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Bone and ivory points in the Lower and Middle Paleolithic of Europe

The existence of shaped bone and ivory points, to be used as awls or with wooden hafts, has been suggested for the Lower Paleolithic sites of Torralba and Ambrona and for several Middle Paleolithic sites, such as Vaufrey, Combe Grenal, Pech de l'Azé I and Camiac. The use of hafted bone and ivory points would imply a spear armature technology similar to that well documented in the Upper Paleolithic, often considered an innovation introduced to Europe by anatomically modern humans.

The controversial ivory points from the two Spanish sites, whose fracture morphology is considered natural by G. Haynes (1991), have been reanalyzed, checking for putative traces of human manufacture and utilization as described by Howell & Freeman (1983), i.e., polish, flaking of stem, ground edges, striations from manufacture and contact with a haft or binding. We have been able to study 19 new proboscidean tusk tips from the ongoing Ambrona excavations by a Spanish team. For these and nine other Middle Paleolithic bone and antler points we use optical and SEM microscope analysis, taphonomic analysis, comparative observations of Upper Paleolithic bone points, experimental observations of manufacturing traces, modern tusk samples, and data on several bone and antler pseudo-points from carnivore accumulations.

We show that none of the objects we have studied can be interpreted as an intentionally shaped point. The absence of hafted bone points in the Middle Paleolithic of Europe is contrasted with evidence of the use of hafted stone points since OIS 5 or earlier in Eurasia and Africa. We suggest that the absence of organic spear armatures in the Middle Paleolithic is not due to a deficiency in the technology of Neandertals but may be tied to the organizational strategies of the hunters and to patterns of game choice and capture.

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Introduction

We know that bone was used as a raw material for implements in the Lower and Middle Paleolithic. This is now well documented by the discovery in the early 1980s of Acheulian-type bifaces, made by flaking elephant long bones, in three Middle Pleistocene sites in the Latium region of Central Italy, i.e., Castel di Guido, Fontana Ranuccio and Malagrotta (Cassoli *et al.*, 1982; Radmilli, 1985; Biddittu & Bruni, 1987; Radmilli & Boschian, 1996). The Castel di Guido and Fontana Ranuccio specimens, in particular, show multiple scars on both faces (more than ten on one face) with clear negative bulbs of percussion in an orderly pattern and symmetrical, naturally improbable, shapes. The extent and frequency of flake scars on these specimens are not to be found in naturally broken elephant bones documented by Haynes (Haynes, 1991; Lyman, 1994) nor in bones broken for marrow extraction. A few more artefacts on elephant bones with less distinctive shapes but with multiple invasive removals

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and regularly worked edges, still identifiable as deliberately made and not as the incidental byproduct of marrow fracturing, are known from other Middle Pleistocene Italian sites, including La Polledrara, another Latium site near Castel di Guido (Biddittu & Segre, 1982; Villa, 1991; Anzidei & Arnoldus Huyzenveld, 1992; Anzidei *et al.*, 1999; Villa *et al.*, 1999). Castel di Guido, La Polledrara and Malagrotta belong to the Torre in Pietra Faunal Unit of the Aurelia Formation, correlated with OIS 9 (Caloi *et al.*, 1998) while Fontana Ranuccio appears to be older and has been dated by K-Ar to about 450 ka (Biddittu *et al.*, 1979). All these are pieces that we have been able to examine; all show the diagnostic attributes of percussion flaking and shaping, as expressed in true stone artefacts (Clark, 1958, 1961, 1977; Villa *et al.*, 1999). In addition, none of the Italian sites can be characterized as carnivore-accumulated assemblages where gnawed bones with pseudo-retouches mimicking hammerstone percussion often occur (Capaldo & Blumenschine, 1994; Villa & Bartram, 1996). Another site where flaked bone artefacts have been reported and may warrant inclusion is Bilzingsleben (Mania, 1995; Gaudzinski, 1999*a*). The use of long bone shaft fragments, horse phalanges and antler bases to retouch stone artefacts is also well documented at Middle and even Lower Paleolithic sites (e.g., Boxgrove, Combe Grenal, Artenac, La Quina, Riparo di Fumane and Riparo Tagliente in Italy; Chase, 1990; Armand & Delagnes, 1998; Malerba & Giacobini, 1998; Roberts & Parfitt, 1999).

In the case of the bone bifaces, the pre-modern hominids applied to bone the same techniques they used in knapping stone artefacts; in the case of retouchers, they used bone as they used stone hammers. Scholars that have a reductive view of the technological and cognitive abilities of early hominids and Neandertals often consider the transfer of percussion flaking to bone as an indication that early humans were incapable of developing sophisticated techniques specifically conceived for bone materials, based not on percussion but on shaping by cutting, scraping, grinding and polishing. Thus, it has been argued that Mousterian and early technology was essentially immediate and involved only a short series of single-stage operations and a lower degree of conceptualization than Upper Paleolithic tools which often involved several stages of manufacture (Dennell, 1983). Similar viewpoints are expressed by Noble & Davidson (1996) who argue about lack of a concept of intended form in Middle and Early Late Pleistocene industries. Mithen (1998) also sees no evidence of creative thinking in the design of Neandertal hunting weapons and reasons that this is due to lack of integration between different cognitive domains.

