36, 37, 38, 43, 45, 46, 47, 48 were present and found in their alveolar sockets. Mandibular front teeth are fragmented. All teeth have the 1st degree of abrasion, except 11, 12, 13, 14, 36, and 46 which have 2nd degree. Caries was not detected. Hypoplasia was detected on teeth 13 (linear, 1 line), 22 (pit and linear, 2 lines), 27 (linear, 1 line), 48 (linear, 1 line). Supraginigval calculus of degree score 1 was detected on teeth 12, 13, 22, 31, 32, 34, 41, 42, 43 and 45, while teeth 35-38, 46-48 have calculus of degree 2.

Pathology: Cribra orbitalia was not detected. Porotic hyperostosis was detected on frontal (degree score 1, activity score 2), parietal (degree score 2, activity score 2) and occipital (degree score 1, activity score 2) bones.

Metric analysis: All measurements and calculated indices are presented in Table 6.

Starch grain analysis: ninety three starch grains have been found inside the dental calculus.

Vinča IX?

Inside this box, skeletal remains of at least three individuals have been found and since they can belong to any individual from Vinča group burial, they were excluded from analysis.

Individual 1

Preserved bones: fragments of frontal bone and one fragment of parietal bone were discovered and due to its thickness, these fragments belong to child.

Individual 2

Preserved bones: one fragment of frontal bone, right fragment of temporal bone, two fragments of occipital bone. According to suture closure, it could belong to middle aged adult (40-50 years old).

Individual 3

Preserved bones: small fragments of parietal bone, which according to the degree of suture closure indicate young adult (20-30).

Vinča X,

Adult, more than 30 years

Absolute chronology: 5535-5385 cal BC (Tasić et al. 2015)

Preserved bones: partially fragmented frontal bone, ½ of the left fragmented parietal bone, ½ of right fragmented parietal bone, fragmented maxilla.

Sex: On the skull glabela and supraorbital margin are very prominent. However, due to poor preservation of material sex could not be estimated.

Age: The degree of coronal and sagittal sutures closure indicates age around 40 years, while tooth abrasion points to younger age, between 25-30 years.

Dental analysis: Teeth 12, 13, 14, 15, 16, 17, 18, 21, 22, 24, 25, 26, 27, 35, 36 are present and found in their alveolar sockets. Teeth 11, 23 and 28 were lost postmortem. They all show 2nd degree of abrasion, except 27 which has 1st degree. Caries was detected on tooth 27. Hypoplasia was noted on tooth 13 (linear, 1 line and pit) and 24 (linear, 1 line). Supragingival calculus of degree score 1 was detected on teeth 13-17, 21, 22 and 26.

Pathology: Cribra orbitalia was detected on orbital roofs (degree score 1, activity score 2). Porotic hyperostosis was detected on parietal bones (degree score 1, activity score 2).

Metric analysis: All measurements and calculated indices are presented in Table 6.

Starch grain analysis: one starch grains have been found inside the dental calculus.

Vinča M,

Adult, more than 30 years

Preserved bones: partially left parietal bone, ¼ of frontal bone, partially fragmented squama of occipital bone.

Sex: On the skull, only nuchal crest was possible to observe, which is very gracile.

Age: The degree of coronal sutures closure indicates age around 30 years.

Pathology: Porotic hyperostosis was not detected on preserved bones.

GRIVAC

Grave 1

Description: The individual was buried inside the pit in flexed position. Left arm was contracted with the hand placed on the neck. Right humerus was in an extended position while ulna and radius were contracted. Fragments of the face bones, jaws and teeth were found on the right side of the deceased. This burial was probably damaged and skull bones were dislocated (as well as the bones found in 1954 and 1969) when later Vinča settlement damaged Starčevo layer (Bogdanović 2004: 45). The individual is oriented south-north, with the deviation toward east.

Individual 1,

Adult, 30-35 years

Preserved bones: The skeleton is poorly preserved. Present cranial bones: left and right parietal bones, fragmented basilar and lateral part of the occipital bone, right mastoid process, left maxilla, left condyloid mandible process. Postcranial bones: fragmented acromion process of left scapula, part of scapular spine, fragmented spinous process of thoracic vertebrae, ten fragments of vertebrae; one vertebral and two sternal rib ends; fragmented body of vertebrae, left scaphoid, left pisiform, left triquetral, left trapezium, half of the first metacarpal bone, one proximal, medial and distal hand phalanges and one medial foot phalanx.

Sex: On the skull only mastoid processes could be observed and they show to be very robust.

Age: The degree of sagittal sutures closure indicates age around 30 years, while tooth abrasion points to similar age, between 25-30 years.

Dental analysis: Teeth 11, 22, 25 are present and found outside their alveolar sockets. All teeth have 2^{nd} degree of abrasion. Supragingival calculus was detected on all of them (degree 1). Caries and dental hypoplasia were not detected.

Pathology: Porotic hyperostosis was not detected.

Stable isotope analysis: Isotopic values of $\delta^{13}C$ and $\delta^{15}N$ indicate mostly terrestrial diet with small input of aquatic resources.

Other observations: During the anthropological analysis several animal bones were recovered: four fragments of the long bone shafts of medium sized mammals, rib fragment and thoracic vertebrae fragment of medium sized mammal; fragmented thoracic, caudal and lumbal vertebra, fragmented proximal epiphysis of humerus, fragmented scapula and pelvis of large size mammal; one intermedial of domesticated cattle, two fragments of atlas, most likely of domestic cattle.

Individual 2,

Child, 5-10 years

This skeleton is poorly preserved. Only fragmented frontal bone and four body fragments of ribs, and one fragment of long bone diaphysis have been preserved.

Age: According to the size of the present bones estimated age is between 5-10 years.

Pathology: Cribra orbitalia was detected on the left orbital roof (degree score 1, activity score 2). Porotic hyperostosis was not detected.

RUDNIK KOSOVSKI

Grave 1,

Female, more than 50 years

During the excavations in 1984 five graves have been discovered. They were located outside of the houses, but inside the settlement. All individuals were buried in flexed position. Graves 1, 2, 3 and 4 were at the bottom of one shallow pit. Grave 1 is well preserved, while graves 2, 3, and 4 were damaged since subsequent settlement layers damaged this Starčevo layer. Beside animal bones found inside the pit, in graves 1, 3 and 4 ceramic vessels and one amulet have been discovered as grave goods near the deceased. The fifth grave was found 20 m away from other graves. It was very damaged and dislocated (Mikić 1989).

Preserved bones: Today only the scull of this individual is present and it is well preserved.

Sex: On the skull nuchal crest, gracile mastoid processus, glabela, supraorbital margin and mental eminence are not pronounced and indicate female.

Age: The degree of all sutures closure indicates age above 50 years.

Dental analysis: Teeth 11-17, 21-23, 25-28, 31-36, 41-47 are present and found in their alveolar sockets. Teeth 37, 38 were lost antemortem, while tooth 48 was lost postmortem. Degree of tooth abrasion could not be observed since maxilla and mandible were glued. Caries was detected on teeth 34, 35, 36, 46 and 47. Hypoplasia was not detected. Supragingival and subgingival calculus of degree 1 were detected on teeth 11-17, 23, 26 and 28, while on teeth 22, 32, 33, 42 and 43, calculus of degree 2 was detected.

Pathology: Cribra orbitalia was not detected. Porotic hyperostosis was detected on parietal bones (degree score 1, activity score 2) and occipital bone (degree score 1, activity score 2).

Metric analysis: All measurements and calculated indices are presented in Table 7.

Stable isotope analysis: Isotopic values of $\delta^{13}C$ and $\delta^{15}N$ indicate very terrestrial diet.

Table 1a. Golokut-Vizić - Measurements of cranial bones and calculated indices

BURIAL NUMBER	**2/1984**	**3/1984**	**4/2003**	**BURIAL NUMBER**	**2/1984**	**3/1984**	**3/2003**	**4/2003**
Skull Maximum length	18.4	18.5	17.0	**Nasal Index**	-	-	-	-
Maximum breadth	14.1	13.1	12.3	**Mandible: bicondylar breadth**	-	-	-	-
Maximum height	-	12.8	–	**Bigonial breadth**	9.35	9.3	-	-
Minimum frontal breadth	9.9	10.4	9.0	**Height of ascending ramus**	6.6	-	2.8	-
Index Cranial index	76.63(brachicrane)	70.81(mesochrane)	-	**Thickness of mandible body**	-	1.1	1.8	-
Length - Height Index	-	69.18(hamechrane)	-	**Height of mandible body**	3.0	2.9	-	-
Breadth – Height Index	-	97.70 (metriocran)	-	**Height of mandibular symphysis**	2.8	3.0	3.3	-
Frontoparietal Index	70.21(eurimetopic)	79.38(eurimetopic)	-	**Minimum breadth of ascending ramus**	1.1	1.0	-	-
Facial Skeleton Total facial height	-	-	-	**Index Ascending ramus**	16.6	-	-	-
Upper facial height	-	-	5.9	**Frontomandibular**	106.45 (eurimandibular)	111.83 (eurimadibular)	-	-
Facial width	-	13.6	10.6	**Maxillae Maxilloalveolar length**	-	5.2	-	-
Facial index	-	-	-	**The Palate Palatal length**	-	1.4	-	-
Nose Nasal height	-	-	4.3	**Palatal breadth**	-	-	-	3.5
Nasal width	-	-	2.3					
The Orbits Orbital height	3.3	3.2	3.1 (l.); 3.2 (r.)					
Orbital breadth	4.0	3.8	3.7 (l.); 3.8(r.)					
Orbital Index	82.5 (hamechonic, wide)	84.21 (mesochonic)	-					

Table 1b. Golokut-Vizić - Measurements of postcranial bones and calculated indices

BURIAL NUMBER	2/1984	3/1984	1/2003	3/2003
Femur Maximum length	-	43.6 (l.)	22.6 (r.)	40.9 (r.)
Bicondylar lenght	-	-	-	-
Anterior-posterior diameter of the midshaft	-	3.25 (l.)	-	2.5 (l.,r.)
Mediolateral diameter of the midshaft	-	3.25 (l.)	-	2.2 (l.); (r.)
Maximum diameter of the head	4.05 (l.); 4.26 (r.)	4.67 (l.)	-	4.0 (r.)
Subtrochanteric anterior - posterior diameter	2.32 (l.)	2.45 (l.)	-	2.3 (l.); 2.5 (r.)
Subtrochanteric mediolateral diameter	3.20 (l.)	3.5 (l.)	-	2.8 (l.); 2.7 (r.)
Circumference of the midshaft	-	9.8	5.4	7.3 (l.); 7.2 (r.)
Bicondylar width	-	7.9	-	-
Platymeric index	72.5 (platimeric)	70.0 (platimeric)	-	-
Tibia Maximum length	32.8 (l.)	-	-	29.4 (l)
Anterior–posterior diameter at the nutrient foramen	3.01 (l.); 2.87 (r.)		-	3.2 (l.)
Medio-lateral diameter at the nutrient foramen	2.31 (l.); 2.9 (r.)	-	-	2.2 (l.)
Circumference at the nutrient foramen	8.7 (l.); 9.0 (r.)	-	-	8.5 (l.)
Proximal width	12.1		-	-
Distal width	-	-	-	-
Platycnemic index	77.7 (l.); 101.04 (l) (euricnemic)	-	-	-
Fibula Maximum length	-	-	-	29.5 (l.)
Clavicle Maximum length	13.4 (r.)	15.0 (r.)	-	11.5 (r.)
Circumference at middle of bone	3.8	3.9 (r.)	-	3.0
Robustness Index	28.35	26.0	-	-
Humerus Maximum length	27.3 (r.)	32 (l.)	-	28.7(l.,r.)
Maximum diameter midshaft	1.78 (r.)	2.13 (l.)	-	1.7 (l.,r.)
Minimum diameter midshaft	1.72 (r.)	1.96 (l.)	-	1.4 (l.); 1.5 (r.)
Maximum diameter of the head	3.9 (r.)	-	-	4.2 (l.,r.)
Least circumference of the shaft	5.8 (r.)	6.5 (l.)	-	5.2 (l.,r.)
Articular width	4.0 (r.)	4.20 (l.)	-	5.0 (l.,r.)
Biepicondylar width	5.6 (l.)	5.93(r.)	-	4.0 (l.,r.)
Robustness Index	21.24 (r.)	20.31 (l.)	-	-
Claviculohumeral Index	49.08 (r.)	-	-	-
Radius Maximum length	20.7 (l.)	24.5 (l.); 24.4 (r.)	-	22.0 (l.)
Humeroradial Index	-	76.56	-	-
Ulna Maximum length	23.1 (r.)	26.1 (l.); 26.3 (r.)	-	23.7 (l.,r.)
Physiological length	20.7 (r.)	23.4 (l.); 23.6 (r.)		-
Least circumference of the shaft	3.5 (r.)	3.9 (l.,r.)	-	2.9 (l.,r.)
Caliber Index	16.9 (r.)	16.95	-	-
Sacrum Maximum anterior height	12.0	-	-	-
Maximum anterior breadth	11.2	-	-	9.3
Sacral Index	93.33	-	-	-

