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Wild plant use in European Neolithic subsistence economies: a formal assessment of preservation bias in archaeobotanical assemblages and the implications for understanding changes in plant diet breadth

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ABSTRACT

In this paper we estimate the degree to which the range and proportion of wild plant foods are under-represented in samples of charred botanical remains from archaeological sites. We systematically compare the differences between central European Neolithic archaeobotanical assemblages that have been preserved by charring compared to those preserved by waterlogging. Charred archaeobotanical assemblages possess on aggregate about 35% of the range of edible plants documented in waterlogged samples from wetland settlements. We control for the ecological availability of wetland versus terrestrial wild plant foods on assemblage composition and diversity, and demonstrate that the significantly broader range of wild plant food taxa represented is primarily a function of preservation rather than subsistence practices. We then consider whether observed fluctuations in the frequency of edible wild taxa over time can also be attributed to preservation, and demonstrate that it cannot; and thus conclude that there are significant changes in plant food diets during the Neolithic that reflect different strategies of land use and, over time, a decreasing reliance on foraging for wild plant foods. The wild species included in our analyses are not spatially restricted—they are common throughout central Europe. We maintain, therefore, that our results are relevant beyond our study area and more generally illustrate the challenges of attempting to reconstruct the relative importance of wild plant foods—and thus plant diet breadth—in Neolithic archaeobotanical assemblages from charred data alone.

1. Introduction: charred plant remains, missing plant foods, and Neolithic subsistence economies

The disparity between the quantity and range of remains preserved in waterlogged and charred form has long been recognised. This is apparent with regard to both crops and wild taxa and, for example, records of waterlogged specimens can outnumber those of charred specimens by hundreds, or even thousands (Brombacher and Jacomet, 1997, Tables 36 and 37; Heer 1865; Jacomet, 2013, 501; Jacomet et al., 1989, Tables 32–34, Figs. 49 and 50; Jacomet et al., 2004, Figs. 84 and 85). Despite this, reconstructions of European Neolithic plant-based diets have unavoidably tended to use the more durable macrofossils, mainly charred seeds and grains of domestic crop species, to make inferences about food choices that emphasise the contribution of cultivars to total diet. Bogucki (2000, 204), for example, states: "The earliest farming communities in north-central Europe grew a suite of crops, including emmer and einkorn wheat, barley, peas, flax and poppy… A recurring set of weeds of cultivation occurs among the carbonized seed samples, but otherwise no wild plants figure prominently in the subsistence of the early farmers." (for further examples see papers in: Colledge and Conolly, 2007; Douglas Price, 2000; Fairbairn, 2000; Milles et al., 1989; Van Zeist et al., 1991). However charred remains represent only a small and biased sample of the edible plant taxa used by Neolithic societies. Our ability to establish the composition and overall contribution of plant-based diets in subsistence is thus biased and inherently limited because of this largely unavoidable reliance on charred macrofossils. Hillman refers to the undetectable component of the diet as the 'missing foods' (Hillman, 1989), and we here present our attempt to identify the extent to which our reconstructions of food choices are biased on the basis of a comparative analysis of waterlogged versus charred plant assemblages from central European Neolithic sites.

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1.1. Formation and interpretation of archaeobotanical samples

In comparison to charring, preservation by waterlogging in anoxic or anaerobic conditions results in less taphonomic bias and the composition of waterlogged samples is likely to resemble more closely the original suites of plants utilised (Jacomet, 2013, 500; Willerding, 1971, 181). There is little or no discrimination (e.g., on the basis of robustness of plant components) as to what is preserved: soft fruits, underground storage organs and leafy vegetables, together with more fragile plant parts, such as pericarp, leaves, flowers, catkins, etc., that rarely survive after exposure to heat remain intact and, by comparison, overall losses are relatively small.

Pétrequin's ethnographic accounts of the deposition and accumulation of debris from daily activities at the pile-dwelling villages of the Toffinu on Lake Nokoué in the Republic of Benin are pertinent to the present study (Pétrequin, 1986). The Toffinu ("men of the water") were previously dryland farmers who subsequently adapted to living on marshes and lakes in pile-dwellings. Pétrequin notes that food waste (including nuts, seeds, grains, shells and fish bones) was thrown into the water through trap doors in floors in the kitchen areas (Pétrequin, 1986, 65). Likewise, human excrement was discharged via openings in houses directly onto the waterlogged sediments below. Rubbish accumulated into dumps that formed artificial islands and use was made of these as small livestock pens. Waste from several families would often form larger islands that provided shelter for larger animals such as cattle. There was a process of sorting on/in the sediments according to density or size of the organic elements ejected from the houses. Pétrequin describes patterns of deposition in layered lenses of a variety of anthropogenic debris at different depths of water such that heavier items (logs, branches) settled further out into the lake and lighter ones closer to the shore (Pétrequin, 1986: Fig. 14). The cycle of deposition of organic materials, accumulation and incorporation in waterlogged sediments continued after houses were abandoned and had collapsed into the water, contents (e.g., tools that were hung from walls) often settled in exactly in the same place as they had done when the houses were occupied.

