ABSTRACT

This research examines how Neanderthals incorporated the need for raw materials for bone tools into their subsistence strategy. Fauna from the Châtelperronian level Xc of the Grotte du Renne, Arcy-sur-Cure was examined to establish patterns of prey procurement, carcass transportation strategies, carcass processing decisions and the raw material available for use as bone tools. Newly identified tool fragments and published data on tools from level Xc were examined with reference to selection for particular elements or mechanical properties by Neanderthals. Data from Level Xc were compared with the fauna from the Aurignacian site of AbriCellier, Dordogne. Neanderthals and modern humans pursued a similar subsistence strategy, and used similar criteria for selecting particular elements as raw material for bone tools, (with the exception of antler, only used in the Aurignacian). The appearance of bone tools in Châtelperronian and Aurignacian is the archaeological signature of an expansion of subsistence practices to exploit animals for raw materials in the form of bone for tools, and hides for clothing and shelter. The adoption of this new technology is likely the result of independent innovation in response to particular ecological problems related to climatic variation at the onset of the last Glacial Maximum.

KEYWORDS: Châtelperronian, Aurignacian, Subsistence

RESUMEN

Esta investigación examina cómo los Neandertales incorporaron en su estrategia de subsistencia los materiales óseos para la producción de herramientas. Se examinó la fauna del nivel Chatelperroniense Xc de la Grotte du Renne en Arcy-sur-Cure (Francia), afín de determinar los patrones de aprovisionamiento de presas, estrategias de transporte y decisiones de procesamiento de las carcasas, así como las materias primas disponibles para la producción de instrumentos óseos. Se estudiaron fragmentos de instrumentos recientemente identificados y otros previamente publicados procedentes del nivel Xc, teniendo en cuenta la selección de elementos particulares o propiedades mecánicas que hicieron los Neandertales. Se compararon los datos del nivel Xc con la fauna de los niveles Aurinacienses del AbriCellier, Dordoña (Francia). De esta comparación surge que tanto los Neandertales como los humanos modernos seguían una estrategia de subsistencia similar y utilizaban criterios semejantes para la selección de materias primas para la producción de instrumentos óseos (con la excepción de cuernos, sólo utilizados en el Auríñacien). La aparición de instrumentos óseos en el Chatelperroniense y el Aurívñacien es un indicio arqueológico de la expansión de prácticas de subsistencia en la explotación de animales para la obtención de materias primas tales como huesos para la elaboración de instrumentos y cueros para la confección de ropas o abrigos. La adopción de esta nueva tecnología es probablemente el resultado de innovaciones independientes, en respuesta a problemas ecológicos particulares relacionados con la variación climática en el inicio del último máximo glacial.

PALABRAS CLAVE: Chatelperroniense, Aurínacien, Subsistencia

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INTRODUCTION

Compared with later worked bone assemblages from the Mesolithic through the Middle Ages, Upper Palaeolithic bone tool manufacturing techniques are relatively simple and the osseous artifact assemblage is not particularly elaborate (Ramseyer 2004). Bone tool use is known in the Lower and Middle Palaeolithic (e.g. Burke and d'Errico 2008; Soressi et al. 2013; Tartar 2009), evidenced at sites such as Arcy-sur-Cure (Hardy et al. 2014). The presence of bone tools as a consistent part of the toolkit is not documented in the archaeological record in Europe until the Châtelperronian and Aurignacian of the Early Upper Palaeolithic. Bone tools are used for many tasks, including bark scraping and lithic production. Additionally, ethnographic studies indicate that they are frequently used to work fragile materials such as hides and plant material that do not survive in the archaeological record (Barrett and Gifford 1933; Ewers 1945; Lipunova and Miklukho 1996; Soffer 2004; Steinbring 1966). This is further indicated by use wear studies - for example, work on the Châtelperronian tools at the Grotte du Renne have demonstrated intensive use of the awls for hideworking (d'Errico et al. 2003).

Thus, bone tools serve as proxies for “missing elements of technology” (Le Moine 2007:16). In the Châtelperronian and Aurignacian, the presence of bone tools becomes particularly important as a means of examining aspects of Neanderthal and modern human cultural behavior during a period of unstable and increasingly cool climate (Girard et al. 1990; van Andel 2003) that are not directly present in the archaeological record.