Table 2a. Klisa - Measurements of cranial bones and calculated indices

BURIAL NUMBER	8	10a	BURIAL NUMBER	8	10a
Skull **Maximum length**	17.0	18.2	**Nasal** **Index**	-	-
Maximum breadth	13.0	14.5	**Mandible: bicondylar breadth**	11.6	-
Maximum height	-	-	**Bigonial breadth**	9.7	-
Minimum frontal breadth	9.8	10.5	**Height of ascending ramus**	5.3	-
Index **Cranial index**	76.47 (mesocrany)	79.67	**Thickness of mandible body**	1.3	1.7
Length - Height Index	-	-	**Height of mandible body**	-	-
Breadth – Height Index	-	-	**Height of mandibular symphysis**	3.35	-
Frontoparietal Index	75.38 (eurymetopic)	72.41	**Minimum breadth of ascending ramus**	3.3	3.8
Facial Skeleton **Total facial height**	-	-	**Index** **Ascending ramus**	62.26	-
Upper facial height	-	-	**Frontomandibular**	101.03 (mesomandibular)	-
Facial width	-	-	**Maxillae** **Maxilloalveolar length**	-	-
Facial index	-	-	**The Palate** **Palatal length**	-	-
Nose **Nasal height**	-	-	**Palatal breadth**	-	-
Nasal width	-	-			
The Orbits **Orbital height**	-	3.0			
Orbital breadth	-	3.9			
Orbital Index	-	76.92			

Table 2b. Klisa - Measurements of postcranial bones and calculated indices

BURIAL NUMBER	8	10a
Femur Maximum length	42 (l.)	-
Bicondylar lenght	-	-
Anterior-posterior diameter of the midshaft	2.2 (l.)	-
Mediolateral diameter of the midshaft	2.3 (l.)	-
Maximum diameter of the head	4.4 (l.)	-
Subtrochanteric anterior - posterior diameter	2.5 (l.)	2.9 (r.)
Subtrochanteric mediolateral diameter	3.1 (l.)	3.8 (r.)
Circumference of the midshaft	7.5 (l.)	-
Bicondylar width	-	-
Platymeric index	80.64 (platymeric)	76.31 (platymeric)
Tibia Maximum length	33.7 (l.)	-
Anterior–posterior diameter at the nutrient foramen	3.1 (l.)	-
Medio-lateral diameter at the nutrient foramen	2.2 (l.)	-
Circumference at the nutrient foramen	8.1 (l.)	-
Proximal width	-	-
Distal width	-	-
Platycnemic index	70.96 (eurycnemic)	-
Fibula Maximum length	-	-
Clavicle Maximum length	-	15.0 (r.)
Circumference at middle of bone	-	4.8 (r.)
Robustness Index	-	32
Humerus Maximum length	27.2 (l.)	32.0 (r.)
Maximum diameter midshaft	1.7 (l.)	2.1 (r.)
Minimum diameter midshaft	1.6 (l.)	2.6 (r.)
Maximum diameter of the head	-	4.1 (r.)
Least circumference of the shaft	5.3 (l.)	7.5 (r.)
Articular width	4.1 (l.)	-
Biepicondylar width	5.5 (l.)	-
Robustness Index	19.48	23.3
Claviculohumeral Index	-	-
Radius Maximum length	19.1 (l.)	22.0 (r.)
Humeroradial Index	-	-
Ulna Maximum length	19.9 (l.)	23.0 (r.)
Physiological length	-	-
Least circumference of the shaft	-	4.7
Caliber Index	-	-
Sacrum Maximum anterior height	-	-
Maximum anterior breadth	-	-
Sacral Index	-	-

Table 3a. Sremski Karlovci - Measurements of cranial bones and calculated indices

BURIAL NUMBER	1	BURIAL NUMBER	1
Skull Maximum length	17.6	**Nasal Index**	56.66 (platyrrhiny)
Maximum breadth	13.8	**Mandible: bicondylar breadth**	10.8
Maximum height	12.6	**Bigonial breadth**	9.7
Minimum frontal breadth	9.3	**Height of ascending ramus**	5.4
Index **Cranial index**	70.40 (brachycrany)	**Thickness of mandible body**	1.8
Length - Height Index	71.59 (hypsicrany)	**Height of mandible body**	-
Breadth – Height Index	91.30 (tapeinocrany)	**Height of mandibular symphysis**	2.85
Frontoparietal Index	67.39 (metriometopic)	**Minimum breadth of ascending ramus**	3.8
Facial Skeleton **Total facial height**	10.0	**Index** **Ascending ramus**	70.37
Upper facial height	-	**Frontomandibular**	95.87 (mesomandibular)
Facial width	11.0	**Maxillae** **Maxilloalveolar length**	-
Facial index	90.90 (leptoprosopy)	**The Palate** **Palatal length**	-
Nose **Nasal height**	3.0	**Palatal breadth**	-
Nasal width	1.7		
The Orbits **Orbital height**	3.5		
Orbital breadth	3.5		
Orbital Index	100 (hypsiconchy)		

Table 3b. Sremski Karlovci - Measurements of postcranial bones and calculated indices

BURIAL NUMBER	1
Femur Maximum length	-
Bicondylar lenght	-
Anterior-posterior diameter of the midshaft	-
Mediolateral diameter of the midshaft	-
Maximum diameter of the head	-
Subtrochanteric anterior - posterior diameter	-
Subtrochanteric mediolateral diameter	-
Circumference of the midshaft	-
Bicondylar width	6.6 (r.)
Platymeric index	-
Tibia Maximum length	-
Anterior–posterior diameter at the nutrient foramen	-
Medio-lateral diameter at the nutrient foramen	-
Circumference at the nutrient foramen	-
Proximal width	-
Distal width	-
Platycnemic index	-
Fibula Maximum length	-
Circumference	-
Clavicle Maximum length	14.0 (l.); 14.2 (r.)
Circumference at middle of bone	3.7 (l.); 3.9 (r.)
Robustness Index	26.42 (l.); 27.46 (r.)
Humerus Maximum length	27.5 (r.)
Maximum diameter midshaft	2.1 (r.)
Minimum diameter midshaft	1.8 (r.)
Maximum diameter of the head	4.1 (r.)
Least circumference of the shaft	5.8 (r.)
Articular width	-
Biepicondylar width	-
Robustness Index	21.09
Claviculohumeral Index	-
Radius Maximum length	-
Humeroradial Index	-
Ulna Maximum length	-
Physiological length	-
Least circumference of the shaft	-
Caliber Index	-
Sacrum Maximum anterior height	-
Maximum anterior breadth	-
Sacral Index	-

Table 4a. Perlez-Batka - Measurements of cranial bones and calculated indices

BURIAL NUMBER	C“,1	B“, ?	BURIAL NUMBER	C“,1	B“,?
Skull Maximum length	16.5	-	**Nasal Index**	-	-
Maximum breadth	13.1	-	**Mandible: bicondylar breadth**	-	-
Maximum height	-	-	**Bigonial breadth**	-	-
Minimum frontal breadth	-	-	**Height of ascending ramus**	-	-
Index **Cranial index**	79.39 (brachycrany)	-	**Thickness of mandible body**	-	-
Length - Height Index	-	-	**Height of mandible body**	-	-
Breadth – Height Index	-	-	**Height of mandibular symphysis**	3.35	-
Frontoparietal Index	-	-	**Minimum breadth of ascending ramus**	3.1	-
Facial Skeleton **Total facial height**	-	-	**Index** **Ascending ramus**	-	-
Upper facial height	-	-	**Frontomandibular**	-	-
Facial width	-	-	**Maxillae** **Maxilloalveolar length**	-	-
Facial index	-	-	**The Palate** **Palatal length**	-	-
Nose **Nasal height**	-	-	**Palatal breadth**	-	-
Nasal width	-	-			
The Orbits **Orbital height**	-	-			
Orbital breadth	-	-			
Orbital Index	-	-			

Table 4b. Perlez-Batka - Measurements of postcranial bones and calculated indices

BURIAL NUMBER	C“,1	B“, ?[1]
Femur Maximum length	35.0 (r.)	34.3 (r.)
Bicondylar lenght	-	-
Anterior-posterior diameter of the midshaft	2.0 (r.)	2.4 (r.)
Mediolateral diameter of the midshaft	2.3 (r.)	2.0 (r.)
Maximum diameter of the head	-	-
Subtrochanteric anterior - posterior diameter	2.3 (r.)	2.6 (r.)
Subtrochanteric mediolateral diameter	2.7 (r.)	3.0 (r.)
Circumference of the midshaft	6.9 (r.)	7.0 (r.)
Bicondylar width	-	-
Platymeric index	85.18 (eurymeric)	86.66 (eurymeric)
Tibia Maximum length	30.5 (l.); 30.5 (r.)	28.0 (l.); 27.5 (r.)
Anterior–posterior diameter at the nutrient foramen	2.5 (l.); 2.5 (r.)	2.8 (l.); 2.8 (r.)
Medio-lateral diameter at the nutrient foramen	1.8 (l.); 1.8 (r.)	2.3 (l.); 2.3 (r.)
Circumference at the nutrient foramen	7.4 (l.); 7.1 (r.)	7.9 (l.); 7.9 (d.)
Proximal width	-	-
Distal width	-	-
Platycnemic index	72.0 (l.) (eurycnemic); 72.0 (r.) (eurycnemic);	82.14 (l.) (eurycnemic); 82.14 (r.) (eurycnemic)
Fibula Maximum length	27.0 (l.)	27.0 (r.)
Circumference	3.8 (l.)	3.9 (r.)
Clavicle Maximum length	-	-
Circumference at middle of bone	-	-
Robustness Index	-	-
Humerus Maximum length	25.0 (l.); 25.0 (r.)	24.0 (r.)
Maximum diameter midshaft	1.8 (l.); 1.8 (r.)	1.5 (r.)
Minimum diameter midshaft	1.5 (l.); 1.4 (r.)	1.9 (r.)
Maximum diameter of the head	-	-
Least circumference of the shaft	5.1 (l.); 5.1 (r.)	-
Articular width	-	-
Biepicondylar width	-	-
Robustness Index	20.4 (l.); 20.4 (l.)	-
Claviculohumeral Index	-	-
Radius Maximum length	19.5 (l)	18.8 (l.)
Humeroradial Index	78.0	-
Ulna Maximum length	21.6 (l.)	20.9 (l.); 20.9 (r.)
Physiological length	19.2 (l.)	-
Least circumference of the shaft	3.1 (l.)	3.0 (l.); 3.0 (r.)
Caliber Index	16.14	-
Sacrum Maximum anterior height	-	-
Maximum anterior breadth	-	-
Sacral Index	-	-

[1] Without epiphysis measurements

Table 5a. Starčevo - Measurements of cranial bones and calculated indices

BURIAL NUMBER	1	BURIAL NUMBER	1
Skull Maximum length	17.8	**Nasal Index**	-
Maximum breadth	14.8	**Mandible: bicondylar breadth**	-
Maximum height	-	**Bigonial breadth**	-
Minimum frontal breadth	10.0	**Height of ascending ramus**	-
Index **Cranial index**	83.14 (brachycrany)	**Thickness of mandible body**	-
Length - Height Index	-	**Height of mandible body**	-
Breadth – Height Index	-	**Height of mandibular symphysis**	-
Frontoparietal Index	90.90 (eurymetopic)	**Minimum breadth of ascending ramus**	-
Facial Skeleton **Total facial height**	-	**Index** **Ascending ramus**	-
Upper facial height	-	**Frontomandibular**	-
Facial width	-	**Maxillae** **Maxilloalveolar length**	-
Facial index	-	**The Palate** **Palatal length**	-
Nose **Nasal height**	-	**Palatal breadth**	-
Nasal width	-		
The Orbits **Orbital height**	-		
Orbital breadth	3.2		
Orbital Index	-		

