EMMA LIGHTFOOT / PRESTON T. MIRACLE / DINKO RADIĆ / MARIO ŠLAUS / TAMSIN C. O'CONNELL

STABLE ISOTOPE ANALYSIS OF HUMAN DIETS DURING THE MESOLITHIC AND NEOLITHIC PERIODS AT VELA SPILA CAVE, KORČULA

ANALIZA LJUSKE PREHRANE U RAZDOBLJU MEZOLITIKA I NEOLITIKA U VELOJ SPILI NA OTOKU KORČULI PROVEDENA PUTEM ANALIZE STABILNIH IZOTOPA

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Emma Lightfoot
UK, Cambridge
Department of Archaeology
University of Cambridge
Downing Street, CB2 3DZ
elfl2@cam.ac.uk.

Preston T. Miracle
UK, Cambridge
Department of Archaeology
University of Cambridge
Downing Street, CB2 3DZ
ptm21@cam.ac.uk

Dinko Radić
HR, 20270 Vela Luka
Centar za kulturu
Arheološka zbirka
dinkoradic@net.hr

Mario Šlaus
HR, 10000 Zagreb
Department of Archaeology
Croatian Academy of Sciences and Arts,
Ante Kovačića 5
mslaus@hazu.hr

Tamsin C. O'Connell
UK, Cambridge
Department of Archaeology
University of Cambridge
Downing Street, CB2 3DZ
tco21@cam.ac.uk

Presented here are the results of stable isotope analyses from Vela Spila, Korčula. Forty faunal samples and four human samples were taken from the Mesolithic layers, and one infant from the Neolithic layers. The results indicate that in the Mesolithic period human diet was based largely on terrestrial resources with a small contribution from marine protein. This is in contrast to the zooarchaeological data which indicates a heavy reliance on marine resources. As the site is thought to have been seasonally occupied, however, these two datasets provide complementary information; while occupying Vela Spila people concentrated on marine resources but during the remainder of the seasonal round their subsistence must have relied upon terrestrial foodstuffs. Comparing the Mesolithic and Neolithic periods, the isotope results echo the zooarchaeological analysis in that there is a decrease in the consumption of marine protein in the Neolithic.

Key words: Carbon, Nitrogen, Isotopes, Diet, Mesolithic, Neolithic, Croatia

Introduction

Stable isotope analysis can be used in conjunction with other techniques in order to provide a fuller picture of past diets. In the case of Vela Spila, a site that is thought to have been occupied on only a seasonal basis, the combination of zooarchaeological and stable isotope analyses is particularly powerful as these two techniques have different resolutions. While zooarchaeological analysis provides direct information on what was available for consumption and indirect evidence about what was eaten, stable isotope analysis provides direct evidence of the proportion in which different foods were actually eaten. Thus through combining the two techniques it is possible to compare the subsistence practices followed while people were based at Vela Spila to the average subsistence over a longer period of time.

Summary of Archaeology and Zooarchaeological Analysis

Both the faunal and human remains have been discussed in detail elsewhere in this volume[1] and thus only a brief summary will be presented here.

The quantity of food remains and the number of hearths in the Mesolithic layers indicate that there was repeated, but probably seasonal, occupation during this period.[2] The faunal remains are dominated by marine resources such as fish and shellfish. The presence of bones from tuna and swordfish suggests that deep-sea fishing took place. Terrestrial land snails are also well-represented. Of the larger mammals, fox, roe deer, red deer, wild pig, hare, hedgehog, and marten are present in smaller numbers.

The faunal remains in the Neolithic layers show that the Mesolithic way of life was partially abandoned, the abundance of marine resources and wild animals decreases, and domestic animals appear.

