

CHAPTER XXV-3

**IDENTIFICATION OF PLANT FOODS IN THE DIETS
BASED ON ANALYSIS OF PLANT MICROFOSSILS TRAPPED
IN DENTAL CALCULUS****Amanda G. HENRY****Abstract**

Neandertals are often portrayed as top-level carnivores, with associated behavioural and biological adaptations. However, the plants in their diet have only rarely been quantified. The plant foods included in the diet of the Neandertals from Spy have been reconstructed based on the plant microfossils preserved in dental calculus on their teeth. The variety and types of microfossils show that these individuals consumed at least six and probably more plant types, including at least one kind of plant underground storage organ and possibly grass seeds. These findings suggest that plant foods may have played a more important role in Neandertal diets than previously supposed.

INTRODUCTION

By examining the diets of Neandertals, researchers have attempted to explore the potential relationships between dietary patterns and many other Neandertal traits, including their social organisation, energetic needs, and behaviour (Kuhn & Stiner, 2006; Stringer *et al.*, 2008; Froehle & Churchill, 2009). Recent research has proposed that, in contrast to modern humans, Neandertals were top-level carnivores who focused almost exclusively on large-bodied mammals (Stiner *et al.*, 2000; Richards & Trinkaus, 2009). This focus on large mammals has been tied to many aspects of Neandertal behaviour, including their more limited technology, possible lack of sexual division of labour, and even their potential competition with and eventual replacement by modern humans (Kuhn & Stiner, 2006). However, due to the scarcity of data about plant foods, the potential role of plants in Neandertal diet has been poorly explored. Stone tool use-wear and dental microwear allow identification only of broad plant types, like hard- or soft-tissue plants. Stable isotopes provide relative proportions of meat versus plant protein, and of relative ratios of C₃ versus C₄ plants. However, none of these methods allows exact identification of the plant species, and in the first two cases, it is unclear if the plant was actually eaten or just pro-

cessed for other uses. Plant macro-remains, such as charred seeds, can provide detailed species lists; unfortunately, macro-remains are rare in modern excavations of Neandertal sites, and are all but unknown from historical excavations. This lack of information about plant foods prevents us from fully understanding the whole of Neandertal diet, and necessarily limits the predictions we can make about the rest of their behaviour.

Plant microfossils, such as phytoliths and starch grains can provide the missing information about plant foods. Both phytoliths and starch grains persist in the archaeological record long after the plant that produced them has decayed, and they are recovered and identified to the plant family, genus or species that produced them by proven laboratory techniques (Mulholland & Rapp, 1992; Pearsall, 2000; Denham *et al.*, 2003; Piperno *et al.*, 2004; Piperno, 2006; Perry *et al.*, 2007). When found in the dental calculus on teeth, they can provide information about the plants that individuals consumed (Lalueza Fox & Pérez-Pérez, 1994; Henry & Piperno, 2008; Piperno & Dillehay, 2008). More than just indicating the plant that produced them, phytoliths and starch grains can also record evidence of food processing, including grinding and cooking (Lineback & Wongsrikasem, 1980; del Pilar Babot, 2003; Henry *et al.*, 2009).

The individuals from Spy provide an important sample for examining the potential role of plant foods in Neandertal diet, because of the cold environment in which they lived (Otte, 1979). Among modern hunter-gatherers, consumption of plant foods varies by temperature, such that groups living in cold environments consume fewer plants (Kelly, 1995). Finding evidence of plant use by the Spy individuals when we might expect to find few or no plant foods would suggest that plants may have been part of Neandertal diet throughout their range of environments. By examining the plant microfossils preserved in the dental calculus from the Spy individuals, we can begin to understand how and under what circumstances Neandertals included plants in their diet.

MATERIALS AND METHODS

In September of 2008 I was granted permission to sample the dental calculus from the Spy fossils in order to use the plant microfossils trapped within the calculus to identify the plant foods these individuals ate. Spy I and Spy II retain associated maxillary and mandibular teeth

with sufficient calculus deposits that were appropriate for my study. Under the direction of Dr. Patrick Semal, I chose four calculus samples, two from each individual. From Spy I, I sampled the disto-lingual surface of the left P_4 #11H and the lingual surface of the right M_1 from fragment #12B (#580c). From Spy II, I sampled the lingual surface of the right P_4 from mandible #3 (#577i) and the mesio-buccal surface of the right M^3 from fragment #2A (#578f) (Figure 1). The numbering reflects the most recent categorisation (see Rougier *et al.*, this volume: chapter XIX).