Table 5b. Starčevo - Measurements of postcranial bones and calculated indices

BURIAL NUMBER	1
Femur Maximum length	41.5 (l.)
Bicondylar lenght	-
Anterior-posterior diameter of the midshaft	2.3 (l.)
Mediolateral diameter of the midshaft	2.2 (l.)
Maximum diameter of the head	3.9 (l.)
Subtrochanteric anterior - posterior diameter	3.2 (l.)
Subtrochanteric mediolateral diameter	2.0 (l.)
Circumference of the midshaft	8 (l.)
Bicondylar width	-
Platymeric index	157.033
Tibia Maximum length	-
Anterior–posterior diameter at the nutrient foramen	2.1
Medio-lateral diameter at the nutrient foramen	1.7
Circumference at the nutrient foramen	8.5 (l.);8.5 (r.)
Proximal width	-
Distal width	-
Platycnemic index	-
Fibula Maximum length	-
Circumference	-
Clavicle Maximum length	-
Circumference at middle of bone	-
Robustness Index	-
Humerus Maximum length	-
Maximum diameter midshaft	1.6 (l.)
Minimum diameter midshaft	1.6 (l.)
Maximum diameter of the head	-
Least circumference of the shaft	0.9 (l.)
Articular width	-
Biepicondylar width	-
Robustness Index	-
Claviculohumeral Index	-
Radius Maximum length	-
Humeroradial Index	-
Ulna Maximum length	-
Physiological length	-
Least circumference of the shaft	-
Caliber Index	-
Sacrum Maximum anterior height	-
Maximum anterior breadth	-
Sacral Index	-

Table 6. Vinča - Measurements of cranial bones and calculated indices

BURIAL NUMBER	II	III	IV	V	VI?	BURIAL NUMBER	II	III	IV	V	VI?
Skull Maximum length	-	-	-	-	-	**Nasal Index**	-	-	-	-	-
Maximum breadth	-	-	-	-	-	**Mandible: bicondylar breadth**	-	-	10	8.5	-
Maximum height	-	-	-	-	-	**Bigonial breadth**	11.1	9.5	8.2	-	-
Minimum frontal breadth	-	-	-	-	-	**Height of ascending ramus**	5.5	6.4	4.6	5.7	-
Index **Cranial index**	-	-	-	-	-	**Thickness of mandible body**	0.8	-	-	0.7	0.7
Length - Height Index	-	-	-	-	-	**Height of mandible body**	-	-	2.1	-	-
Breadth – Height Index	-	-	-	-	-	**Height of mandibular symphysis**	2.4	-	-	2.3	-
Frontoparietal Index	-	-	-	-	-	**Minimum breadth of ascending ramus**	2.8	2.4	2.5	2.6	2.9
Facial Skeleton **Total facial height**	-	-	-	-	-	**Index** **Ascending ramus**	-	-	-	-	-
Upper facial height	-	-	-	-	-	**Frontomandibular**	-	-	-	-	-
Facial width	-	-	-	-	-	**Maxillae** **Maxilloalveolar length**	-	-	-	-	-
Facial index	-	-	-	-	-	**The Palate** **Palatal length**	-	-	-	-	-
Nose **Nasal height**	-	-	-	-	-	**Palatal breadth**	-	-	-	-	-
Nasal height	-	-	-	-	-						
The Orbits **Orbital height**	-	-	-	-	-						
Orbital breadth	-	-	-	-	-						
Orbital Index	-	-	-	-	-						

Table 6. Vinča - Measurements of cranial bones and calculated indices

BURIAL NUMBER	VII	VIII	IX	X	BURIAL NUMBER	VII	VIII	IX	X
Skull Maximum length	16.0	-	-	-	**Nasal Index**	-	-	-	-
Maximum breadth	13	-	13	-	**Mandible: bicondylar breadth**	-	-	-	-
Maximum height	-	-	-	-	**Bigonial breadth**	7.5	-	9.7	-
Minimum frontal breadth	9.3	9.1	9.7	9.5	**Height of ascending ramus**	5.0	5.0	-	-
Index Cranial index	81.25 (brachycrany)	-	-	-	**Thickness of mandible body**	0.7	0.5	0.6	-
Length - Height Index	-	-	-	-	**Height of mandible body**	-	-	-	-
Breadth – Height Index	-	-	-	-	**Height of mandibular symphysis**	2.1	2.0	2.4	-
Frontoparietal Index	71.53 (eurymetopic)	-	74.61 (eurymetopic)	-	**Minimum breadth of ascending ramus**	2.9	2.8	2.7	-
Facial Skeleton Total facial height	-	-	-	-	**Index Ascending ramus**	58	56	-	-
Upper facial height	-	-	-	-	**Frontomandibular**	124 (eurymandibular)	-	100 (mesomandibular)	-
Facial width	-	-	-	-	**Maxillae Maxilloalveolar length**	-	-	-	-
Facial index	-	-	-	-	**The Palate Palatal length**	-	-	-	-
Nose Nasal height	-	-	-	-	**Palatal breadth**	-	-	-	-
Nasal width	-	-	-	-					
The Orbits Orbital height	-	2.4	-	-					
Orbital breadth	-	-	-	-					
Orbital Index	-	-	-	-					

Table 7. Rudnik Kosovski - Measurements of cranial bones and calculated indices

BURIAL NUMBER	**1**	**BURIAL NUMBER**	**1**
Skull Maximum length	17.8	**Nasal** **Index**	-
Maximum breadth	13.0	**Mandible: bicondylar breadth**	-
Maximum height	-	**Bigonial breadth**	9.2
Minimum frontal breadth	10.3	**Height of ascending ramus**	-
Index **Cranial index**	73.03 (mesocrany)	**Thickness of mandible body**	1.1
Length - Height Index	-	**Height of mandible body**	-
Breadth – Height Index	-	**Height of mandibular symphysis**	2.9
Frontoparietal Index	79.23 (eurymetopic)	**Minimum breadth of ascending ramus**	3.6
Facial Skeleton **Total facial height**	-	**Index** **Ascending ramus**	-
Upper facial height	-	**Frontomandibular**	111.95 (euromandibular)
Facial width	-	**Maxillae** **Maxilloalveolar length**	-
Facial index	-	**The Palate** **Palatal length**	-
Nose **Nasal height**	-	**Palatal breadth**	-
Nasal height	-		
The Orbits **Orbital height**	3.2 (r.)		
Orbital breadth	3.7 (r.)		
Orbital Index	86.48 (mesochonchy)		

APPENDIX II

Table 1.Basic chronological and demographic data on all analyzed individuals in this study

SITE	BURIAL	PERIOD	SEX	AGE	AGE CATEGORY	ABSOLUTE DATING (CAL BC)	REFERENCE FOR C14 DATE
AJMANA	1/81	N	ND	3-6	1-4		
AJMANA	2	N	ND	14	10-14		
AJMANA	3	N	ND	9.5-14.5	10-14		
AJMANA	4	N	ND	14-15	10-14		
AJMANA	6	N	M?	20-39	Young adult	6030–5842	Borić 2011
AJMANA	7	N	ND	30-49	Middle aged adult	6214–6008	Borić 2011
AJMANA	8	N	ND	3-5	1-4		
AJMANA	8a	N	F	>50	Old adult		
AJMANA	9	N	F	>50	Old adult		
AJMANA	11	N	F	>30	Middle aged adult		
AJMANA	12	N	ND	3-6	1-4		
AJMANA	13	N	ND	11-14	10-14		
AJMANA	14	N	ND	4.5-7	5-9		
AJMANA	15	N	ND	4.5-7	5-9		
AJMANA	16	N	ND	1.5-4	1-4		
GOLOKUT-VIZIĆ	grave 1/2003	N	ND	7-9	5-9		
GOLOKUT-VIZIĆ	grave 2/2003	N	ND	16-17	15-19		
GOLOKUT-VIZIĆ	grave 3/2003	N	ND	15-18	15-19		
GOLOKUT-VIZIĆ	grave 4/2003	N	ND	12-15	10-14		
GOLOKUT-VIZIĆ	grave ?/2003	N	ND	1-3	1-4		
GOLOKUT-VIZIĆ	3/1984	N	F	30-39	Middle aged adult	5620-5460	Whittle et al. 2002
GOLOKUT-VIZIĆ	2/1984	N	F	40-50	Middle aged adult	5560-5360	Whittle et al. 2002
GRIVAC	1	N	ND	30-35	Middle aged adult		
GRIVAC	1	N	ND	5-10	5-9		
HAJDUČKA	8	M	M	>30	Middle aged	7076–6699	Borić 2011

VODENICA					adult		
HAJDUČKA VODENICA	11	M?	M	>30	Middle aged adult		
HAJDUČKA VODENICA	13	N	M	>50	Old adult	6016–5726	Borić 2011
HAJDUČKA VODENICA	14	M?	ND	4.5-7	5-9		
HAJDUČKA VODENICA	15(1)S.G.	M	ND	>15	Adult Size	6361 – 6050	Borić 2011
HAJDUČKA VODENICA	16	N	ND	14-18	15-19		
HAJDUČKA VODENICA	17	M	F?	>30	Middle aged adult		
HAJDUČKA VODENICA	17(2)	M	ND	20-49	Middle aged adult		
HAJDUČKA VODENICA	18	M?	ND	10.5-12.5	10-14		
HAJDUČKA VODENICA	18(3)	M	ND	>15	Adult Size		
HAJDUČKA VODENICA	19	N	M	>50	Old adult		
HAJDUČKA VODENICA	20	N	M	>50	Old adult	6368–6068	Borić 2011
HAJDUČKA VODENICA	20(1)	N	ND	>15	Adult size		
HAJDUČKA VODENICA	21	M	ND	3-6	1-4		
HAJDUČKA VODENICA	22	M	M?	>50	Old adult		
HAJDUČKA VODENICA	23	M	M?	>50	Old adult		
HAJDUČKA VODENICA	23-25	N	ND	>15	Adult size		
HAJDUČKA VODENICA	24	N	?*	?*			
HAJDUČKA	26_28	N	ND	>30	Middle aged		

VODENICA					adult		
HAJDUČKA VODENICA	26-28 (3)	N	ND	7.5-11	5-9		
HAJDUČKA VODENICA	29	M	M	>50	Old adult	6680–6434	Borić 2011
HAJDUČKA VODENICA	29(1)	M	ND	?*			
HAJDUČKA VODENICA	30	M?	F	>15	Adult size		
HAJDUČKA VODENICA	31	M	ND	>30	Middle aged adult		
HAJDUČKA VODENICA	33 same as profil 11-20	M	F	>15	Adult size		
HAJDUČKA VODENICA	33(1) same as profil 11-20 (1)	M	ND	>15	Adult size		
KLISA	6	N	ND	4-5	4-9		
KLISA	10A	N	M	40	Middle aged adult		
KLISA	8	N	F	15-18	15-19		
LEPENSKI VIR	6	N	F?	15-18	15-19		
LEPENSKI VIR	7/I	N	M	>50	Old adult	6230-5985	Bonsall et al. 2015
LEPENSKI VIR	7/II	N	ND	>50	Old adult	6080–5746	
LEPENSKI VIR	8	N	F	30-49	Middle aged adult	5990-5790	Bonsall et al. 2015
LEPENSKI VIR	9	N	ND	>15	Adult size	5980-5740	Bonsall et al. 2015
LEPENSKI VIR	11	N	ND	10.5-17	10-14		
LEPENSKI VIR	13	N	M?	>15	Adult size		
LEPENSKI VIR	14	N	F	>15	Adult size	6235-5990	Bonsall et al. 2015
LEPENSKI VIR	16	N	F?	>15	Adult size		
LEPENSKI VIR	17	N	ND	15-30	Young adult	5776–5575	Borić 2011
LEPENSKI VIR	19	N	F	25-39	Middle aged adult	5984–5752	Borić 2011
LEPENSKI VIR	20	N	F	>15	Adult size		
LEPENSKI VIR	21	M	ND	>15	Adult size		
LEPENSKI VIR	22	M	M?	>15	Adult size	7580–7190	Borić 2011
LEPENSKI VIR	24	N	?*	?*			