However, the recent discovery of six wooden spears, at the 400 ka years old site of Schöningen in Germany confirms what was already known from Clacton and Lehringen, that Middle Pleistocene hominids were quite capable of designing pointed tools for the hunt, and shaping wood with specific techniques, such as shaving and scraping (Oakley *et al.*, 1977; Thieme & Veil, 1985; Thieme, 1997, 2000). The occurrence of four wooden hafts at another locus (Schöningen 12) also suggests the existence of composite tools already in the middle part of the Middle Pleistocene (OIS 11).

Thus, it becomes reasonable to ask whether Neandertals and earlier hominids developed techniques specifically conceived for bone and ivory materials and possessed an organic spear armature technology, comparable to that documented in the Upper Paleolithic/Later Stone Age. Bone and antler projectile points are known from many Upper Paleolithic sites as early as the earliest Aurignacian (Knecht, 1993). Ivory spear points are also well-documented at

Western and Central European Aurignacian sites (e.g., Spy and Goyet in Belgium, Geissenklösterle, Vogelherd, Wildscheuer and Sirgenstein in Germany, Mladeč in Moravia and Dzeravá Skála in Slovakia; Hahn, 1988, 1995; Oliva, 1995; Otte, 1995) and later at various Gravettian and Magdalenian sites from Western to Eastern Europe (e.g. Laugerie-Haute Est in France, Maisières in Belgium, Gönnersdorf and Kniegrotte in Germany, Předmostí and Dolní Věstonice in Moravia, Molodova, Yudinovo, Khotylevo, Avdeevo and Sungir in Ukraine and Russia; Rybakov, 1984; Abramova & Grigorieva, 1995; Gvozdover, 1995; Hahn, 1995; Oliva, 1995; Otte, 1995; Christensen, 1999). Most of these spear points and the byproducts of ivory manufacture found at these sites show unambiguous manufacturing traces left by the tasks of breaking the raw material into pieces, producing longitudinal blanks and fashioning. A variety of techniques were used: percussion flaking or grooving and chiselling around the tusk before snapping it across its length; splitting-and-wedging to produce longitudinal strips; scraping, gouging, and polishing with fine abrasive for shaping (Lister & Bahn, 1994; Abramova & Grigorieva, 1995; Hahn, 1995; White, 1995). Though adapted to this peculiar raw material, several of these techniques are reminiscent of those used at contemporary sites to produce bone and antler spear points (Knecht, 1993), and left comparable diagnostic features on finished and unfinished objects.

Although it is generally believed that only modern humans developed those advanced techniques of working bone, antler and ivory which are considered a distinctive feature of the Upper Paleolithic (e.g., Klein, 1994*a*,*b*, 1995, 1998, 2000; McBrearty & Brooks, 2000; Ambrose, 2001), there have been suggestions in the past that working of bone and ivory and organic spear armatures might antedate the Upper Paleolithic (e.g., Veyrier *et al.*, 1951; Howell & Freeman, 1983; Vincent, 1993). These suggestions have remained mostly unnoticed in the recent literature and deserve perhaps a closer look now, in view of the recent discoveries in Central Europe and the increasing number of shaped bone tools reported from MSA sites in Africa. Two technological features are clearly relevant to this discussion: hafting and the use of specific techniques for shaping pointed bone tools.

Hafting, shaped bone points and spear points

The oldest evidence for modification and use of bone points comes from the sites of Swartkrans and Sterkfontein in South Africa (Brain *et al.*, 1988; Brain & Shipman, 1993; Backwell & d'Errico, 2001) and from the site of Drimolen in the same region (Keyser *et al.*, 2000; Kuman, personal communication) . The Swartkrans and Sterkfontein points are not formally shaped tools but naturally pointed bone fragments, apparently used for digging termites out of termite mounds and modified through use. However, shaped bone tools and bone points have been reported from the Middle Stone Age sites of Klasies River and Blombos Cave in South Africa (Singer & Wymer, 1982; Henshilwood & Sealy, 1997; Deacon & Deacon, 1999; Wurz, 2000; and personal observations). Some of the bone tools with short or very thin points are clearly awls but at least two pieces from Blombos and one from Klasies River have been interpreted as projectile points (Singer & Wymer, 1982; Henshilwood & Sealy, 1997; McBrearty & Brooks, 2000), although the attribution of the Klasies River point to the Middle Stone Age is in doubt (Deacon, personal communication).

Hafting of the South African bone points has not yet been documented but there is strong evidence of stone spear points in the African Middle Stone Age. Hafting of stone points has been suggested for some Middle Stone Age occurrences in Africa (Mason,

1962) including Blombos and Klasies River (Wurz, 1999; McBrearty & Brooks, 2000). Hafting of stone points and other tools is clearly indicated by tanged pieces in the Aterian assemblages of North Africa, some of which are now dated to OIS 5 (Clark, 1988; Cremaschi *et al.*, 1998).