Bone tool research for this period has focused on the method of manufacture and possible use (e.g. d'Errico et al. 2003; Julien et al. 2002; Liolios 2003, 2006; Tartar 2009; Tartar et al. 2006). During the Châtelperronian and Aurignacian manufacturing techniques are similar, using grooving, splitting and shaving or abrading to give shape to a tool. The Châtelperronian bone tool assemblage at the Grotte du Renne is associated with Neanderthal fossils and pre-dates any Aurignacian occupation (Bailey and Hublin 2008; Hublin et al. 1996; Hublin et al. 2012; Welker et al. 2016). Given the production of bone tools in the Châtelperronian at Arcy-sur-Cure, Neanderthals clearly had the capacity to work bone, but the nature of the performance may differ from the production of bone tools in the Aurignacian. Within the Aurignacian, production of bone and antler tools by modern humans appears to have been differentiated into separate spheres of manufacture and production associated with different groups of tasks, such as bone tools for hide working and bark removal and antler points for hunting (Tartar et al. 2006).

This paper will discuss datasets from the Grotte du Renne and Abri Cellier focusing on a different aspect of bone tool production, specifically the acquisition of the raw material itself. It will explore the choices made by Neanderthals and modern humans at these sites in terms of transportation and support selection. Ethnography, ethnoarchaeology and experimental studies indicate that bone tool manufacture and technology require specialist knowledge of the properties of bone and antler, and manufacturing techniques that utilize these properties (Currey 1979; MacGregor 1985; MacGregor and Currey 1983; Margaris 2009, 2014; Scheinsohn and Ferretti 1995). The manufacture of bone tools for specific purposes requires elements or supports that have particular mechanical properties. These may be obtained as part of the general subsistence pattern through hunting, or could be acquired as a part of a logistical pattern, where particular elements were required for particular tools, or were only seasonally available, as is the case for antler. This raises some interesting questions. Did the introduction of formal bone tool technology result in any changes in carcass transportation and processing decisions? In other words, were particular taxa preferably targeted for use as a source of particular skeletal elements that were preferred for toolmaking, or were bone tool supports derived from the carcasses of animals hunted for subsistence? Further, did the Neanderthals at the Grotte du Renne and the modern humans at Abri Cellier make similar or different choices in transportation of raw material and tool support selection?
The Grotte du Renne is one of a series of solution caves found on the southern face of the Massif d’Arcy overlooking the River Cure in Burgundy, France. The cave contains a sequence of levels defined by cave sediments: Mousterian (Levels XIV through XI), Châtelperronian (X through VIII), Aurignacian (VII), Gravettian (VI, V) and Solutrean (IV) (David et al. 2001; Schmider 2002). Level Xc represents the earliest Châtelperronian occupation, and was found in a thin (5cm deep) blackened sandy-clay matrix. Recent radiocarbon dates indicate that the Châtelperronian occupation began between 39,000 and 40,000 BP and lasted until 35-36,000 BP (Hublin et al. 2012). The fauna from Level Xc indicate a cool, open environment, dominated by reindeer (Rangifer tarandus) with smaller numbers of horse (Equus caballus), large cervids such as red deer (Cervus elaphus) and bovids (David and Poulain 1990; David et al. 2001; Farizy 1990). The occupation is interpreted as a winter camp, with construction of tents or windbreaks, and evidence of time investment in leveling and cleaning the sites. This implies a long-term occupation that could produce a larger sample of artifacts than a shorter-term campsite or hunting camp. The Grotte du Renne is one of the most northerly Châtelperronian sites and is relatively late in date.

The Grotte du Renne remains controversial because it is the richest assemblage of worked bone and bone and ivory ornaments known for the Châtelperronian (Pelegrin and Soressi 2007). The assemblage is rare but not unique, as though still unpublished, bone tools have been reported from the Châtelperronian contexts at Quinçay (d’Errico et al. 2003). The Châtelperronian of the Grotte du Renne is noteworthy for the relatively large number of worked bone tools recovered (David et al. 2001; Farizy 1990). Over 120 bone or ivory tools or ornaments are known from Levels X and IX (Baffier and Julien 1990). Forty-four tools from the Level X assemblage were recovered from Level Xc, and included awls and worked ivory (Baffier and Julien 1990; d’Errico et al. 2003). The appearance of a developed worked bone industry has caused researchers to argue that the assemblage is the product of post-depositional mixing (Higham et al. 2010; White 2001). However, the lithic assemblage does not indicate any significant post-depositional disturbance (Caron et al. 2011) and radiocarbon dates on cut-marked bones have produced a coherent set of clustered dates for the three Châtelperronian levels (Hublin et al. 2012).