LEPENSKI VIR	25	N	ND	>15	Adult size		
LEPENSKI VIR	26	N	M	20-25	Young adult	6025-5890	Bonsall et al. 2015
LEPENSKI VIR	27a	N	F?	>40	Middle aged adult		
LEPENSKI VIR	27b	N	ND	>15	Adult size		
LEPENSKI VIR	27d	N	M?	>50	Old adult		
LEPENSKI VIR	28	N	M	>15	Adult size		
LEPENSKI VIR	31a	N	ND	>15	Adult size	6361–5902	Borić 2011
LEPENSKI VIR	32a	N	F	>50	Old adult	6076–5731	Borić 2011
LEPENSKI VIR	32b	N	F?	>30	Middle aged adult	6080-5720	Borić 2011
LEPENSKI VIR	34a	N	F?	>15	Adult size		
LEPENSKI VIR	34b	N	ND	>15	Adult size		
LEPENSKI VIR	34c	N	ND	>15	Adult size		
LEPENSKI VIR	35	N	ND	8-13	10-14	5748–5475	Borić 2011
LEPENSKI VIR	37	N	ND	17-20	15-19		
LEPENSKI VIR	39	N	F?	>15	Adult size		
LEPENSKI VIR	43	N	ND	9-18	10-14		
LEPENSKI VIR	45a	N	ND	15-30	Young adult		
LEPENSKI VIR	45b	N	M	>40	Middle aged adult	6355-6015	Bonsall et al. 2015
LEPENSKI VIR	47	N	F	>15	Adult size		
LEPENSKI VIR	48	N	ND	15-30	Young adult		
LEPENSKI VIR	50	M	M	>30	Middle aged adult	8310–7970	Borić and Price 2013
LEPENSKI VIR	52a	N	ND	>15	Adult size		
LEPENSKI VIR	54e	N	F	20-25	Young adult	6210-5930	Bonsall et al. 2015
LEPENSKI VIR	56	N	ND	6-9.5	5-9		
LEPENSKI VIR	57	N	ND	>12	15-19		
LEPENSKI VIR	57(1)	N	ND	>15	Adult size		
LEPENSKI VIR	60	M	M	30-39	Middle aged adult	9175-8635	Bonsall et al. 2015
LEPENSKI VIR	61	N	ND	4-7	5-9	6225-5915	Bonsall et al. 2015
LEPENSKI VIR	64	M	M	30-49	Middle aged adult		
LEPENSKI VIR	64(1)	M	ND	>15	Adult size		

LEPENSKI VIR	66	N	ND	25-30	Young adult		
LEPENSKI VIR	67	M	ND	14-18	15-19		
LEPENSKI VIR	68	M	F	>40	Middle aged adult		
LEPENSKI VIR	69	M	M	30-49	Middle aged adult	7940-7590	Bonsall et al. 2015
LEPENSKI VIR	71	N	ND	4-6	5-9		
LEPENSKI VIR	72	N	ND	1.5-3	1-4		
LEPENSKI VIR	73	N	M	40-49	Middle aged adult	6005–5845	Borić 2011
LEPENSKI VIR	74	N	M?	>15	Adult size		
LEPENSKI VIR	75	N	F?	>50	Old adult		
LEPENSKI VIR	76	N	ND	>15	Adult size		
LEPENSKI VIR	78	N	ND	>15	Adult size		
LEPENSKI VIR	79a	N	M?	>50	Old adult	6020-5890	Bonsall et al. 2015
LEPENSKI VIR	79b	N	ND	15-30	Young adult		
LEPENSKI VIR	82	N	ND	>15	Adult size		
LEPENSKI VIR	83a	N	ND	>15	Adult size		
LEPENSKI VIR	84	N	ND	4-6	1-9		
LEPENSKI VIR	86	N	ND	>15	Adult size		
LEPENSKI VIR	87	N	ND	4.5-7.5	5-9		
LEPENSKI VIR	87(1)	N	ND	>15	Adult size		
LEPENSKI VIR	87(2)	N	ND	3-5	1-4		
LEPENSKI VIR	88	N	F	30-49	Middle aged adult	5984–5644	Borić 2011
LEPENSKI VIR	89a	N	ND	>15	Adult size	6060-5780	Bonsall et al. 2015
LEPENSKI VIR	89b	N	ND	4-6	1-4		
LEPENSKI VIR	90	N	M	>15	Adult size		
LEPENSKI VIR	91	N	ND	>15	Adult size		
LEPENSKI VIR	92	N	ND	1-3.5	1-4		
LEPENSKI VIR	93	N	F	>30	Middle aged adult		
LEPENSKI VIR	105	M	ND	>15	Adult size		
LEPENSKI VIR	122	N	ND	15-18	15-19	6208–5987	Borić 2011
LEPENSKI VIR	126	N	F?	>15	Adult size		
OBREŽ-BAŠTINE	1	N	ND	4-6	5-9		

PADINA	1	M	ND	>15	Adult size		
PADINA	1A	M	F	>15	Adult size	6494 – 6239	Borić 2011
PADINA	2	M	M	>60	Old adult	6648 – 6470	Borić 2011
PADINA	4	N	M	>30	Middle aged adult	6061–5841	Borić 2011
PADINA	5	N	F	30-59	Middle aged adult	6224–5878	Borić 2011
PADINA	5A	N	ND	>15	Adult size		
PADINA	6	M	F	>15	Adult size		
PADINA	6A	M	F	>50	Old adult		
PADINA	7	M	F	>60	Old adult	8208 – 7613	Borić 2011
PADINA	9	M	ND	>15	Adult size	9221–8548	Borić 2011
PADINA	11	M	ND	4.5-7.5	5-9	8616–8296	Borić 2011
PADINA	12	M	M	20-29	Young adult	8753-8351	Borić 2011
PADINA	12(1)	M	?*	?*			
PADINA	13	M	F?	20-29	Young adult		
PADINA	14	M	F	>50	Old adult	8703 – 8246	Borić 2011
PADINA	14(1)	M	F?	>15	Adult size		
PADINA	15	M	F	>30	Middle aged adult	8237–7761	Borić 2011
PADINA	15-16	M	ND	30-59	Middle aged adult		
PADINA	16	M	F?	20-29	Young adult	8200-7800	Borić 2011
PADINA	16a	M	F	>50	Old adult		
PADINA	17	M	F?	>30	Middle aged adult		
PADINA	17(1)	M	ND	>15	Adult size		
PADINA	18	M	F?	>40	Middle aged adult		
PADINA	18B	M	F	>30	Middle aged adult		
PADINA	19a	M	F	>50	Old adult		
PADINA	20	M	F	>15	Adult size		
PADINA	21	M	F	>30	Middle aged adult	8810–8352	Borić 2011
PADINA	22	M	ND	>15	Adult size		

PADINA	22(1)	M	ND	>15	Adult size		
PADINA	23	M	ND	3-6	1-4		
PADINA	24	M	F	>30	Middle aged adult		
PADINA	25	M	F	>15	Adult size		
PADINA	25(1)	M	ND	>15	Adult size		
PADINA	26	M?	F	>50	Old adult		
PADINA	26a	M	ND	1.5	1-4		
PADINA	27	M	ND	9.5-14.5	10-14	7306–6590	Borić 2011
PADINA	30	M	F	>30	Middle aged adult		
PERLEZ BATKA B	"?"	N	ND	14	10-14		
PERLEZ BATKA C	1	N	F	>30	Middle aged adult	6090-5880	Whittle et al. 2002
RUDNIK KOSOVSKI	1	N	F	>50	Old adult		
SREMSKI KARLOVCI	1	N	F	35-50	Middle aged adult		
STARČEVO	1	N	F	55-60	Old adult		
STARČEVO	1	N	ND	5-7	5-9		
VINČA	I?	N	ND	30	Young adult		
VINČA	II	N	ND	30-35	Middle aged adult	5515–5380	Tasić et al. 2015
VINČA	III	N	ND	30-40	Middle aged adult	5570–5475	Tasić et al. 2015
VINČA	IV	N	ND	20-30	Young adult	5620–5485	Tasić et al. 2015
VINČA	V	N	ND	20-30	Young adult	5565–5470	Tasić et al. 2015
VINČA	VI?	N	ND	20-30	Young adult		
VINČA	VIb?	N	ND	30-40	Middle aged adult		
VINČA	VII	N	F	15-18	15-19	5565–5470	Tasić et al. 2015
VINČA	IX	N	F	25-30	Young adult	5660–5555	Tasić et al. 2015
VINČA	VIII	N	M	30-40	Middle aged adult		
VINČA	X	N	ND	>30	Middle aged adult	5535–5385	Tasić et al. 2015

VINČA	M	N	ND	>30	Middle aged adult		
VLASAC	3	M	ND	>15	Adult size		
VLASAC	4A	M	M	15-18	15-19		
VLASAC	6	M	M	30-39	Middle aged adult	6600–6235	Borić 2011
VLASAC	8	M	ND	>15	Adult size		
VLASAC	9	M	F	>50	Old adult		
VLASAC	13	M	ND	>15	Adult size		
VLASAC	14	M	F	>60	Old adult		
VLASAC	15	M	F	>30	Middle aged adult		
VLASAC	16	M	M	>50	Old adult		
VLASAC	17	M	F	25-29	Young adult	8286–7749	Borić 2011
VLASAC	18a	M	M	>40	Middle aged adult		
VLASAC	18c	M	ND	5.5-8.5	5-9		
VLASAC	18c(2)	M	ND	7-9.5	5-9		
VLASAC	19A	M	ND	>15	Adult size		
VLASAC	20	M	?*	?*			
VLASAC	22	M	ND	>15	Adult size		
VLASAC	23	M	ND	>30	Middle aged adult		
VLASAC	24	M	F	25-29	Young adult	6640–6220	Borić 2011
VLASAC	25	M	ND	>40	Middle aged adult	7026–6481	Borić 2011
VLASAC	26	M	M	30-49	Middle aged adult		
VLASAC	27	M	F	30-49	Middle aged adult		
VLASAC	27(1)	M	?*	?*			
VLASAC	28	M	ND	30-59	Middle aged adult		
VLASAC	29	M	F	25-29	Young adult		
VLASAC	29a	M	ND	>15	Adult size		
VLASAC	30	M	ND	<50	Middle aged		

					adult		
VLASAC	31	M	M	18-20	Young adult	6823–6436	Borić 2011
VLASAC	32	M	F	30-39	Middle aged adult		
VLASAC	33	M	ND	>30	Middle aged adult		
VLASAC	34	M	ND	>15	Adult size		
VLASAC	35a(2)	M?	?*	?*			
VLASAC	37	M	ND	>30	Middle aged adult		
VLASAC	38	M	F	30-59	Middle aged adult		
VLASAC	39	M	?*	?*			
VLASAC	40	M	F	>30	Middle aged adult		
VLASAC	41	M	M	>50	Old adult		
VLASAC	43	M	M	>50	Old adult		
VLASAC	44	M	M	>50	Old adult		
VLASAC	45	M	F?	>30	Middle aged adult	6654–6411	Borić 2011
VLASAC	46	M	F	>40	Middle aged adult		
VLASAC	47	M	ND	>15	Adult size		
VLASAC	48	M	F	>50	Old adult	7024-6430	Borić 2011
VLASAC	49	M	F?	>25	Middle aged adult		
VLASAC	49(1)	M	ND	>30	Middle aged adult		
VLASAC	50	M	M?	>30	Middle aged adult		
VLASAC	51	M	ND	7.5-10.5	5-9		
VLASAC	51a	M	F	>30	Middle aged adult	7572–7082	Borić 2011
VLASAC	51b	M	ND	7.5-11.5	5-9		
VLASAC	52	M	F	>40	Middle aged adult		

VLASAC	53	M	ND	5-8	5-9		
VLASAC	53(1)	M	M?	15-30	Young adult		
VLASAC	54	M	M	>40	Middle aged adult	7024 – 6394	Borić 2011
VLASAC	54(1)	M	ND	>15	Adult size		
VLASAC	54(2)	M	?*	?*			
VLASAC	55	M	F	>40	Middle aged adult		
VLASAC	56	M	F	>15	Adult size		
VLASAC	60	M	M	>50	Old adult		
VLASAC	64a	M	ND	7-12	5-9		
VLASAC	64b	M	ND	7-12	5-9		
VLASAC	65	M	M?	>15	Adult size		
VLASAC	67	M	F	30-49	Middle aged adult		
VLASAC	69	M	ND	>30	Middle aged adult		
VLASAC	69a	M	M	>30	Middle aged adult		
VLASAC	69a(1)	M	?*	?*			
VLASAC	70	M	ND	>30	Middle aged adult		
VLASAC	71	M	F	25-29	Young adult		
VLASAC	73	M	ND	25-49	Middle aged adult		
VLASAC	74	M	ND	>50	Old adult		
VLASAC	75	M	ND	>15	Adult size		
VLASAC	76	M	ND	15-30	Young adult		
VLASAC	77	M	F	>15	Adult size		
VLASAC	77(1)	M	?*	?*			
VLASAC	78	M	M	>30	Middle aged adult		
VLASAC	78A	M	M	>30	Middle aged adult		
VLASAC	79	M	F	>60	Old adult		
VLASAC	80A	M	F	20-49	Middle aged		

					adult		
VLASAC	82	M	M	>40	Middle aged adult		
VLASAC	82A	M	ND	>30	Middle aged adult		
VLASAC	82B	M	F	>15	Adult size		
VLASAC	82C	M	ND	>15	Adult size		
VLASAC	83	M	F	>50	Old adult	7024–6430	Borić 2011
VLASAC	83A	M	ND	>15	Adult size		
VLASAC	84	M	M?	>15	Adult size		

? -* Data on sex or age were not available for these individuals.