Recent discoveries suggest that hafting technology was also practiced in the Middle Paleolithic of Eurasia; hafting of stone spear points is documented by direct evidence of mastic, by a point tip embedded in a vertebra and by more indirect evidence of wear and impact scars. One convergent scraper, three Levallois flakes and one cortical flake with traces of bitumen adhesive used for hafting have been found in Mousterian levels dated to about 60,000 years ago at the site of Umm El Tlel; one blade from the Hummalian level (Middle Paleolithic) at Hummal carries similar traces. Both sites are in the El Kwom Basin, Syria. More direct evidence for stone-tipped spears also comes from Umm El Tlel where a Levallois point has been found embedded in the third cervical vertebra of a wild ass (Boëda *et al.*, 1996, 1998*a*,*b*, 1999; cf. also Shea, 1988, 1997; 1998*a*; Friedman *et al.*, 1994). Older occurrences of hafted Levallois points and convergent scrapers have been suggested on the basis of microwear analysis from the open-air site of Biache (end of OIS 7) and, less securely, from the cave site of Vaufrey (estimated age OIS 7) in France (Beyries, 1988*a*,*b*). The author favored a multifunctional interpretation of these pieces, later also suggested for the Levallois points of Kebara and Umm El Tlel (Plisson & Beyries, 1998; *contra* Shea, 1998*b*) although the recent discoveries of Umm el Tlel clearly prove that some of the points were originally made as hunting devices, as Shea had originally proposed (Bar Yosef, 2000). Distinctive impact scars, associated by experiments with use of projectile points, occur on the tips of several Mousterian points from layer 5 at La Cotte de St Brelade, Channel Islands (OIS 6; Callow, 1986). Examples of basal trimming of Mousterian stone points most probably related to hafting are provided by Mellars (1996).

Although the Middle Stone Age bone artefacts from South Africa firmly document specialized bone working techniques, such as scraping and polishing, evidence of hafting of bone points before the Later Stone Age in Africa remains elusive. Eight bone barbed points with grooved bases to facilitate hafting, similar to harpoons found in the Later Stone Age, but apparently associated with MSA stone artefacts, have been described from the site of Katanda (eastern Zaire) dated to between 150 and 90 ka (Brooks *et al.*, 1995; Yellen *et al.*, 1995; Yellen, 1998; McBrearty & Brooks, 2000). Given the uniqueness of these kind of artefacts, which antedate well documented Later Stone Age harpoons by 50,000 years or more, it is clear that the age estimates of these objects need additional verification (Klein, 2000).

Bone, antler and ivory points in the Lower and Middle Paleolithic of Europe

The existence of bone, antler and ivory points in the Lower and Middle Paleolithic of Europe is also controversial. Solid evidence of worked and, in some cases, decorated bone awls come from late Neandertal (Châtelperronian and Uluzzian) sites in France and Italy (Leroi-Gourhan, 1964; Gambassini, 1997; d'Errico *et al.*, 1998*a*,*b*). Whether the manufacture of bone awls by late Neandertals should be interpreted as an autonomous technological development (d'Errico *et al.*, 1998*b*; Zilhão & d'Errico, 1999) or the consequence of cultural contact with early Aurignacian people (Mellars, 1999) is still a matter of controversy. Further demonstration that techniques specifically conceived for working bone are not an exclusive accomplishment of the Aurignacians comes from the site of Buran

Kaya III in Crimea. Level C, with a stone assemblage with no Aurignacian affinities and characterized by bifacial knives and backed segments, has yielded one bone haft made of a horse metapodial and several bone tubes made on wolf and hare long bones. The bone artefacts are dated to between 36 and 32 ka (Yanevich *et al.*, 1997; d'Errico & Laroulandie, 2000; Marks & Monigal, 2000).

For older periods the evidence is more tenuous. Putative bone and ivory points have been reported from at least six Lower Paleolithic sites: Mesvin in Belgium, Bilzingsleben in Germany, Lunel Viel in France, Torralba and Ambrona in Spain, Castel di Guido in Italy (Figures 1 and 2 and Table 1). Bone and antler points are also reported from at least 12 Middle Paleolithic sites: Butesti and Budzujeni in Moldavia, Prolom II in Crimea, Salzgitter-Lebenstedt in Germany, the Broion cave in Italy, Castillo in Spain and several French sites such as Combe Grenal, Vaufrey, La Quina, la Grotte de l'Hermitage, Pech de l'Azé 1 and Camiac (Figure 3 and Table 1). Some of the putative points were interpreted as points hafted on throwing or thrusting spears (Howell & Freeman, 1983; Vincent, 1993 used the term "sagaie" for the Combe Grenal point; Veyrier *et al.*, 1951 speak of Mousterian pointed bones from Baume Neron as "veritables prototypes de sagaies"). Other bone pieces were simply described as worked bone points [e.g., the point from Salzgitter-Lebenstedt (Figure 3(q); Gaudzinski, 1999*b*] or as "epieux" i.e. thrusting spear points (those from Castillo and La Quina; Henri-Martin, 1932; Breuil & Barral, 1955) or as awls and borers (e.g., the pieces from Pech de l'Azé, L'Hermitage, Prolom II, Lunel Viel and Camiac; Bordes, 1954; Mellars, 1973; Bonifay, 1974; Stepanchuk, 1993). Other occurrences of bone points are cited in the literature, but our list contains only those cases for which an illustration or a detailed description was available.