### Table 1. MNI and NISP for mammals identified in level Xc at the Grotte du Renne.

<table>
<thead>
<tr>
<th>Genera</th>
<th>MNI</th>
<th>NISP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reindeer (Rangifer tarandus)</td>
<td>14</td>
<td>875</td>
</tr>
<tr>
<td>Cave Bear (Ursus speleus)</td>
<td>7</td>
<td>134</td>
</tr>
<tr>
<td>Horse (Equus caballus)</td>
<td>4</td>
<td>206</td>
</tr>
<tr>
<td>Hyena (Crocuta sp.)</td>
<td>3</td>
<td>64</td>
</tr>
<tr>
<td>Bovids (Bos/Bison sp.)</td>
<td>2</td>
<td>22</td>
</tr>
<tr>
<td>Red deer (Cervus elaphus)</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>Hare (Lepus sp.)</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Wolf (Canis lupus)</td>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td>Mammoth (Mammuthus sp.)</td>
<td>1</td>
<td>61</td>
</tr>
<tr>
<td>Felids (Panthera)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>38</td>
<td>1389</td>
</tr>
</tbody>
</table>
bovids (Bos/Bison sp.), horse (E. caballus), red deer (C. elaphus), hare (Lepus) and mammoth (Mammuthus sp.). Omnivores and carnivores were also present and included cave bear (Ursus speleus), wolf (Canis lupus), hyena (Crocuta sp.) and a large felid (Panthera sp.) (David and Poulain 1990; Tolmie 2013). A total of 1,390 specimens were identifiable to species or genus (875 reindeer, 206 horse 22 bovid, 8 red deer, 7 hare, 134 cave bear, 64 hyena, 12 wolf, 1 large felis and 61 mammoth) (Table 1). Mammoth was represented by ivory fragments, plus a third phalange. Another 19,366 specimens could not be identified. Of these 17,422 were <2.5cm in size. When MNI were calculated, there were 14 reindeer and 7 horse (Table 1). Five of the seven cave bear were cubs, represented by milk teeth, that left a hibernation den. The two adult bears represent acquisition by Neanderthals present at the site (Bailey and Hublin 2008; Welker et al. 2016).

Taphonomic studies indicate that Neanderthals were the primary bone accumulators at the site and the major agents of bone damage and destruction. Carnivores played a minor role as bone accumulators (Tolmie 2013). Gnawing is present on less than 70 items (5% of total NISP) and damage from digestion is only present on 4 items (0.2% of the NISP). No digested bone was found in the 1810 unidentified bone fragments >2.5cm in size (Tolmie 2013). Weathering damage (Behrensmeyer 1978) is light, occurring on 41% of elements >2.5cm, with the majority showing minor damage. There is no significant correlation between bone density and deletion of elements for horse or reindeer, the dominant species in the assemblage in terms of MNI and NISP (Tolmie 2013). Bone may have been deleted by combustion. Only 25 identified specimens (1.8% of NISP) show evidence of heat alteration, but 42% of small bone fragments less <2.5cm in length are burnt, indicating that bones were reduced to unidentifiable fragments (Tolmie 2013). The fauna is highly fragmented - only 7% of the reindeer bones are intact and these were all small, dense bones. All post cranial horse elements are fractured. Fresh breaks are also present on bovid, red deer and bear long bones. Figure 1 shows the proportions of fresh, undetermined and dry breaks for reindeer and horse (undetermined breaks are those which lacked a clear spiral fracture, but also lacked the characteristics of a dry break). Evidence for butchery was observed on at least one element for each herbivore taxon, with the exception of red deer. Cut marks on herbivores are consistent with processing for meat, sinew and hide (Tolmie 2013). Cutmarks were present on 160 reindeer elements, 16 horse elements, and one bovid element (Table 2).

The cutmarks on the hyena carpals and tarsals and tarsals and phalanges of cave bear suggests hide removal. The wolf tarsals and carpals are unmarked, however the dominance of lower limb bones suggests the presence of pelts with lower limbs attached (Table 2) (Tolmie 2013). Differences in transportation of herbivore carcasses are apparent when axial and appendicular elements are examined. All axial and appendicular elements are represented for reindeer. In contrast, the horse
assemblage is dominated by crania and lower parts of the appendicular skeleton (Tolmie 2013). Element selection strategy (derived from Binford 1978) found that a generalist or unbiased strategy was practiced for reindeer when the General Utility Index (GUI) was calculated, but element selection strategy for horse showed a focus on elements that have low Food Utility Index (FUI) scores (Outram and Rowley-Conwy 1989), but are strongly correlated with high grease indices (Tolmie 2013). There were too few bovid and red deer elements present to calculate selection strategy. Elements present suggest that horse were subjected to initial processing for meat at or near the kill site, and only elements requiring further processing were transported to the site (Tolmie 2013). Transportation decisions are the product of a complex of factors that can result in larger carcasses being partially processed for meat at or near the kill site and limb elements requiring additional processing being transported to the camp or home base (Binford 1978; Monahan 1998; O'Connell et al. 1988,1996).