Table 2. Demographic, chronological and paleopathological data on cribra orbitalia for the skeletons analyzed in this study

SITE	BURIAL NUMBER/INDIVIDUAL	PERIOD	SEX	AGE CATEGORY	LOCATION	DEGREE	ACTIVITY
AJ	1/81	N	ND	1-4	L	4	1
AJ	2	N	ND	10-14	R	1	2
AJ	6	N	M?	Young adult	L/R	0	0
AJ	7	N	ND	Middle aged adult	L/R	0	0
AJ	8a	N	F	Old adult	L/R	0	0
AJ	11	N	F	Middle aged adult	L/R	0	0
AJ	15	N	ND	5-9	R	2	1
GRI	1	N	ND	Middle aged adult	L	1	2
GV	2/1984	N	F	Middle aged adult	R	3	3
GV	3/1984	N	F	Middle aged adult	R	1	2
GV	3/ 1984	N	F	Middle aged adult	L	2	3
GV	2/2003	N	ND	15-19	R	3	3
GV	3/2003	N	ND	15-19	L	4	1
GV	4/2003	N	ND	10-14	L	1	2
HV	8	M	M	Middle aged adult	L	0	0
HV	11	M	M	Middle aged adult	L	1	2
HV	11	M	M	Middle aged adult	R	1	2
HV	14	M	ND	5-9	R	1	2
HV	18	M	ND	10-14	L	2	2
HV	18	M	ND	10-14	R	1	2
HV	20	N	M	Old adult	L/R	0	0
HV	29	M	M	Old adult	R	1	2
HV	31	M	ND	Middle aged adult	L/R	2	2
KL	8	N	F	Young adult		0	0
LVIR	7/II	N	ND	Old adult	L	2	2
LVIR	7/II	N	ND	Old adult	R	1	2
LVIR	8	N	F	Middle aged adult	R	0	0
LVIR	14	N	F	Adult size	L	0	0
LVIR	14	N	F	Adult size	R	0	0
LVIR	20	N	F	Adult size	L	0	0
LVIR	20	N	F	Adult size	R	0	0
LVIR	27a	N	F?	Middle aged adult	R	0	0
LVIR	27d	N	M?	Old adult	L	0	0
LVIR	35	N	?	10-14	L	1	2
LVIR	35	N	?	10-14	R	1	2
LVIR	32a	N	F	Old adult	R	0	0

LVIR	39	N	F?	Adult size	L	0	0
LVIR	43	N	ND	10-14	L	1	2
LVIR	45b	N	M	Middle aged adult	L	0	0
LVIR	45b	N	M	Middle aged adult	R	0	0
LVIR	47	N	F	Adult size	L	0	0
LVIR	47	N	F	Adult size	R	0	0
LVIR	54e	N	F	Young adult	L	0	0
LVIR	60	M	M	Middle aged adult	L	0	0
LVIR	64	M	M	Middle aged adult	L	0	0
LVIR	64	M	M	Middle aged adult	R	0	0
LVIR	66	N	ND	Young adult	L	0	0
LVIR	66	N	ND	Young adult	R	0	0
LVIR	69	N	M	Middle aged adult	L	1	2
LVIR	69	N	M	Middle aged adult	R	1	2
LVIR	71	N	ND	5-9	L	1	1
LVIR	71	N	ND	5-9	R	1	1
LVIR	73	N	M	Middle aged adult	L	0	0
LVIR	73	N	M	Middle aged adult	R	0	0
LVIR	79b	N	ND	Young adult	L	3	1
LVIR	79b	N	ND	Young adult	R	0	0
LVIR	82	N	ND	Adult size	L	1	2
LVIR	82	N	ND	Adult size	R	0	0
LVIR	86	N	ND	Adult size	R	2	3
LVIR	87(2)	N	ND	1-4	R	1	1
LVIR	88	N	F	Middle aged adult	L	0	0
LVIR	88	N	F	Middle aged adult	R	0	0
LVIR	91	N	ND	Adult size	R	1	2
LVIR	93	N	F	Middle aged adult	L	3	2
LVIR	122	N	ND	15-19	R	3	1
LVIR	122	N	ND	15-19	L	3	1
OB	1	N	ND	5-9	R	1	2
PA	5	N	F	Middle aged adult	R	3	3
PA	6	M	F	Adult size	L/R	2	2
PA	11	M	ND	5-9	L/R	0	0
PA	12	M	M	Young adult	L/R	0	0
PA	14	M	F	Old adult	R	0	0
PA	15-16	M	ND	Middle aged adult	L	0	0
PA	15-16	M	ND	Middle aged adult	R	0	0
PA	16a	M	F	Old adult	L/R	0	0
PA	17	M	F?	Middle aged adult	L/R	0	0
PA	17(1)	M	ND	Adult size	L	3	2

PA	18b	M	F	Middle aged adult	L/R	0	0
PA	20	M	F	Adult size	L/R	0	0
PA	22	M	ND	Adult size	R	0	0
PA	24	M	F	Middle aged adult	R	0	0
PA	26a	M	ND	1-4	R	0	0
PA	30	M	F	Middle aged adult	L/R	1	2
PBC	1	N	F	Middle aged adult		0	0
RK	1	N	F	Old adult	L/R	0	0
SM KAR	1	N	F	Middle aged adult		0	0
STA	1	N	F	Old adult	L/R	0	0
VIN	VIb?	N	ND	Young	L	1	2
VIN	VIII	N	M	Middle aged adult	L/R	1	3
VIN	VII	N	F	Young adult	R	1	3
VIN	IX	N	F	Young adult	L/R	0	0
VIN	X	N	ND	MIddle	L/R	1	2
VL	4a	M	M	15-19	R	1	2
VL	8	M	ND	Adult size	L/R	0	0
VL	14	M	F	Old adult	L/R	0	0
VL	17	M	F	Young adult	L/R	1	2
VL	25	M	ND	Middle aged adult	L/R	0	0
VL	29	M	F	Young adult	L	2	3
VL	29	M	F	Young adult	R	1	1
VL	30	M	ND	Middle aged adult	L/R	1	2
VL	31	M	M	15-19	L/R	3	1
VL	34	M	ND	Adult size	L/R	0	0
VL	38	M	F	Middle aged adult	L/R	0	0
VL	43	M	M	Old adult	L/R	0	0
VL	46	M	F	Middle aged adult	L/R	0	0
VL	48	M	F	Old adult	L/R	0	0
VL	53	M	ND	5-9	R	3	1
VL	54(1)	M	ND	Adult size	L	0	0
VL	55	M	F	Middle aged adult	L/R	0	0
VL	56	M	F	Adult size	L/R	0	0
VL	60	M	M	Old adult	L/R	2	2
VL	64a	M	ND	5-9	L	0	0
VL	65	M	M?	Adult size	L	0	0
VL	67	M	F	Middle aged adult	R	2	3
VL	69	M	ND	Middle aged adult	L/R	0	0
VL	69a	M	M	Middle aged adult	L/R	0	0
VL	70	M	ND	Middle aged adult	L	1	2
VL	70	M	ND	Middle aged adult	R	1	2

VL	74	M	ND	Old adult	L/R	1	2
VL	76	M	ND	Young adult	L/R	1	2
VL	78	M	M	Middle aged adult	R	0	0
VL	78a	M	M	Middle aged adult	L/R	0	0
VL	79	M	F	Old adult	L/R	2	2
VL	80a	M	F	Middle aged adult	L/R	0	0
VL	82	M	M	Middle aged adult	L/R	0	0
VL	82a	M	ND	Middle aged adult	L/R	0	0
VL	83	M	F	Old adult	L/R	0	0

Table 3. Demographic, chronological and paleopathological data on porotic hyperostosis for the skeletons analyzed in this study

LOCATION					**FRONTAL BONE**		**PARIETAL BONES**		**OCCIPITAL BONE**	
SITE	**BURIAL NUMBER**	**PERIOD**	**SEX**	**AGE CATEGORY**	**DEGREE**	**ACTIVITY**	**DEGREE**	**ACTIVITY**	**DEGREE**	**ACTIVITY**
AJ	1/81	N	ND	5-9	1	2	2	2	2	2
AJ	2	N	ND	10-14	1	2	2	3	2	3
AJ	3	N	ND	10-14	0	0	1	1	2	1
AJ	4	N	ND	10-14			0	0		
AJ	6	N	M?	Young adult	0	0	1	3	2	1
AJ	7	N	ND	Middle aged adult	2	1	2	1	2	1
AJ	8	N	ND	1-4	0	0	1	3	0	0
AJ	8a	N	F	Old adult	2	1	2	3	3	1
AJ	9	N	F	Old adult	0	0	1	2	1	1
AJ	11	N	F	Middle aged adult	1	2	1	3	2	1
AJ	12	N	ND	1-4	0	0	0	0	0	0
AJ	13	N	ND	10-14	0	0	1	1	1	1
AJ	14	N	ND	5-9	0	0	0	0	0	0
AJ	16	N	ND	1-4	0	0	0	0	1	1
GRI	1	N	ND	5-9	1	2				
GRI	1	N	ND	Middle aged adult			0	0		
GV	2/1984	N	F	Middle aged adult	2	1	2	2	1	2
GV	3/1984	N	F	Middle aged adult	1	2	2	2	2	3
GV	2/2003	N	ND	15-19	0	0	1	1	0	0
GV	3/2003	N	ND	15-19	0	0	3	1	0	0
GV	4/2003	N	ND	10-14	0	0	1	1	1	1
HV	8	M	M	Middle aged adult	1	2	0	0	3	1
HV	11	M	M	Middle aged adult	1	2	1	2		
HV	13	N	M	Old adult			3	3	4	3

HV	14	M	ND	5-9	1	2	1	2	1	3
HV	17	M	F?	Middle aged adult			3	2		
HV	17(2)	M	ND	Middle aged adult			2	2		
HV	18	M	ND	10-14	0	0	1	2	1	2
HV	19	N	M	Old adult	2	2	2	2	3	2
HV	19(1)-2	N	?*	?*					3	3
HV	20	N	M	Old adult	2	3	3	2	3	1
HV	20(1)	N	ND	Adult size			2	2		
HV	22	M	M?	Old adult	1	2	2	2	4	2
HV	23	M	M?	Old adult			1	2	1	2
HV	23-25	N	ND	Adult size			3	2	4	2
HV	24	N	ND	?*			2	2	3	2
HV	26-28	N	ND	Middle aged adult	1	2	2	2		
HV	29	M	M	Old adult	1	2	2	2	3	1
HV	30	M	F	Adult size	0	0	1	2	2	3
HV	31	M	ND	Middle aged or old adult	2	3	3	3	4	3
KL	6	N	ND	1-4	0	0	0	0	0	0
KL	10A	N	M	Middle aged adult	1	2	1	2	0	0
KL	8	N	F	15-19	0	0	0	0	0	0
LVIR	7/I	N	M	Old adult	1	2	2	3	2	2
LVIR	7/II	N	ND	Old adult			2	2	3	3
LVIR	8	N	F	Middle aged adult	1	1	2	2	2	2
LVIR	14	N	F	Adult size	1	2	1	3	3	3
LVIR	17	N	ND	Young adult	1	1	2	3	3	1
LVIR	19	N	F	Middle aged adult			2	2		
LVIR	20	N	F	Adult size	2	2	1	2	2	2
LVIR	24	N	?*	?*	0	0	0	0	2	1
LVIR	25	N	?*	Adult size	0	0	3	3	0	0
LVIR	26	N	M	Young adult	1	2	3	1	3	1
LVIR	27d	N	M?	Old adult	1	2	1	2	2	2