To sample the calculus, the tooth was arranged over a small square of weighing paper so that the flakes of calculus would fall onto the paper. A freshly-cleaned dental curette was used to gently pick off small flakes of calculus, usually less than 2 mm² in total area. This sample was then transferred from the weighing paper to a clean microcentrifuge tube. Upon returning to the laboratory, the sample was then suspended in water and mounted directly on a slide, and examined with transmitted light under 400 times magnification, and variable cross-polarisation.

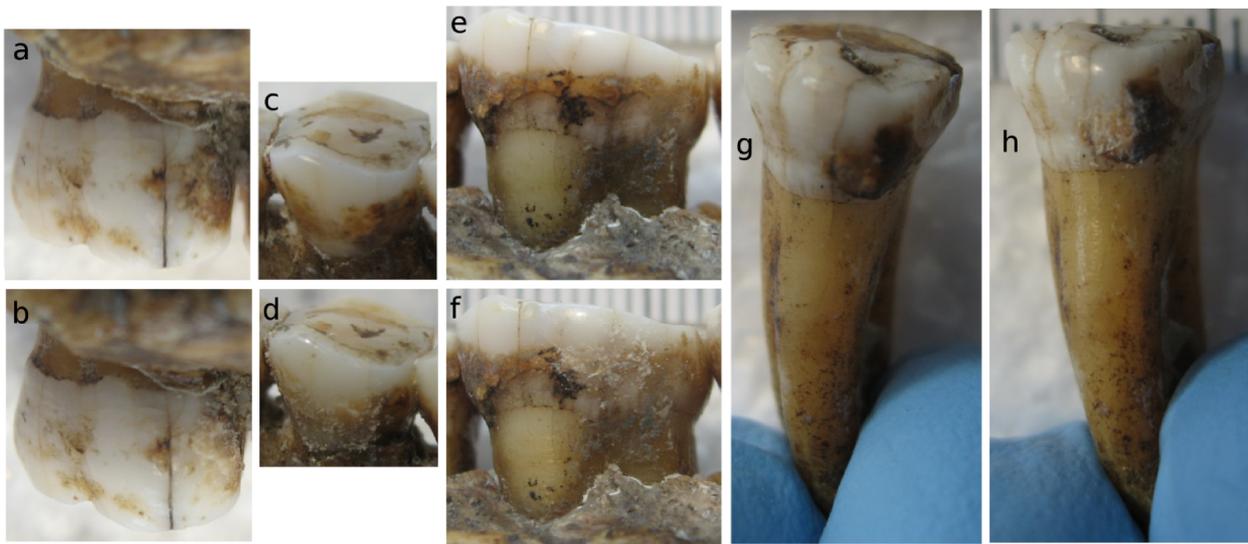


Figure 1. The four sampled teeth from Spy. The top row shows the teeth before sampling, the bottom row shows the teeth after sampling. a,b: the mesio-buccal surface of the right M^3 from fragment #2A of Spy II (#578f); c,d: the lingual surface of the right P_4 from mandible #3 of Spy II (#577i); e,f: the lingual surface of the right M_1 from fragment #12B of Spy I (#580c); g,h: the disto-lingual surface of the left P_4 #11H of Spy I.

Each microfossil was individually described and photographed, and then compared to a reference collection of over 350 plant species. Where possible, plant species, genus, family or general type (e.g. grass seed or underground storage organ [USO]) was identified. Unfortunately, the list of potentially edible wild plant foods from Belgium is much longer than 350 plants, so many of the microfossils could not be confidently identified.