Fragmentation patterns and survivorship rates reflect destruction of elements with high marrow or grease indices. All reindeer long bones are processed for marrow. All horse bones are broken – the metapodials for marrow and the other long bones for processing for white grease (Binford 1978; Costamango 2013; Tolmie 2013). Clearly the prime focus in transportation decisions for herbivores reflects the need to further process portions of the carcass to obtain fat (marrow and bone grease). The only large omnivores present, the adult cave bears, were processed in a manner similar to herbivores for meat, marrow and hide. In contrast, carnivores present were processed for hides (Tolmie 2013).

Of the identifiable remains, reindeer and horse carcasses, particularly reindeer ulnae, humeri, tibiae and metapodials, and horse stylets supplied the majority of the raw materials for bone tools (Table 3). These elements were initially processed for marrow and subsequently adapted for tools. All of these elements were transported to the site as part of a pattern of systematic carcass processing. While there appears to be some selection of particular elements for tools, there does not appear to be strong preference for any taxon as a source or raw material. The most common taxa present, reindeer and horse, furnished the majority of the supports.

This analysis identified five tools, including two fragments of proximal right reindeer tibia. The proximal articular surfaces had been removed and the exposed cancellous bone is flattened and smoothed and exhibits a high degree of polish. The smooth polished surface and high degree of polish indicates use as a tool (M. Julien pers comm to C. Tolmie) (Figure 2). Three diaphysis fragments were also identified as tools (Figure 3). These were flaked, a manufacturing technique reported for Mousterian bone tools. All were made on the diaphysis of large mammals, with retouch along one or more edges (Tolmie 2013).

There is a strong preference for reindeer and horse ulnae and auxiliary bones for awls, which were also manufactured on medium and large mammal.

### Table 2. Location of cutmarks by species and element for fauna from Level Xc, Grotte du Renne.

<table>
<thead>
<tr>
<th>Tool</th>
<th>Stylet (E. caballus)</th>
<th>Reindeer (R. tarandus)</th>
<th>Hyena (Crocuta sp.)</th>
<th>Carnivore</th>
<th>Unid</th>
<th>Total</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>Awl</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>Awl</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>4</td>
<td>Awl</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>Lissoir</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>Awl</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>33</td>
<td>35</td>
<td>Awl, lissoir, unkown</td>
</tr>
<tr>
<td>Total</td>
<td>4</td>
<td>10</td>
<td>3</td>
<td>1</td>
<td>33</td>
<td>51</td>
<td></td>
</tr>
</tbody>
</table>
longbone fragments (Table 3). Experimental studies have demonstrated that bones used for the manufacture of awls, tools that require a high degree of penetration without impact, should be strong and stiff, i.e. with a high E, Young’s modulus (Margaris 2009, 2014; Scheinsohn and Ferretti 1995). Elements used in awl manufacture in level Xc are all from weight-bearing limb bones that would meet the required mechanical properties. Limb bones of herbivores need both stiffness to support the body and also need to resist impact and stresses (Currey 1979). The two reindeer tibiae used as tools were likely chosen for these qualities. Preferences indicate knowledge of the mechanical properties of bones with preferences for elements that could withstand the stresses of penetration without impact and tolerates some pressure and stress, no medullary bones or limb bones. While the elements chosen for supports show preferences for “preforms” and certain mechanical properties, there is no evidence for deliberate transportation of these particular elements to the site for use as tools.

<table>
<thead>
<tr>
<th>Stylet</th>
<th>Horse (E. caballus)</th>
<th>Reindeer (R. tarandus)</th>
<th>Hyena (Crocuta sp.)</th>
<th>Carnivore</th>
<th>Unid</th>
<th>Total</th>
<th>Tool</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2</td>
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<td>Awl</td>
</tr>
<tr>
<td>Metapodial</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>Awl</td>
</tr>
<tr>
<td>Fibula</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>Awl</td>
</tr>
<tr>
<td>Radius</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>Awl</td>
</tr>
<tr>
<td>Tibia</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>Lissoir</td>
</tr>
<tr>
<td>Ulna</td>
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<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>Awl</td>
</tr>
<tr>
<td>Unidentified</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>33</td>
<td>35</td>
<td>Awl, lissoir, unknown</td>
</tr>
<tr>
<td>Total</td>
<td>4</td>
<td>10</td>
<td>3</td>
<td>1</td>
<td>33</td>
<td>51</td>
<td></td>
</tr>
</tbody>
</table>

Figure 2. Tools made on proximal tibia identified during the faunal analysis 61A6.2852; A61.55N.