Stable Isotopes and Dietary Reconstruction

Stable isotope analysis provides individual, quantitative information about past diets. As the body is constructed from raw materials taken from the diet, body chemistry reflects the food and drink consumed during life. In this study, stable carbon and nitrogen isotope ratios of bone collagen were employed to supplement and expand the dietary information obtained from other techniques, such as zooarchaeology.[3]

Due to the effects of metabolic processes, stable nitrogen isotope values ($\delta^{15}N$) provide an indication of the amount of animal protein consumed by an individual.[4] Thus $\delta^{15}N$ values can be used to distinguish between trophic levels; herbivores have lower $\delta^{15}N$ values than omnivores, which have lower $\delta^{15}N$ values than carnivores. Stable carbon isotope analysis allows discrimination between diets based on marine and terrestrial resources, or between diets based on two different types of plants (C_3 and C_4) with different mechanisms of carbon uptake. Diets high in marine resources and C_4 plants can have similar $\delta^{13}C$ values, however these diets can often be distinguished on the basis of $\delta^{15}N$ values, as marine foodchains tend to have higher $\delta^{15}N$ values than terrestrial foodchains.[5] The isotopic ratios at the base of the foodchain vary spatially and temporally,[6] thus it is necessary to analyse contemporaneous faunal samples when using this technique to investigate past human subsistence.

The stable isotope composition of bone collagen reflects the diet over the majority of adult life; it thus indicates an 'average' diet.[7] Changes in diet between foodstuffs of similar isotopic composition will not produce a change in consumer bone collagen stable isotope ratios. Furthermore, physiological effects in the consumer (such as starvation)[8] and environmental influences on soil or plants can theoretically produce isotopic differences in bone collagen.[9] Infants tend to have higher $\delta^{15}N$ values than adults due to a trophic level increase associated with breastfeeding.[10]

Materials and Methods

40 animals and 4 humans were sampled from Mesolithic layers at Vela Spila. One human infant was sampled from the Neolithic layers. Collagen was extracted following the method described in Privat et al..[11] All collagen samples were analysed in triplicate using a Costech elemental analyser coupled in continuous-flow mode to a Finnigan MAT253 mass spectrometer. Carbon and nitrogen stable isotope values are expressed as delta values (for example $\delta^{13}C$) relative to international standards (VPDB and AIR, respectively) in units of per mille (parts per thousand, ‰).[12] Repeated measurements on international and in-

1 Wallduck, Miracle, Radić 2010
2 Čečuk, Radić 2005.
3 Lee-Thorp 2008.
4 O'Connell, Hedges 1999.
5 Schoeninger, De Niro 1984.
6 Stevens, Hedges 2004.
7 Hedges et al. 2007.
8 Mekota et al. 2006.
9 For example Farquar et al. 1982; Heaton 1987.
10 Fuller et al. 2006.
11 Privat et al 2002.
12 Hoefs 2004.