RESULTS

The teeth from Spy produced a large number of microfossils, more than I have recovered to date from any other European Neandertal sample. Both individuals had one tooth that retained many microfossils and one tooth that did not retain as many (Table 1). The most common type of microfossil found on both individuals (Type 1 and Type 1 small) had a

<i>Tooth Number</i>	<i>ID status</i>	<i>Type 1</i>	<i>Type 1 small</i>	<i>Type 2</i>	<i>Type 3</i>	<i>Type 4</i>	<i>Type 5</i>	<i>Type 6</i>	<i>Other</i>	<i>Dmg/Enc.</i>	<i>Totals</i>
Spy II RM ³ #578f	Definite	1						1	1	1	4
	Probable										
Spy II RP ₄ #577i	Definite	15	4	2	1	15	7	3	5	17	82
	Probable	5	3			4	1				
Spy I LP ₄ #11H	Definite					3				1	4
	Probable										
Spy I RM ₁ #580c	Definite	14	7	1	1	2	4	1	3	1*	45*
	Probable	8	3								

* This sample includes a large clump of calculus with up to 30 starches embedded in it. Some of the starches appeared to be similar to Type 1, but others were not. The starches were too encrusted to be accurately identified, and have not been included in the overall counts for this sample.

<i>Type 1</i>	Large, oval to egg-shaped to avocado-shaped, oval in 3D, hilum very eccentric, usually at the thinner end of the oval but sometimes at the fatter end. Hilum is marked with a short transverse fissure. Sometimes are two fissures, one transverse and one longitudinal, sometimes an X-shaped fissure, sometimes no fissures and only a small dimple or faint mark at hilum. Lamellae present and usually quite visible, often most visible at end of grain away from the hilum. Small dimples are occasionally seen. Cross arms are clear and usually smoothly bending across the surface of the grain but on longer grains they sometime bend. Depending on the orientation of the grain the cross can appear X shaped, + shaped or even bird-foot shaped.
<i>Type 1 small</i>	Very similar to Type 1, but grains are much smaller, usually with less-visible lamellae and dimples.
<i>Type 2</i>	Medium, clamshell shaped with off-centre dimpled hilum near bulging long side. No lamellae or other dimples, cross clean, straight arms.
<i>Type 3</i>	Two tightly compound grains, with the juncture between the two unclear. The overall shape is ovoid, while each grain is hemispherical. The hila are centric and unmarked.
<i>Type 4</i>	Small to medium, sub-angular/faceted grains with slightly off-centre dimpled/open hilum, usually but not always marked with a deep single, Y-shaped or stellate fissure, cross arms clean but usually bend over facets. Sometimes two grains are seen still in compounds.
<i>Type 5</i>	Small, spherical to ovoid grains, centre hilum that is sometimes marked with a dimple or dimple and fissure. Cross arms clean and straight across.
<i>Type 6</i>	Large, very irregular, usually ovoid to sub rounded, with deep lines and cracks radiating from the hilum, which is slightly off-centre and usually raised above the rest of the grain. Overall the starch appears to have a "volcano" shape.
<i>Other</i>	A variety of unique/unusual forms that don't fit into the other types.
<i>Dmg/Enc.</i>	A variety of starches that may belong to one of the named types but are too damaged (cracked, broken) or encrusted (covered in calculus material) to be confidently identified.

Table 1. Plant microfossil counts and typology description from the teeth samples from two Spy individuals.

unique, characteristic morphology, implying they came from a single plant species (Figure 2). The ovoid shape, large size, off-centre hilum with distinctive crack, clear lamellae, and features of the polarisation cross identified these starches as being from plant USOs. They share many similarities with the starches from the USOs of waterlilies, but do not match either of the common local waterlily species

(*Nymphaea alba* and *Nuphar lutea*; Figure 3). The next most common type were medium to small, angular/ faceted grains with slightly off-centre hila marked with fissures (Type 4). This type is similar to the starches found in some Panicoid and Chloridoid grass seeds. Type 5 represents a type of starch grain that is found in a variety of plants and thus may represent one or many different plant components in the diet.

