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Environment and subsistence in north-western Europe during the Younger Dryas: An isotopic study of the human of Rhünda (Germany)

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ABSTRACT

The human skull of Rhünda in Central Germany is one of the rare human remains belonging to the cold episode of the Younger Dryas or GS-1 based on direct radiocarbon dating (10,200 ± 60 uncal BP GrA-15947). The return of periglacial conditions from northern France to northern Germany favoured the expansion of the reindeer herds, as testified by their numerous remains found at the Ahrensburgian sites. The isotopic composition of the collagen ($\delta^{13}C_{coll}$ and $\delta^{15}N_{coll}$) of the Rhünda individual provides insight into the relative dietary contribution of terrestrial ungulates, such as reindeer, compared to the intake of aquatic resources. The systematic higher $\delta^{13}C_{coll}$ values found for reindeer compared to horse during the Younger Dryas in northern Germany, the Ardennes and south-western England result from a different diet specialization, i.e. the high consumption of lichen by reindeer. The isotopic pattern evidenced in the Pleniglacial reflects such a niche partitioning, while the isotopic pattern of the Late-Glacial Interstadial reveals overlapping ranges in ^{13}C abundances in the different ungulates species, resulting most likely from a decrease in niche diversity. Despite their isotopic variability linked to trophic position and habitat, the freshwater fishes of the Belgian Ardennes show systematic higher $\delta^{15}N_{coll}$ values (6.6 to 11.7‰) than those of the terrestrial ungulates (<5‰) of the same region and surrounding areas. The high $\delta^{15}N_{coll}$ value of the Rhünda human (13‰) can thus be explained by an important consumption of freshwater resources, while the $\delta^{13}C_{coll}$ value (−20.5‰) is too low to consider a significant input of anadromous fishes and their marine-influenced isotopic signature. The application of a Bayesian model confirms this pattern with a minimum contribution of 40% of aquatic resources as protein source for the human diet. In contrast, the input of protein of terrestrial origin hardly exceeded 40% of horse and 20% of reindeer meat consumption. Although existing archaeological and isotopic evidence already suggests a significant use of aquatic resources during the Late-Glacial, the human of Rhünda illustrates an intensive exploitation of the freshwater ecosystem at a time and latitude where the access to palatable plants must have been challenging.

1. Introduction

The use of aquatic resources by hominid groups can be tracked back to the Early and Middle Pleistocene (e.g. Stewart, 1994; Joordens et al., 2009; Braun et al., 2010). The expansion of the diet to include aquatic components can be viewed as a valuable nutritional alternative, favouring brain development and cognitive capacities (e.g. Broadhurst et al., 2002; Cunnane and Stewart, 2010). In Europe, a significant intensification (or at least systematization) of the use of aquatic resources in coastal as well as in inland contexts is recognized in the late Upper Palaeolithic, especially during the last millennia before the onset of the Holocene, which correspond to the Late-Glacial (e.g. Aura et al., 1998, 2002; Adán et al., 2009; Le Gall, 1992; Van Neer et al., 2007).

The broadening of the diet spectrum may be linked to rapidly changing climate and environment with a period of global warming, the Late-Glacial Interstadial (or GI-1; ca. 14,700–12,850 cal BP), followed by one last important cold and arid event, the Younger Dryas (or GS-1, ca. 12,850–11,650 cal BP). The Interstadial witnessed in most parts of north-western Europe the replacement of the large herds of migrating reindeer by smaller groups of sedentary red deer (e.g. Sommer et al., 2008, 2014) and the development of light forest of *Pinus* and *Betula* in replacement of the *Artemisia* dominated steppe-tundra (e.g. Merkt and Müller, 1999; Litt et al., 2001; Ammann et al., 2013; Mortensen

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et al., 2015). This dramatic change could have led the human population to adapt their subsistence strategies by broadening their food resource spectrum (e.g. Le Gall, 1992) and exploiting their environment on a reduced territory (e.g. Aura et al., 1998; Debout et al., 2012).