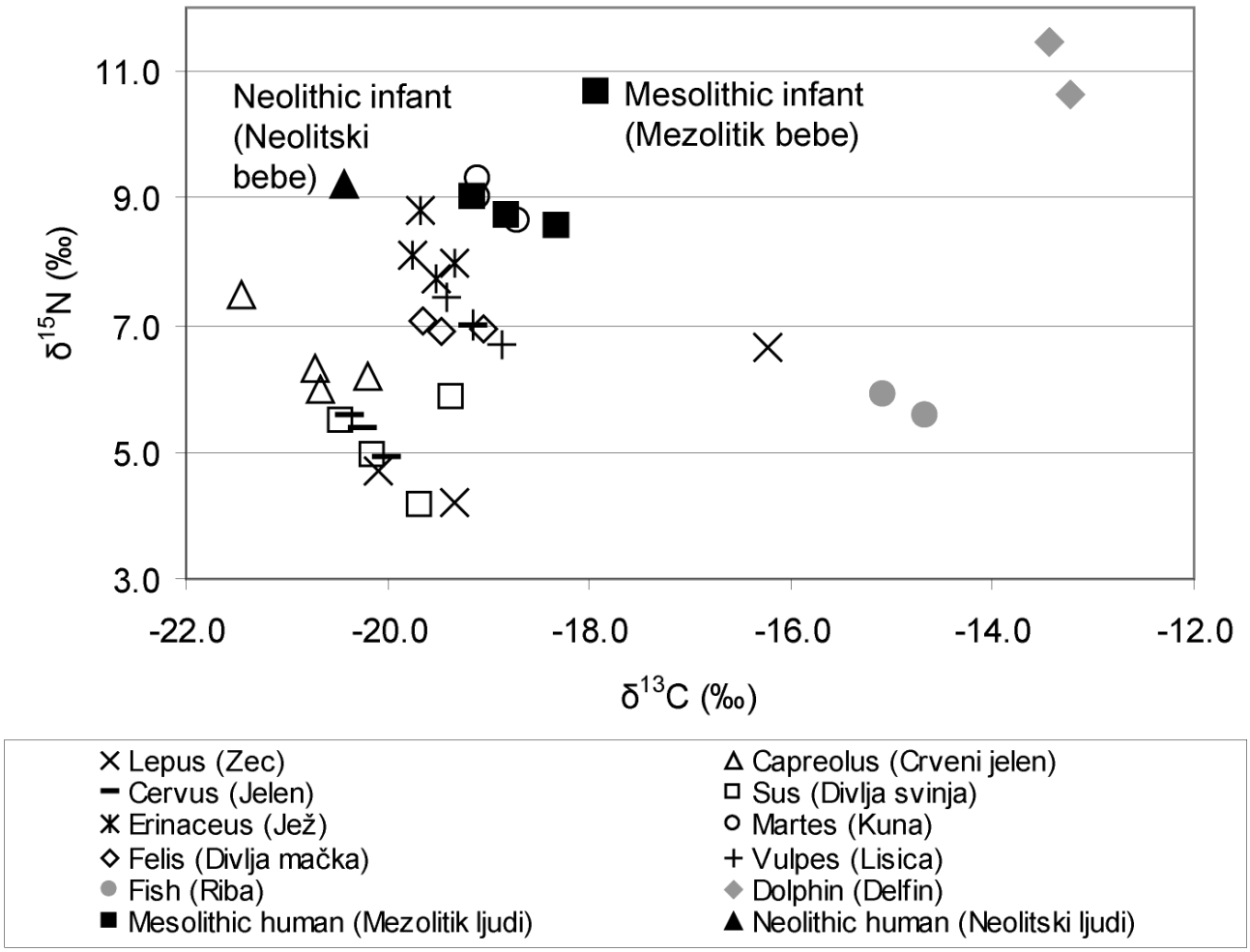

Figure 1.
Scatter graph of human and faunal isotope results

house standards showed that the analytical error was less than <0.2‰ for both carbon and nitrogen.

Measured collagen is deemed to be of good quality if it fulfils the following criteria: an atomic C:N ratio of 2.9 to 3.4;[13] a 'collagen' yield of >1% by mass; final carbon yields of >13%; and final nitrogen yields of >4.8%.[14] All of the human samples produced results deemed to be of good quality. Seven of the animal samples analysed here failed to produce reliable results and are thus excluded from the following analyses and discussions. Unfortunately, sample sizes are too small for reliable statistical analyses.

Results and Discussion

Fauna

The faunal results are consistent with those expected for Europe and comparable to those previously published for early Holocene remains from Pupićina peć, Istria (fig. 1).[15] The terrestrial herbivores (hares, deer, wild boar) generally have $\delta^{13}C$ values indicative of diets based on C_3 ecosystems.[16] Their values plot together with relatively low $\delta^{15}N$ values, indicative of an herbivorous diet. It is noteworthy that the wild boar plot with the herbivores showing that they did not consume significant amounts

13 De Niro 1985.
14 Ambrose 1990.
15 Paine et al. 2009.
16 The one exception to this (VSF032; hare) is likely to have been misidentified and thus will be excluded from further discussions.

of animal protein despite their omnivorous physiology. Cats, foxes, hedgehogs and martens have $\delta^{15}N$ values indicative of higher animal protein consumption, with the martens having the most carnivorous diet.

The four marine samples are clearly separated from the terrestrial fauna in $\delta^{13}C$ values, showing that $\delta^{13}C$ can be used to distinguish between marine and terrestrial foodchains. The marine fish have similar $\delta^{15}N$ values to the terrestrial fauna, which is surprising as they have been tentatively identified as seabream, a carnivorous species. The dolphins have the highest $\delta^{15}N$ values of any of the faunal samples, however these values are notably lower than dolphins analysed in non-Mediterranean studies. These data and modern studies[17], suggest that Mediterranean fauna generally have lower $\delta^{15}N$ values than fauna from the Atlantic coast of Europe.[18]

Humans

The faunal data presented above provide a good baseline with which to compare the four Mesolithic human results. Three human results cluster with the martens, indicative of a diet based largely upon terrestrial resources. Martens consume a varied diet including small mammals, birds, fish, insects and eggs.[19] Thus we can infer that humans consumed largely terrestrial protein, probably combined with small amounts of marine protein. The single infant sample has enriched $\delta^{13}C$ and $\delta^{15}N$ values compared to the other samples as a result of breastfeeding.

