Neanderthal self-medication in context

Karen Hardy[1], Stephen Buckley[2] & Michael Huffman[3]

Introduction

In a recent study, Hardy *et al.* (2012) identified compounds from two non-nutritional plants, yarrow and camomile, in a sample of Neanderthal dental calculus from the northern Spanish site of El Sidrón. Both these plants are bitter tasting and have little nutritional value but are well known for their medicinal qualities. Bitter taste can signal poison. We know that the bitter taste perception gene *TAS2R38* was present among the Neanderthals of El Sidrón (Lalueza-Fox *et al.* 2009), and their selection of yarrow and camomile was hence probably deliberate. With few nutritional benefits, reasons must be sought for why the Neanderthals collected and ingested these plants. They could have consumed them as flavouring, but this presupposes a degree of complexity in cuisine for which there is little evidence. The widespread evidence for animal self-medication, or zoopharmacognosy, however, offers an attractive behavioural context. We propose, indeed, that these plants were selected and ingested deliberately for the purpose of self-medication. Here, we investigate the implications of this new finding for Neanderthal knowledge of plants and we offer a context for plant knowledge and self-medication among early human and hominin populations.

Plant remains rarely survive at early prehistoric sites and for many years absence of evidence was largely understood to mean evidence of absence. The lack of evidence for plants, together with the large numbers of animal bones found on many sites (Burke 2000), led to a perspective on Neanderthal diet that was dominated by meat. This appeared to be consolidated by stable isotope analyses since the δ^{15}N values were consistent with a meat-rich diet (Bocherens 2009; Richards & Trinkaus 2009). The potential contribution of plant foods has not, however, been investigated in stable isotope analyses of Neanderthal diet (Trinkaus in Barras 2012). Furthermore, although this method is widely used as a primary indicator of diet, a proportion of the diet can consist of plants without being visible in the stable isotope signal (Jones 2009). A new perspective on Neanderthal diet is offered by the increasing numbers of plant remains recovered from sites and by the development of microscopic and biomolecular techniques which are revealing new evidence for plant foods. We are little further forwards, however, in understanding the extent of plant consumption.

The Neanderthal occupation at El Sidrón dates to between 47 300 and 50 600 BP (Wood *et al.* 2013). This places it in a relatively mild climatic period (Van Andel 2003) and most probably a deciduous forested environment (Huntley & Allen 2003). In addition to yarrow and camomile, the dental calculus study identified an oil shale or bitumen source, a range of different carbohydrates, evidence for cooking, what may have been green vegetables and

Debate

[1] *ICREA, Department of Prehistory, Universitat Autònoma de Barcelona, Bellaterra, 08193 Barcelona, Spain (Email: khardy@icrea.cat)*
[2] *BioArch, University of York, York YO10 5DD, UK (Email: sb55@york.ac.uk)*
[3] *Primate Research Institute, Kyoto University, Inuyama, Aichi 484, Japan (Email: huffman@pri.kyoto-u.ac.jp)*

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nuts, and inhalation of wood smoke or smoked food, but no evidence for meat ingestion despite evidence for collagen survival (Hardy *et al.* 2012).

Yarrow is a flowering plant in the Asteraceae family, common across temperate regions. It was used as a vegetable in the Middle Ages, notably as a component of soup, but has an extended history of medicinal use, in particular as an astringent (Chandler *et al.* 1982). Camomile tea is well-known today as an aid for stomach complaints and nervousness, though there is little record of it as a food. Bioactive constituents are linked to antimicrobial and anti-inflammatory properties (McKay & Blumberg 2006), while its ability to assist with general anxiety disorder has been demonstrated (Jay *et al.* 2009).

The same qualities that make plants medicinal can also make a plant poisonous and are caused by plant secondary compounds (PSCs). These are complex chemicals that are not essential to the life of the plant. The many thousands of PSCs that exist have numerous roles, among them the production of pigments and flavouring substances which are used in cooking. PSCs also include many and diverse natural toxins that act as pesticides and anti-grazing agents (Fraenkel 1959). Bitter taste is linked to certain plant secondary compounds, and bitterness can warn of toxins. Possession of the bitter taste perception gene *TAS2R38,* which permits individuals to taste the bitter compound phenylthiocarbamide (PTC), suggests a predisposition to plant eating (Miller 2011) because the bitter taste can prevent ingestion of potentially toxic substances (Kim & Drayna 2004).

Charred edible plant remains have been found on several Neanderthal sites (Jones 2009) and plant microfossils have been found in samples of Neanderthal dental calculus (Henry *et al.* 2011; Hardy *et al.* 2012). While there is no doubt that Neanderthals ate substantial amounts of meat (Bocherens 2009), they were not obligate carnivores. This means they had to consume something other than meat to counter the high levels of nitrogen which are generated by a high-meat diet (Jones 2009; Hardy 2010).