In contrast, the Younger Dryas favoured the re-expansion of the steppe plant species such as Graminea and *Artemisia* (e.g. Merkt and Müller, 1999; Litt et al., 2001; Ammann et al., 2013), even if they did not necessarily re-occupy former forested areas under more continental conditions (Theuerkauf and Joosten, 2012). The impact of the Younger Dryas was far more pronounced in the higher latitudes of France, Benelux and Germany, regions where the return of periglacial conditions, including permafrost re-expansion, induced the return of reindeer herds in steppe-tundra landscape (e.g. Renssen and Vandenberghe, 2003; Benecke, 2004). Reindeer seemed to significantly contribute to the subsistence of hunter-gatherers of the Ahrensburgian culture in northern Germany and Belgium (Baales, 1996; Bratlund, 1996a), in southern England (Lewis and Rackham, 2011), and potentially in the area of the Dry North Sea. On the other hand, the discovery of fishhooks from northeast Germany and its surroundings directly dated to the Younger Dryas period (Hanik, 2009; Gramsch et al., 2013) raises the question of the exploitation of fish.

Due to its low archaeological visibility, the consumption of fish and other aquatic prey has been investigated using direct trackers such as carbon and nitrogen isotope abundances in bone collagen (e.g. Richards et al., 2001; Drucker and Henry-Gambier, 2005; Bocherens et al., 2007). Indeed, the $\delta^{13}C$ and $\delta^{15}N$ values of the collagen reflect those of the consumed food, especially those with high protein content (Ambrose and Norr, 1993; Tieszen and Fagre, 1993; Jim et al., 2004). Since the plant tissues have lower nitrogen content than animal meat (1% of nitrogen in terrestrial plants against 14% in animal meat; Phillips and Koch, 2002), their impact on the ^{13}C and ^{15}N abundances of the human consumers is not significant unless they represent more than 50% in weight of the diet (see Bocherens, 2009). Interestingly, the majority of modern hunter-gatherers derives 55 to 65% of their food from animal products (Cordain et al., 2000). As a result, the ^{13}C and ^{15}N abundances in collagen of ancient hunter-gatherers inform us on the origin of the animal protein they foraged over the last years of the individual's life (e.g. Hedges and Reynard, 2007; Bocherens, 2009), such as aquatic vs. terrestrial. Indeed, for a comparable trophic position, specimens from an aquatic ecosystem deliver higher ^{15}N abundances than specimens from terrestrial context (e.g. Schoeninger and DeNiro, 1984; Richards and Hedges, 1999; Dufour et al., 1999).

Here we present the results of $^{13}C_{coll}$ and $^{15}N_{coll}$ abundances of the human specimen of Rhünda from Central Germany. The isotopic analysis of this individual provides an insight into the relative consumption of aquatic to terrestrial resources and thus connects archaeological evidences and the use of the exploited resources at an individual scale during the Younger Dryas in north-western Europe. To this aim, we examined the $\delta^{13}C_{coll}$ and $\delta^{15}N_{coll}$ values of faunal remains from archaeological sites as close as possible to the location and dating of the human of Rhünda. An isotopic enrichment in bone collagen of about 0.8 to 1.3‰ in $\delta^{13}C$ values and of 3 to 5‰ in $\delta^{15}N$ values is expected between a consumer and the consumed prey (Bocherens and Drucker, 2003). On the other hand, the isotopic signature of the potential preys depends on their dietary preferences and habitat conditions (e.g. Drucker et al., 2003; Stevens and Hedges, 2004). Hence, the isotopic values obtained on terrestrial herbivores are useful not only as comparative data to reconstruct the diet of the human of Rhünda, but also to reconstruct aspects of the ecosystem of the Younger Dryas.

2. Material and methods

The human of Rhünda was found as an isolated skull on the bank of the river of the same name in Hesse (Germany) after a violent storm in June 1956 (Fig. 1). After being first attributed to a female Neanderthal (Jacobshagen, 1957), the morphological reconstruction by Heberer and Kurth (1963) confirmed that this adult specimen belonged to the species *Homo sapiens*, possibly from the Postglacial period based on indirect dating of surrounding sediment due to the lack of archaeological artefacts (ca. 9000 uncal BP; Jacobshagen et al., 1962). More recently, direct AMS dating was conducted directly on the skull (Rosendahl, 2002) and placed this individual in the Younger Dryas with a result of 10,200 ± 60 uncal BP GrA-15947 (11,695–12,127 cal BP using Calib 7.1 programme based on Intcal13 calibration curve Reimer et al., 2013). A piece of ca. 0.5 g was taken for stable isotope investigation.