LVIR	32a	N	F	Old adult	0	0	1	2	2	2
LVIR	34a	N	F?	Adult size			1	3	2	1
LVIR	34b	N	ND	Adult size			2	1		
LVIR	35	N	?	10-14	0	0	2	3	2	2
LVIR	43	N	ND	10-14	0	0	2	2	2	2
LVIR	45a	N	ND	Young adult	1	2	1	2	2	2
LVIR	45b	N	M	Middle aged adult	4	3	4	3	4	2
LVIR	47	N	F	Adult size	0	0	3	3	2	2
LVIR	48	N	ND	Young adult	1	2	3	1	2	2
LVIR	50	M	M	Middle aged adult			1	2	2	2
LVIR	52a	N	ND	?*	0	0				
LVIR	54e	N	F	Young adult	1	2	2	3	2	3
LVIR	60	M	M	Middle aged adult	1	2	4	2	1	2
LVIR	61	N	ND	5-9	0	0	1	1	1	1
LVIR	64	M	M	Middle aged adult	4	3	4	3	2	2
LVIR	66	N	ND	Young adult	1	2	1	2		
LVIR	67	M	ND	15-19			0	0	1	1
LVIR	68	M	F	Middle aged	1	2	3	1	3	1
LVIR	69	M	M	Middle aged adult	2	2	2	2	3	3
LVIR	71	N	ND	5-9	0	0	0	0	0	0
LVIR	72	N	ND	1-4	0	0	0	0		
LVIR	73	N	M	Middle aged adult	0	0	1	2	0	0
LVIR	75	N	F?	Old adult			3	3	4	3
LVIR	76	N	?*	Adult size			2	3		
LVIR	79a	N	M?	Old adult			2	3	4	1
LVIR	79b	N	ND	Young adult	1	2	2	2	2	2
LVIR	79c	N	?*	?*			0	0		
LVIR	82	N	ND	Adult size	3	3	2	3	1	2
LVIR	83a	N	ND	Adult size	1	2	1	3	1	1
LVIR	86	N	ND	Adult size	0	0				

LVIR	87	N	ND	5-9	0	0	0	0	0	0
LVIR	87(1)	N	ND	Adult size	3	3	2	2		
LVIR	88	N	F	Middle aged adult	1	2	1	2	2	1
LVIR	89a	N	ND	Adult size	0	0	0	0	0	0
LVIR	90	N	M	Adult size	3	2	3	2	3	2
LVIR	91	N	ND	Adult size	1	2	0	0	2	3
LVIR	93	N	F	Middle aged adult	0	0	2	2	2	3
LVIR	122	N	ND	15-19	0	0	0	0	0	0
OB	1	N	ND	5-9	0	0	0	0	0	0
PA	1	M	ND	Adult size			0	0		
PA	4	N	M	Middle aged adult			3	3	0	0
PA	5	N	F	Middle aged adult	1	2	2	3	3	1
PA	6	M	F	Adult size	1	2	2	3	3	3
PA	6A	M	F	Old adult	1	2	0	0	2	1
PA	7	M	F	Old adult	2	2	1	2		
PA	9	M	ND	Adult size	2	1	1	1	2	1
PA	11	M	ND	5-9	0	0	0	0	0	0
PA	12	M	M	Young adult	2	1	2	1	4	1
PA	13	M	F?	Young adult			1	2	1	2
PA	14	M	F	Old adult	2	2	2	2	2	2
PA	15-16	M	ND	Middle aged adult	0	0	2	2	2	1
PA	16a	M	F	Old adult	1	2	2	3	3	1
PA	17	M	F?	Middle aged adult	0	0	2	3	3	1
PA	17(1)	M	ND	Adult size	1	2	2	2		
PA	18B	M	F	Middle aged adult	0	0	1	2	1	2
PA	19a	M	F	Old adult	0	0	2	2		
PA	20	M	F	Adult size	0	0	1	2	1	2
PA	21	M	F	Middle aged or old adult			3	3	3	3
PA	22	M	ND	Adult size	3	1	2	1	4	3
PA	24	M	F	Middle aged or old adult	0	0	1	2	2	2

PA	25	M	F	Adult size	0	0	0	0	1	2
PA	26	M	F	Old adult	1	3	2	3	2	2
PA	26a	M	ND	1-4	0	0	0	0		
PA	27	M	ND	10-14			2	1		
PA	30	M	F	Middle aged adult	1	2	2	3	2	2
PBC	1	N	F	Middle aged adult	0	0	1	1	1	1
RK	1	N	F	Middle aged adult	0	0	1	2	1	2
SM KAR	1	N	F	Middle aged adult	2	1	2	1	3	1
STA	1	N	F	Old adult	0	0	1	2	3	3
VIN	M	N	ND	Middle aged adult			0	0	0	0
VIN	II	N	ND	Middle aged adult			1	2		
VIN	III	N	ND	Middle aged adult			1	3		
VIN	IV	N	ND	Young adult	0	0	1	2		
VIN	V	N	ND	Middle aged adult			0	0		
VIN	VIb?	N	ND	Young adult	0	0	2	3		
VIN	VII	N	F	15-19	1	2	1	2	1	2
VIN	VIII	N	M	Middle aged adult	2	3	2	3	3	3
VIN	IX	N	F	Young adult	1	2	2	2	1	2
VIN	X	N	ND	Middle aged adult	0	0	1	2		
VL	3	M	ND	Adult size			3	3		
VL	4A	M	M	15-19	2	2	2	2	4	2
VL	6	M	M	Middle aged adult	2	2	2	2	3	2
VL	9	M	F	Old adult	1	2	1	2	2	2
VL	14	M	F	Old adult	0	0	0	0	1	2
VL	15	M	F	Middle aged adult	1	2	2	2	4	2
VL	16	M	M	Old adult					4	2
VL	17	M	F	Young adult	1	2	2	2	1	2
VL	18a	M	M	Middle aged adult	3	2	3	3	4	2
VL	19A	M	ND	Adult size			1	2	2	2
VL	20	M	?*	?*			2	2		

VL	23	M	ND	Middle aged adult	1	2	1	2	3	2
VL	24	M	F	Young adult	2	2	3	2	3	2
VL	25	M	ND	Middle aged or old adult	2	3	2	2	1	2
VL	27	M	F	Middle aged adult	0	0	2	2	3	2
VL	27(1)	M		NO DATA			2	2		
VL	28	M	ND	Middle aged adult			3	2	4	2
VL	29	M	F	Young adult	1	2	2	3	2	3
VL	30	M	ND	Middle aged adult	1	2	1	2	3	3
VL	31	M	M	Young adult	1	2	2	3	2	3
VL	32	M	F	Middle aged adult	1	2	2	2	2	2
VL	33	M	ND	Middle aged adult	1	3	3	3	3	3
VL	34	M	ND	Adult size	1	3	3	1	3	3
VL	37	M	ND	Middle aged adult	1	2	3	3	3	1
VL	38	M	F	Middle aged adult	1	2	2	3	2	1
VL	39	M	ND	?*					3	1
VL	40	M	F	Middle aged adult			1	2		
VL	41	M	M	Old adult	1	2	1	2	1	2
VL	43	M	M	Old adult	4	3	4	3	4	3
VL	44	M	M	Old adult	2	2	2	2		
VL	45	M	F?	Middle aged adult	1	2	2	2	2	3
VL	46	M	F	Middle aged adult	0	0	2	2	2	2
VL	47	M	ND	Adult size	0	0	1	3	0	0
VL	48	M	F	Old adult	1	2	4	2	3	1
VL	49	M	F?	Middle aged adult			1	2	2	3
VL	50	M	M?	Middle aged adult	1	2	2	2	2	3
VL	51	M	ND	5-9	1	2	2	2		
VL	52	M	F	Middle aged adult	1	2	2	2	4	1
VL	53	M	ND	5-9	0	0	4	2	3	3
VL	54	M	M	Middle aged adult	2	2	2	2	1	2
VL	54(1)	M	ND	Adult size	1	1				

VL	54(2)	M	?*	?*	1	1				
VL	55	M	F	Middle aged adult	1	2	3	3	2	2
VL	56	M	F	Adult size	1	2	3	2	2	2
VL	60	M	M	Old adult	3	2	3	2	2	2
VL	64A	M	ND	5-9	0	0	1	2		
VL	65	M	M?	Adult size	2	2				
VL	67	M	F	Middle aged adult	1	3	3	3	2	3
VL	69	M	ND	Middle aged adult	0	0	1	2	2	3
VL	69a	M	M	Middle aged adult			1	2	2	3
VL	70	M	ND	Middle aged adult	0	0	3	2	2	3
VL	74	M	ND	Old adult	1	2	2	2	3	2
VL	75	M	ND	Adult size	2	3	1	2		
VL	76	M	ND	Young adult	1	2	1	2	2	2
VL	77	M	F	Adult size	1	2	3	2	2	2
VL	78	M	M	Middle aged adult	2	2	2	2	3	3
VL	78A	M	M	Middle aged adult	2	3	3	3	2	3
VL	79	M	F	Old adult	1	2	4	2	3	3
VL	80A	M	F	Middle aged adult	0	0	2	2	2	2
VL	82	M	M	Middle aged adult	2	2	3	2	2	2
VL	82a same as 82(1)	M	ND	Middle aged adult	4	2	4	2	0	0
VL	83	M	F	Old adult	0	0	1	2	2	3

Table 4. Demographic, chronological and data on dental calculus for the skeletons analyzed in this study

SITE	INDIVIDUAL	PERIOD	SEX	AGE CATEGORY	DEGREE 0	DEGREE 1	DEGREE 2	DEGREE 3	PRESENCE OF SPG CALCULUS	PRESENCE OF SBG CALCULUS
AJ	1/81	N	ND	1-4	7	0	0	0	0	0
AJ	3	N	ND	10-14	12	9	0	0	1	0
AJ	6	N	M?	Young adult	3	16	9	0	1	0
AJ	7	N	ND	Middle aged adult	0	6	20	1	1	1
AJ	8	N	ND	1-4	4	0	0	0	0	0
AJ	9	N	F	Old adult	8	13	2	0	1	1
AJ	11	N	F	Middle aged adult	12	8	6	0	1	0
AJ	12	N	ND	1-4	26	1	0	0	1	0
AJ	13	N	ND	10-14	12	8	2	0	1	0
AJ	14	N	ND	5-9	30	1	0	0	1	0
AJ	15	N	ND	5-9	21	2	0	0	1	0
AJ	16	N	ND	1-4	3	0	0	0	0	0
GRI	1	N	ND	Middle aged adult	0	3	0	0	1	0
GV	1/2003	N	ND	5-9	7	0	0	0	0	0
GV	2/2003	N	ND	15-19	1	0	0	0	0	0
GV	3/2003	N	ND	15-19	20	11	0	0	1	0
GV	4/2003	N	ND	10-14	5	0	0	1	1	0
GV	3/1984	N	F	Middle aged adult	13	16	0	0	1	0
GV	2/1984	N	F	Middle aged adult	3	0	2	0	1	0
HV	8	M	M	Middle aged	0	3	0	0	1	0

				adult						
HV	11	M	M	Middle aged adult	3	7	8	0	1	0
HV	13	N	M	Old adult	1	6	1	0	1	0
HV	14	M	ND	5-9	21	2	0	0	1	0
HV	15(1)S.G.	M	ND	Adult size	6	0	0	0	0	0
HV	16	N	ND	15-19	4	0	0	0	0	0
HV	18	M	ND	10-14	9	5	0	0	1	0
HV	18(3)	M	ND	Adult size	2	7	0	0	1	0
HV	19	N	M	Old adult	1	3	1	0	1	0
HV	20(1)	N	ND	Adult size	0	0	2	0	1	0
HV	21	M	ND	1-4	7	0	0	0	0	0
HV	23-25	N	ND	Adult size	1	0	0	0	0	0
HV	26_28	N	ND	Middle aged adult	2	0	0	0	0	0
HV	26-28 (3)	N	ND	5-9	2	0	0	0	0	0
HV	29	M	M	Old adult	3	4	3	1	1	1
HV	29(1)	M	ND	?*	0	1	0	0	1	0
HV	30	M	F	Adult size	0	3	0	0	1	0
HV	33	M	F	Adult size	3	4	0	0	1	0
HV	33(1)	M	ND	Adult size	1	0	1	1	1	0
KL	6	N	ND	1-4	22	0	0	0	0	0
KL	10A	N	M	Middle aged adult	8	0	0	0	0	0
KL	8	N	F	15-19	18	5	0	0	1	0
LVIR	6	N	F?	15-19	5	11	2	0	1	0
LVIR	7/I	N	M	Old adult	17	3	0	0	1	1
LVIR	7/II	N	ND	Old adult	5	0	0	0	0	0
LVIR	8	N	F	Middle aged adult	5	13	4	1	1	0