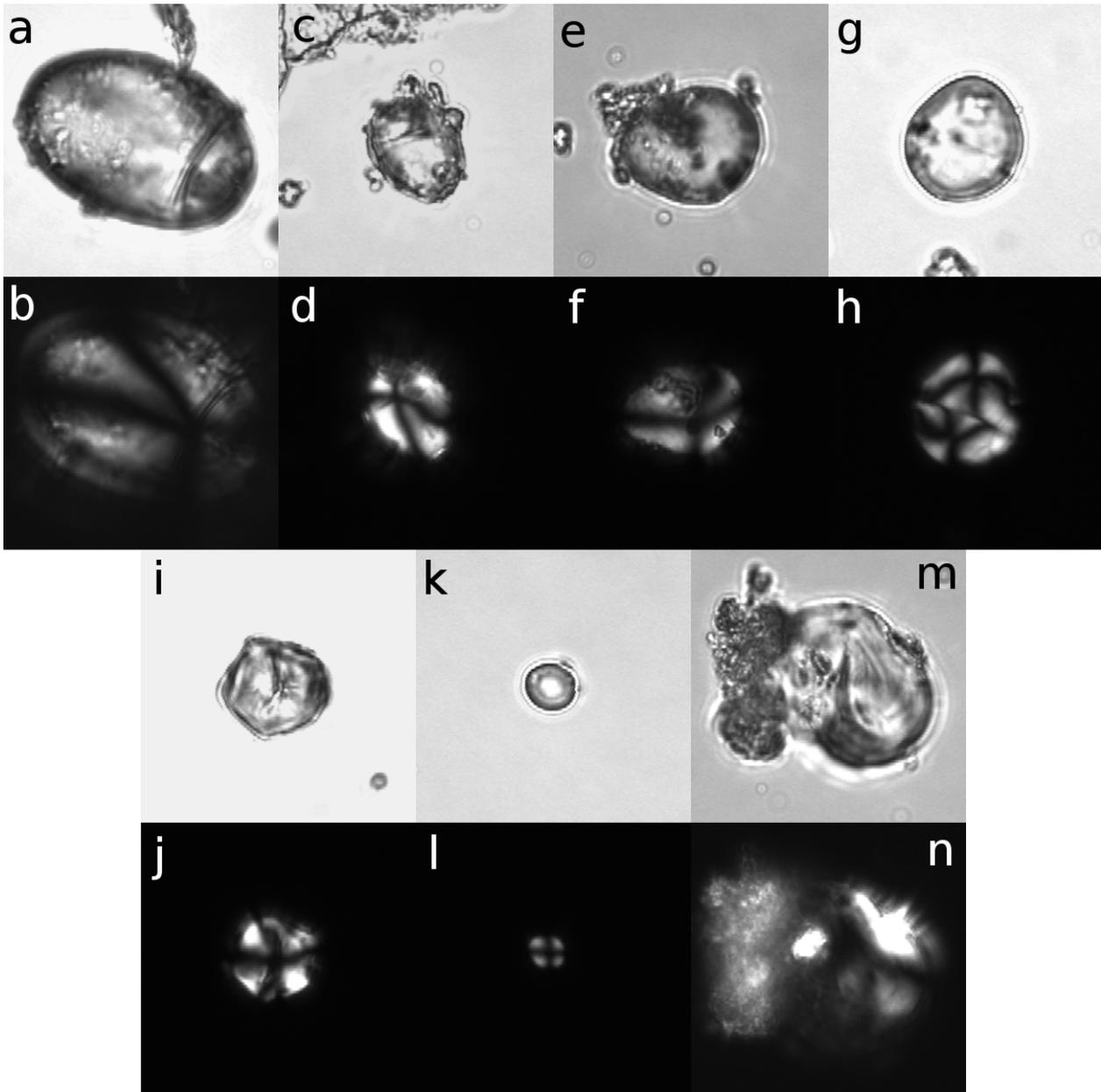


Figure 2. Microfossils recovered from the Spy teeth. The top image of each pair shows the starch grain under normal light, the bottom under cross-polarised light. Each square is 50 μm on a side. a&b illustrate Type 1; c&d: Type 1 small; e&f: Type 2; g&h: Type 3; i&j: Type 4; k&l: Type 5; m&n: Type 6.