Most of these objects have been published without a validating microscopic analysis of the bone surfaces to show possible traces of manufacture and use. This kind of documentation is necessary because we know that natural processes can produce pseudo-bone points similar to those attributed to humans (Brain, 1967, 1981; Sutcliffe, 1973, 1977; Shipman & Rose, 1988; Olsen, 1989; Haynes, 1991; Backwell & d'Errico, 2001). In general, however, our knowledge of natural processes producing pseudopoints is still quite limited; moreover this knowledge has never been integrated in a systematic method of study combining taphonomic observations, actualistic data, replicative experiments and detailed analytical procedures including optical and scanning electron microscopy. The aim of this paper is to develop this methodology and to apply it to a number of European Lower and Middle Paleolithic putative points including the largest known series of such objects from Torralba and Ambrona.

Clearly not all of the techniques we have used are applicable to every kind of organic artefact. Thus SEM and optical microscopy would not be very useful for studying the macroscopic morphology of bone edges shaped by percussion flaking, nor does the identification of the Italian bone bifaces as artefacts require such studies, although their flaked edges could be examined for microwear. Microscopic techniques are effectively employed for a correct diagnosis of surface features such as manufacturing marks or other kinds of stone tool marks *vs.* vascular grooves, natural abrasion, predator or carnivore marks and to recognize traces of digestion or a functional working edge (Olsen, 1988; Olsen & Shipman, 1988; Shipman & Rose, 1988; Shipman, 1989; d'Errico & Villa, 1997; Backwell & d'Errico, 2001). Moreover, the general procedures followed here, combining evidence