All animals except obligate carnivores consume plants to a greater or lesser extent and have mechanisms for avoiding toxic PSCs. Wild herbivores avoid certain foods and have metabolic mechanisms to break down or excrete toxins (Freeland & Janzen 1974). Among higher primates, gorillas have enlarged colons which enable higher rates of fermentation to accommodate a fibrous diet of low quality plant fibres and greater processing of indigestible plant secondary compounds than smaller bodied apes (Remis *et al.* 2001; Leonard *et al.* 2007). Humans and other higher primates deal with toxins either by avoidance or through processing. That processing may be conducted in the mouth, for example through bitter pith chewing or wadging (Huffman & Seifu 1989; Huffman *et al.* 1993) or geophagy (Mahaney *et al.* 2005; Klein *et al.* 2008). Alternative strategies are 'timely dextrous unpacking' including peeling and removal of spines, and 'ecological intelligence' (Jones 2009) that allows understanding of when a plant or part of a plant is at its most edible. Among human populations, food processing is largely conducted using external mechanisms. When cooking developed is unknown, but control of fire is certain by 300 000–400 000 years ago (Roebroeks & Villa 2011) and possibly significantly earlier (Carmody & Wrangham 2009), while grinding tools have been recorded at Middle (Van Peer *et al.* 2003) and Upper (Aranguren *et al.* 2007) Palaeolithic sites. Less visible processing methods such as cleaning, peeling, soaking, drying, leaching, salting and fermenting leave no trace but are likely to have a long history and are still widely used in food preparation today.

The care that is needed in the selection and ingestion of plants so as to exclude noxious secondary compounds is essential for survival and requires methods of knowledge transfer. Observation by infants of their mothers' feeding behaviour is an early mechanism of knowledge acquisition (see Huffman & Seifu 1989 for the self-medication context). Socially influenced copying of conspecifics among adults has also been observed among several populations of chimpanzees (Huffman & Hirata 2004; Huffman *et al.* 2010).

In the hominin lineage, the fossil evidence from around 1.8 million years ago indicates a reduction in gut size linked to important changes in the diet with the emergence of *Homo erectus* (Aiello & Wheeler 1995; Snodgrass *et al.* 2009). This led to greater efficiency in processing and digesting food but it also reduced the capability to process and expel toxic PSCs. An increasing sophistication in plant knowledge would have been indispensable from that stage.

Johns (1990) and Huffman (2001) propose that plant processing techniques thereafter came to play an increasingly important role. Cooking and other processing methods help to make food safer, more palatable and more digestible (Carmody & Wrangham 2009; Jones 2009) as well as reducing the effects of toxic PSCs and tannins. The development of language may have speeded the flow of information and ideas. This will have resulted in an increasingly complex knowledge not only of plants but also of their effectiveness in treating ailments, and the processing and preparation methods that could reduce the effects of toxins and make plants more digestible (Huffman 2001; Cousins & Huffman 2002).

Self-medication

Animal self-medication or zoopharmacognosy (Rodriguez & Wrangham 1993) is a huge subject that remains little studied (Engel 2002), but it is clear that most animals from caterpillars (Singer *et al.* 2009) to higher primates (Wrangham 1995; Huffman 1997) practise some degree of self-medication. Parasite expulsion is a primary reason to self-medicate for many species, but evidence also suggests that a wide range of illnesses could be treated, given the diversity of bioactivities found in many of the plant items ingested (Huffman 2001, 2003; Cousins & Huffman 2002; Krief *et al.* 2006; Masi *et al.* 2012).

Identifying deliberate self-medication in animals can be challenging since many food plants also have medicinal qualities and the boundaries between food and medicine can at times be hazy (Huffman 1997). When they are in their known environment, animals are able to keep themselves and their offspring in good health by selecting the 'right' things to eat, which may be specifically chosen to address a health problem (Engel 2002).

Neanderthals must also have selected self-medicating plants when they needed them. They lived in widely fluctuating climatic and environmental regimes with great variability in plant and animal resources. Berries, roots and nuts are good cold climate sources of plant food (Nelson 1899; Jones 2009; Hardy 2010); warmer climates will have provided an even greater availability of edible plant foods. Neanderthals also had the genetic capability for language (Krause *et al.* 2007), practised food processing techniques and probably engaged in conspecific care (Hublin 2009). Their ability to taste, select and use bitter-tasting plants indicates a sophisticated knowledge which fits into the continuum of acquired, essential know-how that occurs very widely across the animal kingdom.

Though all primates (and other animals) have varying levels of enzymes which make us more or less tolerant of certain toxins, there are plants which are poisonous to all; in order to survive, hominins needed to know which plants not to eat and how and when to eat those plants they selected. The use of edible bitter tasting plants by the Neanderthals of El Sidrón suggests their knowledge was sufficiently refined to use plants with confidence even when their bitter taste warned of potential toxicity. This demonstrates that their knowledge of plants was at least equal to today's higher primates; with their additional linguistic and technological abilities it may have been far more elaborate. Rather than contradicting the extensive evidence for consumption of meat, the evidence for the use of plants adds a rich new dimension to our developing knowledge of Neanderthal life. We can never know for sure why yarrow and camomile were ingested at El Sidrón, but we propose that the evidence for self-medication offers the most convincing behavioural context.

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