Changes in the chemical balance of the water or waterlogged sediments (e.g., addition of chemical contaminants, changes in the availability of oxygen or increased acidity or alkalinity) can, however, initiate the decomposition process and also create conditions in which bacteria that cause organic decay are activated (Brinkkemper, 2006; Caple and Dungworth, 1998; Holden et al., 2006). Decomposition of plant materials may be accelerated in near surface sediments, which are more prone to periodic drying-out and higher rates of oxygen diffusion than those at greater depths, however there appears to be no consensus as to whether or not this is the case for all sites (e.g., urban versus rural settlements; Caple and Dungworth, 1998, Section 3.7; Carrott et al., 1996, 7; Jones et al., 2007, 83; Kenward and Hall, 2000; Willerding, 1991, 31). Moreover, waterlogged deposits of plant remains are relatively rare across Neolithic Europe and are restricted to the Alpine lakes and very few other wetland areas in northern Europe (e.g., northern Germany: Kirleis et al., 2012; Kroll, 2007; Netherlands: Kubiak-Martens, 2006, 2012; Out, 2009; Raemaekers et al., 1997; Van Haaster, 2001). Neolithic wells are as rare in central Europe but several structures have been found with stratified waterlogged deposits (e.g., below the water table) and from which diverse assemblages of plant remains have been recovered (Zerl and Herbig, 2012).

Plant materials used as fuels are a common source of charred remains, as are stored products that are destroyed in accidental or deliberate fires (e.g., to dispose of infested crops, or as a result of acts of violence; Van der Veen, 2007, 979). In addition, charred remains typically derive from the unintentional burning of plant foods and plant materials during preparation, processing or cooking (Hillman, 1981, 139–140). Modern charring experiments have demonstrated that the ability of plants to survive is dependent on their morphology (i.e., both physical and chemical) and on the construction, temperature and duration of the fires (Boardman and Jones, 1990; Guarino and Sciarrillo, 2004; Gustafsson, 2000; Märkle and Rösch, 2008; Wilson, 1984; Wright, 2003). Dry seeds with low densities combust more readily when heated and are more likely to survive intact than those that are fresh and have higher densities. Equally likely to survive are specimens with low oil content (Wilson, 1984, 204–205; Wright, 2003, 578). The experiments also demonstrate that plant materials burned in a reducing atmosphere (e.g., buried in the deposits underlying the fire or completely embedded within its fabric) can withstand higher temperatures for longer than under oxidising conditions and that exposure to intense heat over long periods results in the greatest losses (Boardman and Jones, 1990, Fig. 1; Wilson, 1984, Table 6; Wright, 2003, 578). Cereal chaff was shown to be less durable than grains at high temperatures (Boardman and Jones, 1990, 4–6 and Fig. 1); other less robust plant parts, such as soft fruits, leaves, roots/rhizomes/bulbs (etc.), are rarely preserved in charred assemblages (Willerding, 1971, 1991).

The seeds of some species are able to withstand considerable additional heat after charring and prior to total destruction whereas others have a much narrower range of survival and are thus more fragile in charred form. In oxidising conditions, for example, cereals tolerate greater increases in temperature than oil rich seeds such as *Linum usitatissimum* (domestic flax) and *Papaver somniferum* (opium poppy) before being reduced to ash (Boardman and Jones, 1990, 4–5; Märkle and Rösch, 2008, S260–261). The fragility of the plant components is highlighted by the fact that proportional losses after burning have been shown to be great: in experimental firing of hearths and houses between 60 and 80% of cereal grains failed to survive and there were similar, if not greater losses for seeds of wild species (Guarino and Sciarrillo, 2004, Figs. 3, 6 and 11; Gustafsson, 2000, Figs. 3 and 6). Archaeological samples after burning are therefore likely to comprise species with more resilient seeds and the probability is low that their overall composition bears direct relationship to the original taxa proportionality or diversity. Incomplete burning resulting in charring is a means by which only a subset of the plants originally used at a settlement survives and partial destruction is a more apt description of the process than preservation (cf. Wilson, 1984, 201).

In spite of these taphonomic limitations the analytical scope of charred assemblages is considerable. Charred remains dominated by crops (e.g., cereals and pulses) and wild plant species (e.g., mostly those common to cultivated fields) are ubiquitous on Neolithic and later sites across Eurasia (Hillman, 1981; M. Jones, 1984, 1988; Knörzer, 1971, 90–91; Van der Veen, 1992, 77). Their great interpretative strength hinges on the overall representational consistency of crops and wild species, thus facilitating spatial and temporal comparisons between sites or groups of sites (for example, see papers in Colledge and Conolly, 2007). The frequency with which the charred assemblages occur has enabled the development of sophisticated models concerning all aspects of arable farming systems: from the apportioning of responsibilities for production (at inter- and intra-site levels), the type of cultivation systems implemented, the organisation and scheduling of labour, the pre- and post-harvest tending of fields and crops, and the storage, processing and preparation of crops prior to consumption (whether by humans or animals). The basis for the interpretative models is the quantitative assessment of inter-assemblage compositional variability in the proportions of grains, chaff and seeds of wild plants.