Table 3. Elements used as tool supports from Level Xc of the Grotte du Renne (d’Errico et al. 2003; Tolmie 2013).
The high degree of processing of skeletal elements indicates the primary focus of the occupants of Level Xc was to maximize the nutritional value of herbivore carcasses. The supports are either “riders” to bones valued for marrow (Binford 1978) that were transported to the site or derived from elements split to obtain marrow. The use of reindeer and horse elements is consistent with the dominance of these two species in terms of both MNI and NISP. The supports appear to be the by-product of quotidian subsistence practices.

ABRI CELLIER, DORDOGNE

Abri Cellier is a large rock shelter located on the east slope of a limestone ridge overlooking the confluence of a minor drainage and the Vézère River, Dordogne, France. The site overlooks a sharp bend in the Vézère, and is well placed to monitor the movement of game along the river and also the small valley that leads to the uplands. Excavations undertaken in the early 20th century found evidence of a sequence of occupations from the Mousterian through the Aurignacian (Peyrony 1946). Two Aurignacian levels were excavated within the rock shelter in 1927 by the Logan Museum of Anthropology, Beloit College, Wisconsin (Collie 1928; Nesbitt 1928). Site location and the faunal remains suggest that the site served as a short-term occupation camp to exploit nearby resources. The site was excavated in two levels, although the excavators suggested a palimpsest of occupation levels, particularly during the Aurignacian I (Collie 1928; Nesbitt 1928). The lower, thicker, level dates to the Aurignacian I, and the thinner upper level to the Aurignacian II (Woods 2011). No radiocarbon dates are available for the material. In line with archaeological approaches of the time, there is a strong excavator bias towards formal stone tools, identifiable large bone fragments and bone and antler tools. Bone and antler tools were analyzed by White and Knecht (1992) and the lithics by Woods (2011). The unworked faunal material remained unanalyzed apart from an initial brief description by Nesbitt (1928) until this study (Tolmie 2013). A total of 1279 faunal elements (including modified teeth and worked items) are known from Abri Cellier, of which 1199 were excavated and are held at Beloit College. Another 60 specimens were recovered during test excavations by Peyrony and are held at the Musée National de Préhistoire, Les Eyzies, France. These 60 items had little or no stratigraphic information and are not included in the analysis and discussion below, which focused on the Beloit material. In the Beloit Collection, 832 of the 1279 elements were identified. Approximately 60% of the Aurignacian II and 80% of the Aurignacian I fauna was identifiable to genus or species (Tolmie 2013). Although the
excavators are reported to have only collected potentially identifiable bones (mostly teeth and proximal or distal ends of long bones) and bone and antler tools, a high proportion of unidentified bone fragments were noted in the lower Aurignacian I level of the site (Nisbett 1928).

Herbivores dominated the faunal assemblage: reindeer (R. tarandus), horse (E. caballus), red deer (C. elaphus), bovidae (Bos/Bison sp.), saiga (Saiga tatarica), hare (Lepus sp.), and mammoth (Mammuthus sp.). The Aurignacian I fauna was dominated by reindeer (MNI=8), followed by horse (MNI=3), saiga (MNI=2) and bovid (MNI=2) (Tolmie 2013). The Aurignacian II fauna was dominated by bovid (MNI=7), red deer (MNI=6), horse (MNI=4) and reindeer (MNI=4) were also identified. Other taxa were represented by single individuals (Table 4).

Non-herbivores in the assemblage comprise bear (Ursus sp.), wolf (C. lupus), fox (Vulpes sp.), and waterfowl (Anatidae). Bear (MNI=1) fox (MNI=2) and wolf (MNI=1) were present in the Aurignacian II. In the Aurignacian I, only wolf (MNI=1) was present (Tolmie 2013). The majority of these non-herbivores are represented by teeth modified for suspension. Bird long bones from waterfowl were only recovered from the Aurignacian I level - all but one are modified.

Bone preservation was good, with some post-excavation damage present in the form of modern breaks (approximately 6%). Only 20% of bone breaks were dry, and the remainder were fresh (51%) or indeterminate (22%). Weathering was present on 29% of the elements in the collection but the majority of the bones exhibited Behrensmeyer’s (1978) weathering stages 2 or 3. There was no statistical evidence for density mediated attrition on reindeer elements from either level but this was operating on horse and red deer elements in the Aurignacian II level (Tolmie 2013). The reason for this difference in preservation is unclear at this time.

There is very little evidence for carnivores as bone accumulators: 11 items from the Aurignacian I and 12 from the Aurignacian II show evidence of carnivore damage. Damage is most common on reindeer phalanges, and on unidentified mammal bone fragments. The damage patterns suggest the scavenging of butchered items (Tolmie 2013). Little burnt or heat altered bone is present, although the excavators noted the presence of hearths in both levels (Nesbitt 1928).