LVIR	9	N	ND	Adult size	1	13	0	0	1	0
LVIR	11	N	ND	10-14	7	7	4	1	1	0
LVIR	13	N	M?	Adult size	16	9	1	0	1	0
LVIR	14	N	F	Adult size	4	11	4	0	1	0
LVIR	16	N	F?	Adult size	4	5	1	0	1	0
LVIR	17	N	ND	Young adult	4	3	4	0	1	0
LVIR	19	N	F	Middle aged adult	8	5	0	0	1	0
LVIR	20	N	F	Adult size	14	4	6	1	1	0
LVIR	21	M	ND	Adult size	11	1	0	0	1	0
LVIR	22	M	M?	Adult size	1	5	5	0	1	0
LVIR	26	N	M	Young adult	10	7	4	0	1	0
LVIR	27a	N	F?	Middle aged adult	0	0	4	0	1	1
LVIR	27b	N	ND	Adult size	1	3	0	0	1	0
LVIR	27d	N	M?	Old adult	0	7	0	0	1	0
LVIR	28	N	M	Adult size	1	2	6	0	1	1
LVIR	31a	N	ND	Adult size	1	0	0	0	0	0
LVIR	32a	N	F	Old adult	6	3	1	0	1	0
LVIR	32b	N	F?	Middle aged adult	0	0	3	1	1	1
LVIR	34c	N	ND	Adult size	7	0	0	0	0	0
LVIR	37	N	ND	15-19	3	2	2	0	1	1
LVIR	39	N	F?	Adult size	6	0	0	0	0	0
LVIR	43	N	ND	10-14	3	0	0	0	0	0
LVIR	47	N	F	Adult size	1	5	5	1	1	0
LVIR	48	N	ND	Young adult	2	2	0	0	1	0
LVIR	50	M	M	Middle aged adult	3	12	1	0	1	0
LVIR	54e	N	F	Young adult	3	10	1	0	1	0

LVIR	56	N	ND	5-9	14	0	0	0	0	0
LVIR	57	N	ND	15-19	8	14	5	0	1	0
LVIR	57(1)	N	ND	Adult size	0	7	4	0	1	0
LVIR	60	M	M	Middle aged adult	4	12	3	0	1	0
LVIR	61	N	ND	5-9	16	5	2	0	1	0
LVIR	64	M	M	Middle aged adult	11	9	0	0	1	0
LVIR	64(1)	M	ND	Adult size	2	0	0	0	0	0
LVIR	66	N	ND	Young adult	7	8	1	0	1	0
LVIR	67	M	ND	15-19	10	8	0	0	1	0
LVIR	69	M	M	Middle aged adult	21	7	1	0	1	0
LVIR	71	N	ND	5-9	3	0	0	0	0	0
LVIR	72	N	ND	1-4	3	0	0	0	0	0
LVIR	73	N	M	Middle aged adult	7	9	11	1	1	0
LVIR	74	N	M?	Adult size	2	3	0	0	1	0
LVIR	75	N	F?	Old adult	3	0	0	0	0	0
LVIR	78	N	ND	Adult size	0	2	0	0	1	0
LVIR	79a	N	M?	Old adult	5	5	5	0	1	0
LVIR	79b	N	ND	Young adult	8	4	0	0	1	0
LVIR	82	N	ND	Adult size	7	1	0	0	1	0
LVIR	83a	N	ND	Adult size	22	5	1	0	1	0
LVIR	84	N	ND	1-9	5	0	0	0	0	0
LVIR	86	N	ND	Adult size	3	0	0	0	0	0
LVIR	87	N	ND	5-9	5	0	0	0	0	0
LVIR	87(1)	N	ND	Adult size	2	0	0	0	0	0
LVIR	88	N	F	Middle aged adult	16	0	0	1	1	1

LVIR	89a	N	ND	Adult size	4	2	0	0	1	0
LVIR	89b	N	ND	1-4	5	0	0	0	0	0
LVIR	91	N	ND	Adult size	2	0	0	1	1	1
LVIR	92	N	ND	1-4	6	0	0	0	0	0
LVIR	93	N	F	Middle aged adult	21	2	1	0	1	1
LVIR	105	M	ND	Adult size	4	9	0	0	1	0
LVIR	122	N	ND	15-19	1	5	1	0	1	0
LVIR	126	N	F?	Adult size	4	0	0	0	0	0
OB	1	N	ND	5-9	12	0	1	0	1	0
PA	1A	M	F	Adult size	4	1	0	0	1	0
PA	2	M	M	Old adult	0	6	1	0	1	0
PA	5	N	F	Middle aged adult	3	3	1	0	1	0
PA	5A	N	ND	Adult size	3	1	0	0	1	0
PA	6	M	F	Adult size	1	0	0	0	0	0
PA	6A	M	F	Old adult	0	2	0	0	1	0
PA	9	M	ND	Adult size	0	9	6	0	1	0
PA	11	M	ND	5-9	30	4	0	0	1	0
PA	12	M	M	Young adult	8	6	7	0	1	0
PA	14	M	F	Old adult	8	2	0	0	1	0
PA	14(1)	M	F?	Adult size	2	0	3	1	1	1
PA	15	M	F	Middle aged adult	3	5	3	0	1	0
PA	16	M	F?	Young adult	1	6	2	1	1	1
PA	16a	M	F	Old adult	8	6	4	0	1	0
PA	17	M	F?	Middle aged adult	1	4	0	0	1	0
PA	18	M	F?	Middle aged adult	3	9	2	1	1	0

PA	18	M	F	Middle aged adult	6	2	3	0	1	0
PA	20	M	F	Adult size	0	2	2	1	1	0
PA	21	M	F	Middle aged adult	1	6	1	0	1	0
PA	22	M	ND	Adult size	1	5	2	0	1	0
PA	23	M	ND	1-4	16	0	0	0	1	0
PA	24	M	F	Middle aged adult	4	3	1	0	1	0
PA	25	M	F	Adult size	2	2	0	0	1	0
PA	25(1)	M	ND	Adult size	0	1	0	0	1	0
PA	26	M	F	Old adult	0	13	9	1	1	0
PA	26a	M	ND	1-4	2	0	0	0	0	0
PA	27	M	ND	10-14	5	0	0	0	0	0
RK	1	N	F	Middle aged adult	13	10	5	0	1	0
SM KAR	1	N	F	Middle aged adult	7	9	0	0	1	1
STA	1	N	F	Old adult	1	2	1	1	1	0
STA	1	N	ND	5-9	5	1	0	0	1	0
VIN	II	N	ND	Middle aged adult	1	8	3	0	1	0
VIN	IV	N	ND	Young adult	4	18	0	0	1	0
VIN	V	N	ND	Young adult	11	5	0	0	1	1
VIN	VI?	N	ND	Young adult	1	8	4	0	1	0
VIN	VII	N	F	15-19	3	10	3	0	1	0
VIN	VIII	N	M	Middle aged adult	0	2	0	0	1	0
VIN	IX	N	F	Young adult	2	10	7	0	1	0
VIN	X	N	ND	Middle aged	4	8	0	0	1	0

				adult						
VL	4A	M	M	15-19	3	8	0	0	1	0
VL	6	M	M	Middle aged adult	0	14	10	0	1	0
VL	9	M	F	Old adult	8	7	0	0	1	0
VL	13	M	ND	Adult size	3	4	0	0	1	0
VL	14	M	F	Old adult	5	0	0	0	0	0
VL	15	M	F	Middle aged adult	2	0	0	0	0	0
VL	16	M	M	Old adult	0	21	5	1	1	0
VL	17	M	F	Young adult	0	3	1	0	1	0
VL	18a	M	M	Middle aged adult	1	8	0	0	1	0
VL	18c	M	ND	5-9	2	12	0	0	1	0
VL	18c(2)	M	ND	5-9	2	2	0	0	1	0
VL	19a	M	ND	Adult size	0	2	0	0	1	0
VL	22	M	ND	Adult size	0	2	0	0	1	0
VL	23	M	ND	Middle aged adult	11	8	3	0	1	0
VL	24	M	F	Young adult	7	6	1	0	1	0
VL	25	M	ND	Middle aged adult	8	2	6	0	1	0
VL	26	M	M	Middle aged adult	4	4	1	0	1	0
VL	27	M	F	Middle aged adult	14	2	2	0	1	0
VL	28	M	ND	Middle aged adult	5	15	1	0	1	1
VL	29	M	F	Young adult	17	4	0	0	1	0
VL	29a	M	ND	Adult size	1	2	0	0	1	0

VL	30	M	ND	Middle aged adult	2	0	6	0	1	1
VL	31	M	M	Young adult	8	15	3	0	1	1
VL	32	M	F	Middle aged adult	6	9	1	0	1	0
VL	34	M	ND	Adult size	3	3	0	0	1	0
VL	38	M	F	Middle aged adult	21	4	0	0	1	0
VL	40	M	F	Middle aged adult	13	1	7	0	1	0
VL	41	M	M	Old adult	10	10	1	0	1	0
VL	43	M	M	Old adult	3	1	3	0	1	1
VL	44	M	M	Old adult	4	1	3	1	1	1
VL	45	M	F?	Middle aged adult	1	13	9	1	1	1
VL	46	M	F	Middle aged adult	6	8	5	0	1	1
VL	47	M	ND	Adult size	0	2	3	0	1	1
VL	48	M	F	Old adult	9	6	3	1	1	1
VL	49	M	F?	Middle aged adult	7	9	1	0	1	0
VL	49(1)	M	ND	Middle aged adult	0	0	3	0	1	0
VL	50	M	M?	Middle aged adult	12	2	0	0	1	0
VL	51	M	ND	5-9	8	12	0	0	1	0
VL	51a	M	F	Middle aged adult	3	6	8	1	1	0
VL	51b	M	ND	5-9	4	0	0	0	0	0
VL	52	M	F	Middle aged	1	7	4	1	1	1

				adult						
VL	53	M	ND	5-9	9	1	0	0	1	0
VL	53(1)	M	M?	Young adult	0	0	1	0	1	0
VL	55	M	F	Middle aged adult	13	8	3	0	1	0
VL	56	M	F	Adult size	8	0	1	0	1	0
VL	60	M	M	Old adult	0	9	10	0	1	0
VL	64a	M	ND	5-9	5	7	0	0	1	0
VL	64b	M	ND	5-9	13	9	0	0	1	0
VL	65	M	M?	Adult size	0	1	1	0	1	0
VL	67	M	F	Middle aged adult	16	4	0	0	1	0
VL	69	M	ND	Middle aged adult	0	3	2	0	1	0
VL	69a	M	M	Middle aged adult	2	12	0	1	1	1
VL	69a(1)	M	?*	?*	1	0	0	0	0	0
VL	70	M	ND	Middle aged adult	4	7	0	1	1	1
VL	71	M	F	Young adult	2	6	3	0	1	0
VL	73	M	ND	Middle aged adult	3	1	0	0	1	0
VL	74	M	ND	Old adult	11	9	2	0	1	1
VL	77	M	F	Adult size	13	5	0	0	1	0
VL	77(1)	M	?*	?*	0	1	0	0	1	0
VL	78	M	M	Middle aged adult	2	2	0	1	1	1
VL	78a	M	M	Middle aged adult	5	13	3	1	1	0
VL	79	M	F	Old adult	5	4	0	0	1	0