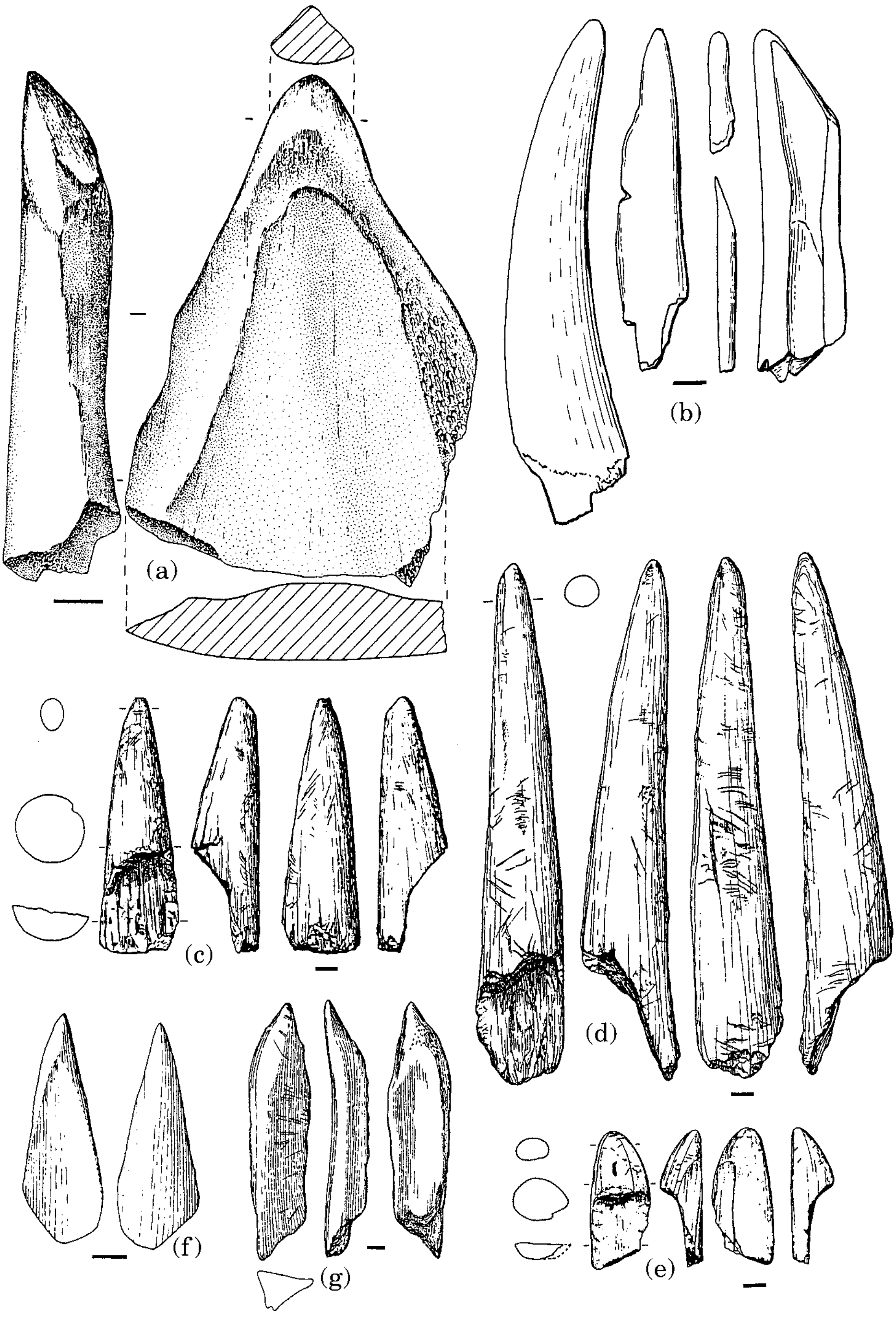

Figure 1. Lower Paleolithic ivory and bone points. (a) Mesvin (Belgium); (b) Swartkrans and Sterkfontein (South Africa); (c), (d) Ambrona 40A/6 and Torralba Q 1258, Howell & Freeman's excavations; (e) Torralba 2644, Cerralbo excavatoins; (f) Lunel Viel (France); (g) Bilzingsleben (Germany).

Figure 2. Ivory point from the site of Castel di Guido (in the Rome region, Italy), scale=1 cm. After Radmilli & Boschian, 1996: Figure 68, reproduced by permission of Dr Boschian.

of depositional context with actualistic and taphonomic data, provide solid foundations to the study of minimally modified bone artefacts, as they have in the past, when archaeologists were concerned with sorting stone artefacts from broken rocks (Clark, 1961; Villa *et al.*, 1999).

Purpose of this study

Our reasons for studying these materials and for adopting this approach are simple. The first is that worked bone and ivory, hafting and the use of composite tools are considered among the important features characterizing modern human behavior (Mellars, 1973, 1996; White, 1982; Klein, 1994*a*,*b*, 1995, 1998, 2000; McBrearty & Brooks, 2000; Ambrose, 2001). As indicated above, all interpretations about the early appearance of worked bone and ivory in the European record have remained at the level of conjecture; their identification was mainly based on visual appreciation of morphological attributes. Before dismissing these ivory and bone minimally modified objects as isolated occurrences of simply utilized, unworked bone pieces or as misinterpreted, nonanthropic objects, it seems useful to adopt a strategy of changing levels of observation, i.e., to conduct concrete, detailed microscopic examinations based on explicit criteria and procedures.

In archaeology, causes and effects or agents and products are not always in a one-to-one relation and observations are not always capable of giving unambiguous information. Changing the level of observation is one way to escape ambiguities and of achieving stronger inferences. This is why various scholars have introduced SEM and optical microscopy in the analysis of artefacts and used detailed taphonomic analyses as ways to resolve ambiguities and to distinguish between competing interpretations. Thus, we hope to reduce or resolve some of the uncertainties concerning early traces of modern behavior in the European record and to provide unambiguous criteria by which, in the future, researchers can assess the anthropic origin of putative bone tools from this and other geographic areas. This should eliminate the risk of interpreting putative bone technologies using the circular reasoning that consists in discarding or accepting, without proper analysis, putative bone tools according to the associated human type and the model adopted to explain how biological and cultural factors interact in human evolution.

Table 1 Purported bone and ivory points from Lower and Middle Paleolithic sites in Europe

Site	Age and/or industry	Points	References
Torralba (Spain)	Acheulean, Middle Pleistocene	10 (ivory)	Biberson, 1964; Howell & Freeman, 1983
Ambrona (Spain)	Acheulean, Middle Pleistocene	26+19 ivory points from old and new excavations	Howell & Freeman, 1983; Howell *et al.*, 1995; this paper
Bilzingsleben (Germany)	Lower Paleolithic, OIS 11 or 9	2	Mania & Weber, 1986
Lunel Viel (France)	Lower Paleolithic	1	Bonifay, 1974
Mesvin (Belgium)	Lower Paleolithic	1	Cahen *et al.*, 1979
Castel di Guido (Italy)	Acheulean, OIS 9 estimated	1 (ivory)	Radmilli & Boschian, 1996
Grotte Vaufrey (France), layer VIII	Early Middle Paleolithic, OIS 7 estimated	1	Vincent, 1993
Combe Grenal (France)	Mousterian (layer 16), OIS 3	1	Bordes, 1972, 1984
Salzgitter-Lebenstedt (Germany)	Middle Paleolithic, about 50 ka based on several absolute dates	1 point, 23 pointed mammoth ribs and fibulae	Gaudzinski, 1999b; for the dates cf. Pastoors, 1998; Gaudzinski & Roebroeks, 2000
Prolom II (Crimea)	Middle Paleolithic, Last Glacial	4	Stepanchuk, 1993
Budzujeni (Moldavia)	Mousterian, ca. 80 ka	2	Borziak & López Bayón, 1996
Butesti (Moldavia)	Mousterian, OIS 3	1	Borziak & López Bayón, 1996
La Quina (France)	Mousterian	1	Breuil & Barral, 1955
Grotte de l'Hermitage (France)	Mousterian	3	Pradel & Pradel, 1955
Camiac (France)	Mousterian, 35,000+2000/−1500 (Ly 1104)	6	Lenoir, 1983; Guadelli *et al.*, 1988
Pech de l'Azé I (France), layer 4	Mousterian (MTA), OIS 3	1	Bordes, 1954
Cueva Beneito (Spain)	Mousterian, 30,160 ± 680 (Gif, number not given), 38,800 ± 1900 (AA 1387)	2	Iturbe *et al.*, 1993
Cueva Morin (Spain)	Mousterian	1	Freeman & Echegaray, 1983; Echegaray, 1988
Castillo (Spain)	Mousterian	1	Breuil & Barral, 1955
Grotta del Broion (Italy)	Middle Paleolithic, Last Glacial	1	Broglio, 1965