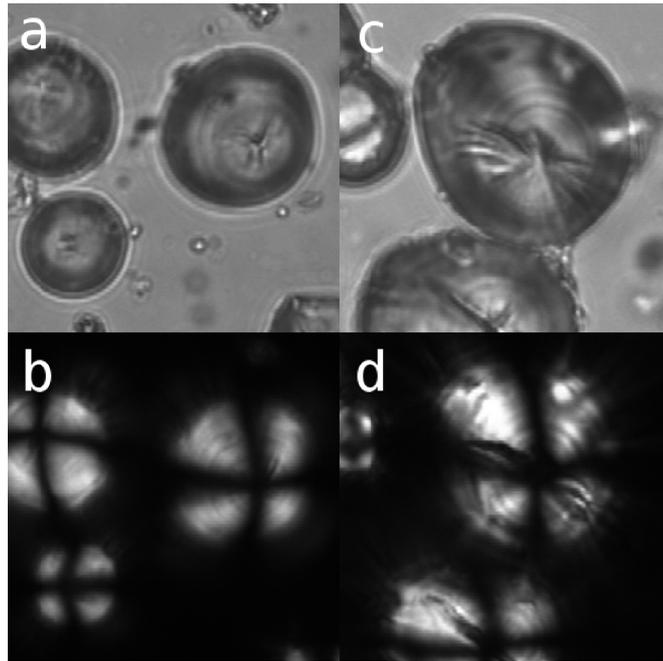


Figure 3. Starch grains from the roots of waterlily species native to Belgium. The top image of each pair shows the starch grain under normal light, the bottom under cross-polarised light. Each square is 50 μm on a side. a&b are from *Nuphar lutea*; c&d: *Nymphaea alba*.

Types 2, 3 and 6, while only in small numbers, are distinctive and each represents a unique, though currently unidentified, plant type. A small number of starches were too damaged or were too covered with other material to be confidently identified. It is interesting to note that of these damaged starches, none showed any of the kinds of damage, such as gelatinisation or cracking, that are distinctive markers of cooking.

The remainder of the starches were provisionally placed into an “other” category. This category includes a variety of forms, including several that may be potentially diagnostic. Despite a large and continually expanding reference collection, the list of potentially edible wild plant foods, even for a cold glacial environment, is quite large (Hardy, 2010) and it is an ongoing task to catalogue the microfossils from these plants. Furthermore, some plants that may have been regularly eaten, like cattails (*Typha latifolia*), have very common starches like Type 5 (small, hemispherical, centre hilum, no lamellae) that can be found in a variety of plants (Messner, 2008) and thus can only be recognised with difficulty.

DISCUSSION

The results above provide strong evidence for the inclusion of at least six, and probably many more, types of plants in the diets of the two Spy adult Neandertals. This demonstrates that these Neandertals made use of a variety of plant foods, despite the extremely cold, glacial environments in which they lived. The abundance of Type 1 starches indicates that this plant type was common and heavily used, suggesting that underground storage organs were an important component of the Spy diet. It is of interest to note that there is no evidence that any of the plant foods were cooked, though it is possible that cooked starch grains are preferentially removed from the oral environment because of their de-crystallised, and therefore more fragile, nature. The use of plant foods by the Spy individuals implies the possibility that plant foods were used across the range of Neandertal environments. Ongoing research into the plant microfossils preserved in dental calculus of Neandertals across Europe and the Near East seeks to address whether plant foods were regularly included in Neandertal diet.

ACKNOWLEDGEMENTS

A.G.H. was supported in part by NSF IGERT 0801634, a Smithsonian Pre-Doctoral Fellowship, a Wenner-Gren Foundation Dissertation Fieldwork Grant, and the Max Planck Society. F. Damblon and A. Chevalier provided Belgian waterlily samples. C. Foltz assisted with the preparation of the modern reference collection. P. Semal and R. Orban provided access to the Spy teeth. The Spy fossils were donated to the RBINS by the family of Professor Max Lohest (1857-1926).