VL	80a	M	F	Middle aged adult	1	2	3	1	1	1
VL	82	M	M	Middle aged adult	4	5	0	0	1	0
VL	82a	M	ND	Middle aged adult	4	5	0	0	1	0
VL	82b	M	F	Adult size	0	2	0	0	1	0
VL	82c	M	ND	Adult size	0	1	3	1	1	0
VL	83	M	F	Old adult	3	17	2	0	1	0
VL	83a	M	ND	Adult size	1	5	3	0	1	0
VL	84	M	M?	Adult size	0	2	2	1	1	0

Table 5. Demographic, chronological and data on AMTL for the skeletons analyzed in this study

SITE	INDIVIDUAL	PERIOD	SEX	AGE CATEGORY	TOTAL NUMBER OF AMTL	TOTAL NUMBER OFALVEOLAR POSITIONS
GV	2/1984	N	F	Middle aged adult	3	5
HV	8	M	M	Middle aged adult	8	6
HV	13	N	M	Old adult	3	17
HV	30	M	F	Adult size	1	17
HV	33 same as profil 11-20	M	F	Adult size	1	21
LVIR	20	N	F	Adult size	2	30
LVIR	32a	N	F	Old adult	1	31
LVIR	83a	N	ND	Adult size	1	31
PA	2	M	M	Old adult	2	10
PA	5	N	F	Middle aged adult	1	21
PA	14(1)	M	F?	Adult size	4	12
PA	18b	M	F	Middle aged adult	2	17
PA	21	M	F	Middle aged adult	1	15
PBC	1	N	F	Middle agded adult	3	10
RK	1	N	F	Old adult	2	30
STA	1	N	F	Old adult	2	5
VIN	II	N	ND	Middle aged adult	1	28
VIN	III	N	ND	Middle aged adult	11	5
VL	14	M	F	Old adult	8	16
VL	15	M	F	Middle aged adult	1	3
VL	25	M	ND	Middle aged adult	9	22
VL	28	M	ND	Middle aged adult	2	28

VL	32	M	F	Middle aged adult	1	28
VL	40	M	F	Middle aged adult	3	29
VL	44	M	M	Old adult	14	23
VL	46	M	F	Middle aged adult	5	26
VL	55	M	F	Middle aged adult	1	30
VL	56	M	F	Adult size	1	23
VL	69a(1)	M	?*	?*	4	11
VL	83	M	F	Old adult	1	26

Table 6. The data on body mass index values and type for the skeletons analyzed in this study

SITE	INDIVIDUAL	PERIOD	BODY MASS	STATURE	BMI	TYPE
AJ	9	N	66.96	171.77	22.7	Normal
AJ	8a	N	59.45	163.51	22.24	Normal
GV 2/1984	2/1984	N	60.11	154.17	25.29	Overweight
GV 3/1984	3/1984	N	68.84	163.64	25.71	Overweight
HV	17-20(1)	N	74.88	175.43	24.33	Normal
HV	20(1)	N	71.92	175.43	23.37	Normal
HV	17-20(2)	M	72.42	182.42	21.76	Normal
LV	8	N	58.87	169.27	20.55	Normal
LV	19	N	57.72	159.74	22.62	Normal
LV	20	N	62.34	168.88	21.86	Normal
LV	32a	N	55.41	153.98	23.37	Normal
LV	88	N	50.78	157.95	20.36	Normal
LV	14	N	57.72	154.93	24.05	Normal
LV	47	N	55.41	155.48	22.92	Normal
LV	54e	N	50.78	151.47	22.13	Normal
LV	54c	N	54.25	156.89	22.04	Normal
LV	93	N	57.72	163.16	21.68	Normal
LV	32b	N	52.14	175.27	16.97	Underweight
LV	50	M	76.02	180.24	23.4	Normal
LV	60	M	66.96	176.64	21.46	Normal
LV	69	M	72.40	181.20	22.05	Normal
LV	73	N	66.96	175.44	21.75	Normal
LV	26	N	66.35	163.76	24.74	Normal
LV	45b	N	69.37	182.54	20.82	Normal
LV	7/I	N	73.00	162.21	27.75	Overweight
LV	44	N	76.93	193.02	20.65	Normal

PA	2	M	82.14	184.44	24.15	Normal
STA	1	N	53.56	156.60	21.84	Normal
VL	25	M	74.68	182.86	22.33	Normal
VL	17	M	71.58	179.24	22.28	Normal
VL	27	M	64.65	165.91	23.49	Normal
VL	29	M	63.50	172.71	21.29	Normal
VL	32	M	65.23	159.97	25.49	Overweight
VL	46	M	62.34	173.50	20.71	Normal
VL	48	M	65.81	163.88	24.5	Normal
VL	52	M	62.34	169.34	21.74	Normal
VL	55	M	65.81	166.54	23.73	Normal
VL	71	M	57.72	163.47	21.6	Normal
VL	80	M	62.34	165.10	22.87	Normal
VL	11	M	76.63	181.63	23.23	Normal
VL	18a	M	68.78	183.49	20.43	Normal
VL	18b	M	68.17	188.48	19.19	Normal
VL	26	M	63.33	176.50	20.33	Normal
VL	4a	M	68.77	176.34	22.12	Normal
VL	31	M	79.65	183.97	23.53	Normal
VL	50b	M	73.00	180.58	22.39	Normal
VL	60	M	89.39	183.70	26.49	Overweight
VL	63	M	65.15	164.13	24.18	Normal
VL	78	M	78.44	171.54	26.66	Overweight
VL	82	M	62.79	164.60	23.17	Normal
VL	2	M	63.41	161.98	24.17	Normal
VL	28	M	64.53	173.49	21.44	Normal
VL	82(1)	M	71.29	180.22	21.95	Normal

BIOGRAPHY

Jelena Jovanović is a physical anthropologist at the BioSense Institute of the University of Novi Sad, Serbia. Her research interests focus on the biological aspects and consequences of the Neolithic Demographic Transition, as well as on the reconstruction of diet and health of prehistoric populations.

She graduated in 2010 from the Department of Archaeology, Faculty of Philosophy, the University of Belgrade. In 2011 she completed master studies in the field of physical anthropology at the Department, and in 2012 she started doctoral studies at the same institution.

Since 2013 she has been working as a teaching assistant to the course Physical Anthropology taught at the undergraduate level at the Department of Archaeology, Faculty of Philosophy, University of Belgrade. In the period 2012-2016 she worked as collaborator on the FP7 project *BEAN – Bridging the European and Anatolian Neolithic: demography, migration, and lifestyle at the advent of civilization* (Marie Curie Initial Training Networks Theme, funded by the European Commission) completed at the Laboratory for Bioarcheology, University of Belgrade. Using the stable isotope analysis of human bone, and in collaboration with Camille de Becdelièvre, she investigated the diet of Mesolithic and Neolithic communities within this project. In the period 2013-2015 she took part in the bilateral Serbian-French project *PREFERT – Prehistoric fertility: duration of lactation during the Mesolithic and Neolithic in South Eastern Europe* (funded by the Ministry of Education, Science and Technological Development of the Republic of Serbia and the French National Centre for Scientific Research (CNRS)); within this project, she analysed the length of lactation through stable isotope analysis of the Danube Gorges Mesolithic and Neolithic humans. As a part of the project, she took up an internship in the LAMPEA laboratory (Laboratorie Méditerranéen de Préhistoire Europe Afrique – CNRS UMR 7269) at the University of Aix Marseille in France. She was there trained in the field of stable isotope analysis by Dr Gwenaëlle Goude and Dr Estelle Herrscher. From 2015 to 2016 she participated in the project *Bioarchaeology of Ancient Europe: humans, animals and plants in the prehistory of Serbia* (Ref: III 47001; funded by the Ministry of Education, Science and Technological Development of the Republic of Serbia) carried out at the Laboratory for

Bioarcheology, University of Belgrade; her task was the analysis of Early Neolithic human skeletal remains from the territory of Serbia. Since September 2016 she has been working as a Research Associate at the BioSense Institute, University of Novi Sad within the project *BIRTH: Births, mothers and babies: Prehistoric fertility in the Balkans between 10000 and 5000 BC* funded by the European Research Council and led by Prof. Dr Sofija Stefanović. Within this project, Jelena Jovanović is in charge of paleo-obstetric analysis, examination of neonatal body characteristics, and assessment of the health status and nutrition through the analysis of human skeletal remains. In addition to this work, she took part in a number of projects conducted by Serbian and foreign institutions for protection of cultural heritage; within these projects, she analysed human skeletal remains from various archaeological sites (e.g. Remezijana, Serbia; Otilovići, Montenegro; Mramorje-Čajniče and Crkvine Šipovo, Bosnia and Herzegovina).

She assisted in the preparation of the exhibition "What Ancient Bones Can Tell Us" organized by the Laboratory for Bioarcheology as part of the manifestation 'Night of Museums 2011'; she was also one of the authors of the exhibition "Bioarchaeology of the Danube Gorges" organised by the same laboratory in 2015. She is the author of 5 articles and 28 conference presentations given at national and international conferences. She is a member of the World Archaeological Congress, the International Union of Anthropological and Ethnological Sciences and the American Association of Physical Anthropologists.

Образац 5.

Изјава о ауторству

Име и презиме аутора **Јелена Јовановић**

Број индекса **7А11-6**

Изјављујем

да је докторска дисертација под насловом

Исхрана и здравствени статус становника централног Балкана у раном неолиту (6200.-5200. г. пре н.е.)

(The diet and health status of the Early Neolithic communities of the Central Balkans (6200-5200 BC))

- резултат сопственог истраживачког рада;
- да дисертација у целини ни у деловима није била предложена за стицање друге дипломе према студијским програмима других високошколских установа;
- да су резултати коректно наведени и
- да нисам кршио/ла ауторска права и користио/ла интелектуалну својину других лица.

Потпис аутора

У Београду, 17.01. 2017.

Jovanović Jelena

Образац 6.

Изјава о истоветности штампане и електронске верзије докторског рада

Име и презиме аутора **Јелена Јовановић**

Број индекса **7А11-06**

Студијски програм **Археологија**

Наслов рада

Исхрана и здравствени статус становника централног Балкана у раном неолиту (6200.-5200. г. пре н.е.)

(The diet and health status of the Early Neolithic communities of the Central Balkans (6200-5200 BC))

Ментор проф.др Софија Стефановић

Изјављујем да је штампана верзија мог докторског рада истоветна електронској верзији коју сам предао/ла ради похрањена у **Дигиталном репозиторијуму Универзитета у Београду.**

Дозвољавам да се објаве моји лични подаци везани за добијање академског назива доктора наука, као што су име и презиме, година и место рођења и датум одбране рада.

Ови лични подаци могу се објавити на мрежним страницама дигиталне библиотеке, у електронском каталогу и у публикацијама Универзитета у Београду.

Потпис аутора

У Београду,17.01.2017.

Jovanović Jelena

Образац 7.

Изјава о коришћењу

Овлашћујем Универзитетску библиотеку „Светозар Марковић" да у Дигитални репозиторијум Универзитета у Београду унесе моју докторску дисертацију под насловом:

Исхрана и здравствени статус становника централног Балкана у раном неолиту (6200.-5200. г. пре н.е.)

(The diet and health status of the Early Neolithic communities of the Central Balkans (6200-5200 BC))

која је моје ауторско дело.

Дисертацију са свим прилозима предао/ла сам у електронском формату погодном за трајно архивирање.

Моју докторску дисертацију похрањену у Дигиталном репозиторијуму Универзитета у Београду и доступну у отвореном приступу могу да користе сви који поштују одредбе садржане у одабраном типу лиценце Креативне заједнице (Creative Commons) за коју сам се одлучио/ла.

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кратак опис лиценци је саставни део ове изјаве).

Потпис аутора

У Београду, 17.01.2017.

Jovanović Jelena