We extended the isotopic data set of herbivore collagen of the Younger Dryas of north-western Europe that consisted of seven specimens of reindeer *Rangifer tarandus* (Drucker et al., 2011) and one remain of bison *Bison bonasus* (Bocherens et al., 2015b) directly dated (10,070 ± 50 uncal BP KIA-3331–11,343–11,828 cal BP; Benecke, 2004), all of them coming from the site of Stellmoor in northern Germany (Fig. 1). Additional isotopic data are available for the GS-1 based on direct dating of one horse from Koslar and one reindeer from Kartstein in the Rhineland region, western Germany (Bronk Ramsey et al., 2002; Stevens and Hedges, 2004; Stevens et al., 2008). Several bone remains of horse *Equus* sp. were sampled from the Ahrensburgian assemblage of Stellmoor (n = 4; Bratlund, 1996a), as well as from the Hamburgian occupation of the neighbouring site of Meiendorf (n = 4; Bratlund, 1996b). One of the Ahrensburgian horse (ATV-5 in Table 1) was dated to 10,150 ± 40 uncal BP KIA-48960 (11,690–12,022 cal BP; this work). The additional reindeer bones and one mandible fragment of horse were obtained from the site of Remouchamps located in the Belgian Ardennes (Fig. 1), which provided a significant Ahrensburgian assemblage (Dewez collection; Dewez, 1974). Finally, we selected one horse metapodial from Nichet 2 at Fromelennes (Ardennes, France) that was directly dated to the Younger Dryas chronozone (Bridault, pers. Comm., 2010).

Isotopic analyses of archaeological fish remains are challenging due to their poorer state of preservation in comparison to mammal remains (e.g. Szpak, 2011; Fuller et al., 2012). As a result, higher amounts of bone are necessary for collagen extraction. Unfortunately, small numbers of fish remains are generally present as it is the case of the site of Stellmoor (Heinrich, 2001). So far, the closest geographical and temporal fish material that could be retrieved for this study was coming from the Magdalenian layers of several Belgian sites (Bois-Laiterie, Trou du Sureau, Trou du Frontal, Trou de Chaleux; Van Neer et al., 2007; Fig. 1) corresponding to the early Late-Glacial phase of the end of the cold GS-2a stadial, slightly predating the GI-1e (Sano et al., 2011). The isotopic analyses of three specimens of Atlantic salmon *Salmo salar* from Trou du Frontal were published in Bocherens et al. (2014). Besides some Cyprinidae that could not be identified at the species level (n = 3), we had access to several other species: burbot *Lota lota* (n = 4), nase *Chondrostoma nasus* (n = 1), pike *Esox lucius* (n = 3), and brown trout *Salmo trutta fario* (n = 5). The remains are of anthropogenic origin and come from large individuals with minimum length sizes of 30 cm for the burbot, nase and brown trout, 40 cm for the pike and Cyprinidae, 70 cm for the Atlantic salmon (Van Neer et al., 2007). The represented species include those encountered in the context of the Younger Dryas in northern Germany: mainly pike and burbot at Stellmoor (Heinrich, 2001), mainly pike at Wustermark 22 (Gramsch et al., 2013). When possible, we used a single bone of a given fish species, but in some cases several pieces were combined to obtain the 0.5 g necessary for the collagen extraction.

Collagen was extracted from human and faunal samples following a protocol based on Longin (1971) and modified by Bocherens et al. (1997). In brief, the extraction procedure includes a step of demineralization in HCl 1 M, a step of soaking in 0.125 M NaOH, and a final step of solubilization in acidified water (pH = 2) before the freeze-drying process. The elemental analyses (C_{coll}, N_{coll}) and isotopic measurements ($\delta^{13}C_{coll}$, $\delta^{15}N_{coll}$) were conducted at the Department of Geosciences of Tübingen University using a NC2500 CHN-elemental analyser coupled to a Thermo Quest Delta + XL mass spectrometer. The international