All large herbivore carcasses (with the exception of mammoth) were processed at or near the site, with both axial and appendicular elements present in the assemblage. Breakage patterns on long bones indicate processing for marrow, but the excavation sampling strategy has resulted in underrepresentation of shaft fragments. Cutmarks are considered indicative of meat removal and carcass disarticulation (Tolmie 2013).

<table>
<thead>
<tr>
<th>MNI</th>
<th>NISP</th>
<th>MNI</th>
<th>NISP</th>
<th>MNI</th>
<th>NISP</th>
<th>MNI</th>
<th>NISP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reindeer (R. tarandus)</td>
<td>8</td>
<td>153</td>
<td>4</td>
<td>73</td>
<td>--</td>
<td>14</td>
<td>240</td>
</tr>
<tr>
<td>Horse (E. caballus)</td>
<td>3</td>
<td>77</td>
<td>4</td>
<td>68</td>
<td>--</td>
<td>0</td>
<td>145</td>
</tr>
<tr>
<td>Bovids (Bos/Bison sp.)</td>
<td>2</td>
<td>16</td>
<td>7</td>
<td>78</td>
<td>--</td>
<td>1</td>
<td>95</td>
</tr>
<tr>
<td>Saiga (Saiga tatarica)</td>
<td>2</td>
<td>29</td>
<td>1</td>
<td>7</td>
<td>--</td>
<td>0</td>
<td>36</td>
</tr>
<tr>
<td>Fox (Vulpes sp.)</td>
<td>2</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>--</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Bird (Anatidae)</td>
<td>1</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>--</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Red deer (C. elaphus)</td>
<td>1</td>
<td>8</td>
<td>6</td>
<td>44</td>
<td>--</td>
<td>0</td>
<td>52</td>
</tr>
<tr>
<td>Hare (Lepus sp.)</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>--</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Wolf (C. lupus)</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>--</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Wild boar (Sus scrofa)</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>--</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Bear (Ursus sp.)</td>
<td>1</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>--</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Cervids (Cervidae)</td>
<td>0</td>
<td>153</td>
<td>--</td>
<td>77</td>
<td>--</td>
<td>11</td>
<td>241</td>
</tr>
<tr>
<td>Mammoth (Mammuthus sp.)</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>--</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>23</td>
<td>456</td>
<td>25</td>
<td>352</td>
<td>--</td>
<td>26</td>
<td>834</td>
</tr>
</tbody>
</table>

Table 4. MNI and NISP for taxa identified in the Abri Cellier fauna held at Beloit College. MNI were not calculated for elements with unknown provenience.
Only three tools (made on long bone fragments and a horse metapodial) are recorded for the Aurignacian II levels. The majority of the bone tools were recovered from the Aurignacian I assemblage. Reindeer and horse supplied the supports for bone tools (Table 5). Tools were made from reindeer: metacarpals, metatarsals, an ulna, a radius and a residual metapodial. The Aurignacian also used horse stylets and a horse metapodial. Horse and bovid incisors were drilled for suspension. One red deer ulna shows some indications of working, being slightly reshaped by shaving, and with a high degree of polish on the distal end (Tolmie 2013; White and Knecht 1992). Antler was also used for tool manufacture: 153 antler tools or fragments from the Aurignacian I, and 71 tools or fragments in the Aurignacian II. The antler for these tools was sourced from reindeer and red deer, with the majority probably derived from reindeer.

Two unusual tools were identified during the present study: a modified bovid horn-core and a highly polished and modified wolf ulna (Tolmie 2013). The horn core (Figure 4) appears to be an ad-hoc tool, with minimal shaving on the distal end of the core to thin the tip to a flat, even edge. In contrast, the wolf ulna (Figure 5) identified using comparative osteological material at the Museum of Natural History, University of Iowa, had clearly been curated and used for some time. The element was heavily worn, resulting in a rounded distal end of the bone exposing the medullar cavity. The inter-osseous crest was partially worn away towards the distal end, and the obverse side was very smooth and flat.