Archeological materials

Ivory points

The Lower Paleolithic sites of Torralba and Ambrona (in the province of Soria, Spain) were first excavated at the beginning of the last century by Cerralbo. More systematic and extensive excavations at both sites were carried out by Clark Howell and Leslie Freeman between 1961 and 1963 and at Ambrona between 1980 and 1983 (Howell *et al.*, 1963, 1995; Howell, 1966; Freeman, 1975, 1994; Howell & Freeman, 1982; Villa, 1990). Starting in 1993, geological and archeological investigations have been resumed at both sites by a Spanish team under the direction of Manuel Santonja and Alfredo Pérez-González and with the participation of one of us (P.V.) (Pérez-González *et al.*, 1997*a*,*b*; Santonja *et al.*, 1997).

In 1983 Howell & Freeman published thirty-seven ivory tusk fragments of which 34 were described as points with a stem for hafting (Figures 1(c–e) and 4). Cerralbo had found eight of these points in Torralba; he thought that humans had used these tusk tips (Howell *et al.*, 1963; Biberson, 1964, 1968). Howell & Freeman (1983) suggested that the Acheulian hunters deliberately fractured *Elephas antiquus* tusk tips by flexion, producing a repetitive shape, in some cases modified by grinding and polishing and/or marginal retouch. These objects were thus considered as evidence that Lower Paleolithic people possessed techniques to produce patterned bone implements, normally thought to be an Upper Paleolithic innovation. In addition to stemmed and hafted points these authors noted the occurrence of an intermediate tusk fragment with fractures at opposite ends and interpreted it as the result of successive breakage by flexion during the manufacturing process or use of the hafted point (Howell & Freeman, 1983). Two more pieces were described as points without a stem.

These pieces were later considered natural by Haynes (Coynbeare & Haynes, 1984; Haynes, 1988, 1991) because their general morphology was similar to that of tusk tips and medial segments found by him in various game preserves of southern Africa around dry-season water holes. Haynes suggested that breakage results from intraspecific fights or when elephants use their tusks in feeding activities or in pushing and lifting heavy objects. In a recent paper Howell *et al.* (1995) defend their interpretation of most of these points as artefacts. According to them, various traces of human manufacture and utilization (striations, grooves, polish on tip or stem, flaking, chipping and faceting), not just the shape of the points, prove that these were artefacts (Table 2). They also say that some morphologies are different from those documented by Haynes.

To assess the validity of Howell and colleagues' renewed interpretation of these traces, we have re-examined all the specimens of Cerralbo and Howell & Freeman's excavations kept in the Museo Numantino (Soria) and in the Museo Arqueologico Nacional (Madrid). A second reason for re-examining these ivory points is that 19 new tusk tips with a stem (Figure 5), three medial segments, three ivory flakes and two points without a stem have been found in the new excavations at Ambrona directed by Manuel Santonja and Alfredo Pérez-González (Figure 6). The excavations have also produced several more or less complete tusks and many annular tusk fragments that are the result of postdepositional breakage.

Bone and antler points

We have analyzed nine specimens from four well-known Mousterian sites in southwest France. They are:

Grotte Vaufrey. Layer VIII of this site, with an estimated date of about 200 ka (Rigaud, 1988) has yielded an elongated cylindrical