The isotopic and zooarchaeological evidence at first sight appear to be inconsistent in that the zooarchaeological evidence indicates far higher marine protein consumption than the isotopic results suggests. However, it is likely the site was only occupied on a seasonal basis and thus the two sources of information represent different facets of past subsistence practices. We can infer therefore that Vela Spila was used seasonally as a base for obtaining marine resources, as reflected in the zooarchaeological evidence, but during the remainder of the seasonal round subsistence strategies concentrated on the procurement of terrestrial resources, as indicated by the isotopic data.

The single Neolithic individual analysed as part of this study is an infant and thus the isotopic results incorporate a trophic level effect from breastfeeding. The $\delta^{15}N$ value of this individual is comparable to that of the Mesolithic human results, however in this case the high $\delta^{15}N$ value likely reflects the consumption of breast milk rather than the consumption of marine foodstuffs. The $\delta^{13}C$ value is more negative than that of the Mesolithic individuals. The results therefore suggest that the Neolithic individual did not consume marine protein in quantities that can be distinguished isotopically.

While the small sample size limits interpretation, a comparison of the Mesolithic and Neolithic results indicates that there was a dietary difference between the two time periods at this site. During the Neolithic this individual consumed a diet based largely upon terrestrial resources and consumed little or no marine protein. The Mesolithic individuals also had a diet based largely upon terrestrial resources, however some marine protein was also consumed. Thus the isotopic data mirror the zooarchaeological evidence for a decrease in fish consumption across the Mesolithic to Neolithic transition. This pattern is echoed at other Mesolithic and Neolithic sites in the area.[20]

Conclusions

The use of stable isotope analysis at Vela Spila, Korčula has shown that the reliance on marine resources evidenced in the zooarchaeological remains only formed part of the annual subsistence pattern. In the remainder of the seasonal round, the people buried at Vela Spila must have relied upon terrestrial resources. Without the isotopic data, it is likely that the diet of these individuals would have been seen as largely based on marine resources. Thus a combination of zooarchaeological evidence and stable isotope analysis has furthered our understanding of past subsistence practices at Vela Spila, adding new insights that could only be obtained through a combination of the two techniques.

17 Jennings et al. 1997; Pinnegar, Polunin 2000.
18 For example Schulting, Richards 2002.
19 Powell 2007.
20 Lightfoot et al. in press

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Sažetak

Analiza ljuske prehrane u razdoblju mezolitika i neolitika u Veloj spili na otoku Korčuli provedena putem analize stabilnih izotopa

Ključne riječi: ugljik, dušik, stabilni izotopi, prehrana, mezolitik, neolitik, Hrvatska

U ovome radu izneseni su rezultati analize stabilnih izotopa iz Vele spile na otoku Korčula. Iz mezolitičkih slojeva uzeto je četrdeset životinjskih uzoraka i četiri ljudska uzorka, a jedan je dječji uzorak uzet iz neolitičkih slojeva. Rezultati upućuju na to da se u razdoblju mezolitika ljudska prehrana uglavnom temeljila na kopnenim resursima uz maleni doprinos morskog proteina. Takav zaključak suprotan je zooarheološkim podacima koji upućuju na veliko korištenje morskih resursa. Međutim, budući da se smatra kako je ova špilja bila sezonsko stanište, ta dva skupa podataka međusobno se nadopunjuju. Dok su živjeli u Veloj spili, ljudi su se koncentrirali na morske resurse, no u preostalo doba godine za prehranu su se zacijelo pretežito koristili kopnenim izvorima hrane. Usporedba rezultata analize izotopa iz mezolitičkog i neolitičkog razdoblja prati rezultate zooarheološke analize budući da upućuje na smanjenje potrošnje morskog proteina u razdoblju neolitika.