BIBLIOGRAPHY

- DEL PILAR BABOT M., 2003. Starch grain damage as an indicator of food processing. *In: D. M. HART & L. A. WALLIS (ed.), Phytolith and starch research in the Australian-Pacific-Asian regions: the state of the art.* Canberra, Pandanus Press: 69-81.
- DENHAM T. P., HABERLE S. G., LENTFER C., FULLAGAR R., FIELD J., THERIN M., PORCH N. & WINSBOROUGH B., 2003. Origins of agriculture at Kuk Swamp in the highlands of New Guinea. *Science*, **301**: 189-193.
- FROEHLE A. W. & CHURCHILL S. E., 2009. Energetic competition between Neandertals and Anatomically Modern Humans. *PaleoAnthropology*, **2009**: 96-116.
- HARDY B. L., 2010. Climatic variability and plant food distribution in Pleistocene Europe: Implications for Neanderthal diet and subsistence. *Quaternary Science Reviews*, **29**: 662-679.
- HENRY A. G., HUDSON H. F. & PIPERNO D. P., 2009. Changes in starch grain morphologies from cooking. *Journal of Archaeological Science*, **36** (3): 915-922.
- HENRY A. G. & PIPERNO D., 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** (7): 1943-1950.
- KELLY R. L., 1995. *The Foraging Spectrum: Diversity in hunter-gatherer lifeways.* Washington, The Smithsonian Institution Press.
- KUHN S. L. & STINER M. C., 2006. What's a mother to do? The division of labor among Neandertals and modern humans in Eurasia. *Current Anthropology*, **47** (6): 953-980.
- LALUEZA FOX C. & PÉREZ-PÉREZ A., 1994. Dietary information through the examination of plant phytoliths on the enamel surface of human dentition. *Journal of Archaeological Science*, **21** (1): 29-34.
- LINEBACK D. R. & WONGSRIKASEM E., 1980. Gelatinization of starch in baked products. *Journal of Food Science*, **45**: 71-74.
- MESSNER T. C., 2008. *Woodland period people and plant interactions: New insights from starch grain analysis.* Ph.D. Dissertation, Philadelphia, Temple University.

- MULHOLLAND S. C. & RAPP JR. G., 1992. Phytolith systematics: An introduction. In: G. RAPP JR. & S. C. MULHOLLAND (ed.), *Phytolith systematics: Emerging issues*. New York, Plenum Press: 1-14.
- OTTE M., 1979. *Le Paléolithique supérieur ancien en Belgique*. Bruxelles, Musées royaux d'Art et d'Histoire, Monographies d'archéologie nationale, **5**: 684 p.
- PEARSALL D. M., 2000. *Paleoethnobotany: A handbook of procedures*. San Diego, Academic Press.
- PERRY L., DICKAU R., ZARRILLO S., HOLST I., PEARSALL D. M., PIPERNO D. R., BERMAN M. J., COOKE R. G., RADEMAKER K., RANERE A. J., RAYMOND J. S., SANDWEISS D. H., SCARAMELLI F., TARBLE K. & ZEIDLER J. A., 2007. Starch fossils and the domestication and dispersal of chili peppers (*Capsicum* spp. L.) in the Americas. *Science*, **315**: 986-988.
- PIPERNO D., 2006. *Phytoliths: A comprehensive guide for archaeologists and paleoecologists*. Lanham (MD), AltaMira 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** (50): 19622-19627.
- PIPERNO D., WEISS E., HOLST I. & NADEL D., 2004. Processing of wild cereal grains in the Upper Paleolithic revealed by starch grain analysis. *Nature*, **430**: 670-673.
- RICHARDS M. P. & TRINKAUS E., 2009. Isotopic evidence for the diets of European Neanderthals and early modern humans. *Proceedings of the National Academy of Sciences USA*, **106** (38): 16034-16039.
- STINER M. C., MUNRO N. D. & SUROVELL T. A., 2000. The tortoise and the hare: Small-game use, the broad-spectrum revolution and Paleolithic demography. *Current Anthropology*, **41** (1): 39-73.
- STRINGER C. B., FINLAYSON J. C., BARTON R. N. E., FERNÁNDEZ-JALVO Y., CÁCERES I., SABIN R. C., RHODES E. J., CURRANT A. P., RODRÍGUEZ-VIDAL J., GILES-PACHECO F. & RIQUELME-CANTAL J. A., 2008. Neanderthal exploitation of marine mammals in Gibraltar. *Proceedings of the National Academy of Sciences USA*, **105** (38): 14319-14324.

AUTHOR'S AFFILIATION

Amanda G. HENRY
 Plant Foods in Hominin Dietary
 Ecology Research Group
 Max Planck Institute for Evolutionary
 Anthropology
 Deutscher Platz 6
 04103 Leipzig
 Germany
amanda_henry@eva.mpg.de