As noted above, only three worked bone fragments


<table>
<thead>
<tr>
<th>Tool Type</th>
<th>Reindeer (R. tarandus)</th>
<th>Red deer (C. elaphus)</th>
<th>Bovid (Bovidae)</th>
<th>Horse (E. caballus)</th>
<th>Wolf (C. lupus)</th>
<th>Bird (Anatidae)</th>
<th>Unid</th>
<th>Total</th>
<th>Tool</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crania</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>Retoucher</td>
</tr>
<tr>
<td>Stylet</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Awl</td>
</tr>
<tr>
<td>Metapodial</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>7</td>
<td>Awl</td>
</tr>
<tr>
<td>Ulna</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>Awl</td>
</tr>
<tr>
<td>Res. Metapodial</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>Awl</td>
</tr>
<tr>
<td>Rib</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>Lissoir</td>
</tr>
<tr>
<td>Unid.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>39</td>
<td>41</td>
<td>Lissoir, awl</td>
</tr>
<tr>
<td>Total</td>
<td>8</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>42</td>
<td>57</td>
<td></td>
</tr>
</tbody>
</table>
were present in the Aurignacian II. Tools from the Aurignacian I of Abri Cellier were made on a diverse range of supports. Lissoirs were made on split ribs from large mammals, awls on reindeer ulnae, metatarsals and metacarpals; two horse stylets and a metatarsal were worked. Bird long bones served to make fine awls and tubes. A number of tools were made on long bone fragments of large and medium sized mammals (White and Knecht 1992). It seems that, as at the Grotte du Renne, bones were selected largely for penetration without impact (i.e. longbones and bones lacking medullary cavities) and their ability to withstand the application of pressure (ribs).

Element choice and raw material procurement
As consistent choices are made for tool supports at both sites, I would argue that in Grotte du Renne, and Abri Cellier manufacturers were aware of the mechanical properties, size and shape of elements they selected and utilized them accordingly (Figures 6 and 7). The identifiable bones chosen are “preforms” and required minor modifications to function as tools. The number of tools relative to the MNI of taxa or NISP of elements present indicates that supports were obtained as part of quotidian subsistence practices: Reindeer and horse lower limb bones dominate the Xc fauna and the Aurignacian I at Abri Cellier and supply the majority of supports. In the Aurignacian II at Abri Cellier, when bovids and red deer dominate the fauna, tools are made on long bone fragments. The osseous industries are consistent with previously analyzed materials for the Châtelperronian and Aurignacian: no antler tools are present in the Châtelperronian levels at the Grotte du Renne, but there are numerous antler points and other tools in the Cellier material. Tines cut from the beam, beam fragments and a shed antler represent all stages of tool production (Doyon 2013). These tools, split based points, wedges and chisels, were used for purposes that required resistance to impact (Margaris 2009; Tartar et al. 2006).

Studies suggest that regular manufacturers of bone tools had a clear understanding of the properties of the different bones used to manufacture tools for different tasks (Buc 2011; Le Moine 1991; Scheinsohn 2010). Metapodials appear to be favored for tool manufacture in many different archaeological and ethnographic cultures. The preference for metapodials could also relate to bone resilience, ease of handling and the ease of access to the material. Ethnographically and archaeologically, raw material for bone tools is...
a by-product of processing animal carcasses for meat and hides across a wide range of economic systems (Scheinsohn 2010). Some exceptions are documented, when bone or antler is suitable for particular tasks and it is not locally available (Margaris 2014; Stenton 1991).

Experimental studies have demonstrated that bones used for the manufacture of tools that require a high degree of penetration without impact, such as awls, defleshers or bark removers, should be strong and stiff (i.e. with a high E, Young’s modulus, see Margaris 2009, 2014; Scheinsohn and Ferretti

Figure 6. Reindeer (R. tarandus) elements used for tool manufacture in Level Xc, Grotte du Renne (left) and Abri Cellier (right).

Figure 7. Horse (E. caballus) elements used for tool manufacture in Level Xc, Grotte du Renne (left) and Abri Cellier (right).
1995). As noted above, there is a strong preference for reindeer and horse ulnae and auxiliary bones for awls at the Grotte du Renne Level Xc, and a similar preference for metapodials and non-medullary long bones at Abri Cellier. Tools were also manufactured on mammal long bone fragments at the Grotte du Renne, and on bird long bones at Abri Cellier. These are all bones that are strong and stiff, but brittle and therefore unable to withstand sudden impact (Margaris 2009). There is no indication of deliberate procurement of particular bones for tools, but the best raw material available from quotidien hunting behavior was used. Antler present at Abri Cellier may or may not be a by-product of the same behavior. These patterns are consistent with data collected by other researchers (Julien et al. 2002; Liolios 2003; Stettler 2000; Tartar 2009; Tartar et al. 2006) for the Early Upper Palaeolithic. Data from Tartar (2009) further emphasizes that bone tools supports were a by-product of carcass processing. In her review of bone tools from four Aurignacian sites (Castanet Sud, Castnet Nord, Brassemposy and Gatzarria) many of the supports were from meat-rich and fat-rich bones, or from “riders” transported with these elements (Binford 1978; Tartar 2009). These sites had a rich, well preserved faunal assemblage and are early Aurignacian in date, providing a large sample to compare with data presented in this paper. As at the Grotte du Renne and Abri Cellier, the selection of supports is a product of the dominant prey animals: horse and reindeer at Castanet and Brassemposy, bovids and red deer at Gatzarria (Tartar 2009). At Castanet, awls were made on the residual metapodials (stylets) from horse, which are ideal ‘preforms’ for awls. Awls at Brassemposy were made on residual phalanges of reindeer and on an ulna. In contrast, at Gatzarria awls were made on fragments of long bones from the larger prey species.