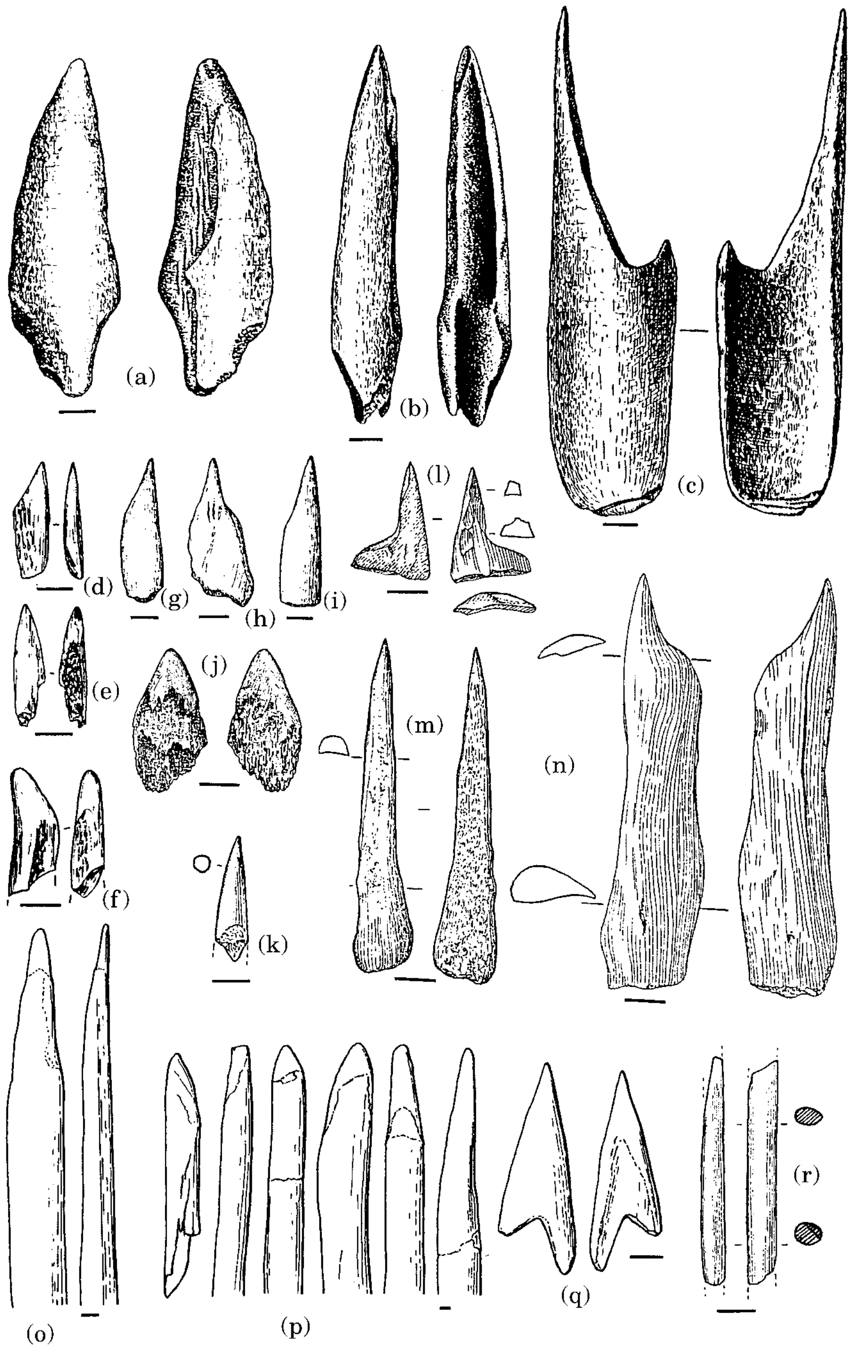

Figure 3. Middle Paleolithic bone points. (a)–(c) Butesti and Budzujeni; (d)–(f) Prolom II (Crimea); (g)–(i) Grotte de l'Hermitage (France); (j) Grotta del Broion (Italy); (k) Combe Grenal (France), layer 16; (l)–(n) Camiac (France); (o)–(q) Salzgitter-Lebenstedt (Germany); (r) Grotte Vaufrey (France), layer VIII.

bone piece, 5·5 cm long, broken at both ends, kept in the Institut de Préhistoire et de Géologie du Quaternaire in Bordeaux. According to Vincent (1993) this bone was intentionally shaped by grinding [Figure 3(r)].

Combe Grenal. In 1972 François Bordes published a small bone point about 2·4 cm long made of reindeer antler [Figure 3(k)] coming from layer 16 of Combe Grenal, associated with a Denticulate Mouterian industry, which he described as the "broken tip of a point made of reindeer antler" (Bordes, 1968, 1984) and considered a "sagaie" tip by Vincent (1993). The layer is dated to OIS 3, at around 60 ka (Mellars, 1996). This object is kept in the Prehistory Museum at Les Eyzies, France.

Camiac. The site of Camiac, dated to 35+2/−1·5 ka BP (Ly 1104) has yielded a late Mousterian industry, a faunal assemblage heavily modified by hyenas and six bone artefacts (Lenoir, 1983; Guadelli *et al.*, 1988), stored at the Institut de Préhistoire et de Géologie du Quaternaire in Bordeaux. One piece (length=8·3 cm) is described as a possible awl [Figure 3(m)]. Five other bone fragments (with length varying from 3 to 10·4 cm) show a pointed end which, according to Lenoir, might be intentionally shaped [Figure 3(l–n)]. He wonders, however, whether these pieces might simply be abraded or modified by hyenas.