The major difference in the two assemblages discussed in this paper is the presence of antler tools in the Aurignacian levels of Abri Cellier, and the absence of worked antler in the Châtelperronian. Antler is a seasonally available raw material. Among modern and recent hunter-gatherers antler could be obtained through hunting or shed antler collected as part of a logistical foraging strategy (Stenton 1991). Did the occupants of Abri Cellier need to collect antler, or could the material also be a by-product of hunting? Aurignacians produced predictably sized blanks by cutting the beam into sections and then splitting the segments (Tejero et al. 2012). Experimental data for red deer antler found that inexperienced antler workers could produce 13 blanks from 2 beams (Tejero et al. 2012). The amount of antler required to produce blanks for tools in this experiment suggests that the Aurignacian inhabitants of Abri Cellier could have obtained adequate supplies of antler for tool manufacture as part of a generalized subsistence strategy, if reindeer were abundant in the fall when antler is mature or shed. While some of the tools are curated items, the relative abundance of reindeer in the Aurignacian I level in terms of MNI and NISP, and evidence of antler processing, indicates some antler was brought to the site and worked. It should also be noted that antler does not preserve well in the fossil record, and natural processes may have deleted a substantial amount of antler from the Cellier assemblage, further skewing the dataset.

The possibility of loss of data through taphonomic processes, plus the excavation and collection

<table>
<thead>
<tr>
<th>Fauna</th>
<th>Castanet Nord*</th>
<th>Castanet Sud</th>
<th>Brassemposy Lower levels**</th>
<th>Brassemposy Upper levels</th>
<th>Gatzarria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reindeer (R. tarandus)</td>
<td>90</td>
<td>90</td>
<td>50</td>
<td>nd</td>
<td>2,7</td>
</tr>
<tr>
<td>Horse (E. caballus)</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>nd</td>
<td>30</td>
</tr>
<tr>
<td>Bovids (Bovidae)</td>
<td>&gt;1</td>
<td>&gt;1</td>
<td>nd</td>
<td>nd</td>
<td>43</td>
</tr>
<tr>
<td>Red deer (C. elaphus)</td>
<td>0</td>
<td>0</td>
<td>nd</td>
<td>nd</td>
<td>22</td>
</tr>
<tr>
<td>Roe deer (Capreolus capreolus)</td>
<td>0</td>
<td>0</td>
<td>nd</td>
<td>nd</td>
<td>16</td>
</tr>
<tr>
<td>Other</td>
<td>4</td>
<td>4</td>
<td>nd</td>
<td>nd</td>
<td>7,3</td>
</tr>
</tbody>
</table>

Table 6. Percentage of NISP for herbivores at four Early Aurignacian sites in southwest and southern France (adapted from Tartar 2009).
techniques employed at Abri Cellier, means that it is not possible to determine if antler was acquired as part of a generalized subsistence strategy, and was therefore a by-product of standard subsistence practices; or if a different acquisition strategy focused specifically on antler procurement was employed. Such an analysis would require material acquired with modern excavation techniques that maintain good spatial control and a better examination of the taphonomic processes. These would need to be assessed in conjunction with information regarding seasonality of site occupation acquired through analysis of microfauna or tooth eruption sequences.

CONCLUSION

The exploitation of animal bones as supports for tools in the Châtelperronian and Aurignacian levels in Grotte du Renne and Abri Cellier did not require any major changes in the transportation of animal parts to a site. The raw material for bone tools was a by-product of subsistence behavior. There is a clear preference for the use of cortical bone for tools, either in the form of fragments of long bones, or use of non-marrow containing appendicular elements such as the ulna or residual metapodials. Both modern humans and Neanderthals used elements that have been demonstrated archaeologically and ethnographically to be favored for penetration without impact. The major difference between the two sites is the adoption of antler for projectile points and other tools in the Aurignacian. Neanderthals and modern humans incorporated the use of bone tools into their existing subsistence strategy by exploiting raw material that was introduced into the site as part of carcass processing for meat, fat and hide. Some elements used (stylets, residual metapodials and ulnae) are ‘riders’ that were transported attached to bones valued for meat, fur, or marrow. Metapodials and other long bones were processed first for marrow and then adapted into tools. What remains to be considered, and it is outside the scope of this paper, is the implication that bone tool manufacture and the appearance of a consistent tool kit for the organization of subsistence behavior. While carcass transportation practices did not change, the new tool kit may imply changes in other areas of Early Upper Palaeolithic hominin socio-economic organization.

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