Pech de l'Azé I. Layer 4, with an estimated age of OIS 3, has yielded a stone industry rich in cordiform bifaces, attributed to the Mousterian of Acheulian Tradition (MTA) type A. In 1954 François Bordes published a pointed bone fragment described as an "awl" coming from layer 4 (Bordes, 1954: Figure 17:1). This is a long bone shaft fragment of a medium to large ungulate (length=15 cm; breadth at 1 cm from the tip=0·6 cm). This object is kept in the Prehistory Museum at Les Eyzies, France. Layer 4 was renamed level 11 by Laville (Laville *et al.*, 1980: Figure 7.6; Mellars, 1996; Soressi, 1999).

Analytical procedures

Six different kinds of reference materials have provided the analogue data and crtieria we have used to assess the anthropic nature of modifications under study:

(1) a modern sample of eleven complete tusks of African elephants killed by poachers and illegally exported, subsequently confiscated by French customs officers. The sample is stored in the Museum d'Histoire Naturelle of Bordeaux;
(2) experimental reproduction of stone tools marks on ivory using retouched and unretouched blanks;
(3) comparative data derived from observations of unbroken archaeological tusks from Ambrona, which are clearly not artefacts;
(4) data from Pleistocene bone accumulations produced by hyenas, specifically eight pseudo-points from the cave site of Bois Roche in the Charente, excavated by Bartram & Villa between 1995 and 1998 and by Villa in 1999 and 2000 (Villa & Bartram, 1996; Bartram & Villa, 1998; Villa & Soressi, 2000). These consist of bone and antler fragments eroded by hyena gastric acids; three also carry gnaw marks;
(5) a modern sample of hyena-regurgitated bones collected by Anthony Sutcliffe in Africa, which includes some pointed fragments (Sutcliffe, 1970; d'Errico & Villa, 1997);
(6) experimental reproduction of bone points and observations of Upper

Figure 4. Ivory points from Howell and Freeman's excavations at Torralba and Ambrona (Soria Museum).

Paleolithic bone points, which carry clear traces of manufacture.

Our reference data are specific to ivory and bone because these two raw materials have different properties. Thus, the first three kinds of reference materials were used in the analysis of ivory objects and were particularly useful for interpreting striations and break facets found on the ivory pieces of Torralba and Ambrona. Observations of carnivore-modified bones and of manufacturing traces on Upper Paleolithic bone points and on experimental replicas support our interpretations of bone pieces. Taphonomic and sedimentary context data were available from the recent Ambrona excavations and have thrown light on questions of mechanical abrasion.

Morphometric data recorded on the Torralba and Ambrona specimens include length, breadth and thickness of points and stems at fixed position. We also noted the presence, location and mode of occurrence of striations (isolated or in groups) and other features such as polish, degree of abrasion, micro-pitting, root marks and preparators' marks. The latter are marks made after excavation when cleaning the surfaces with metal tools (Shipman, 1981). When applicable, the same variables were recorded on the modern and archeological reference material.

Each specimen was examined with a reflected light microscope; selected areas were replicated with Cutter Perfourm Light Vinyl Polysiloxane impression material (Miles Inc., U.S.A.). Positive casts, made in araldite LY 554 (CTS, France), were observed with an SEM 840A Jeol. Transparent replicas obtained with the same replica technique were also observed and photographed in transmitted light with a Wild M3C stereomicroscope. Transmitted light microscopic images of surfaces were digitized while working in museums and later used as archival records.

Results

Ivory points

To investigate the life history of the Torralba and Ambrona pieces we examine in sequence their breakage morphology, their dimensional variability, and various putative traces of manufacture, use and resharpening. We combine these observations with taphonomic, actualistic and experimental data.

Breakage morphology. Contrary to Howell *et al.*'s (1995) statement that some archeological point morphologies are different from those documented by Haynes, our analysis of the old and new points indicates that all shapes found at Torralba and Ambrona are present in Haynes' modern series. About half of the Torralba and Ambrona points have an elliptical section and the other half have a circular section; both varieties are present among the natural points collected in game preserves. Both in the modern and archeological series there are pieces with long and short stems produced by a spiral fracture, pieces without a stem, pieces with a dihedral end, medial tusk segments and different types of ivory flakes (Figures 4 and 5, 7 and 8).

As indicated by Haynes (1991), breakage of tusk tips occurs during the animal's life. In our modern reference collection an adult tusk shows the trace of an elongated tip fracture with smoothed edges [Figure 9(a), (b)]. The resulting ivory point must have been like many Torralba and Ambrona specimens, possessing a short tip and a rather long and flat stem. The rounded edges of the fracture show that the animal continued to use its tusk, smoothing out the broken surface. Ridges fanning out at the fracture edges, as on this specimen, occur also on the stems of the archeological pieces proving that the breakage occurred on fresh ivory [Figure 9(c)].

Table 2 **Characteristics of ivory pieces from Torralba and Ambrona, according to Howell & Freeman, 1983**

Site	Year	Catalog	Location of polish	Location of striations	Faceting	Flaking	Marginal flaking	Grooves, tool marks	Techniques
AMB	62/63	41C/62	Right side, stem	Several locations			Stem		Flexion
AMB*	62/63	12/22	Stem	Unspecified location					
AMB	62/63	8a/33	Stem	Point					
AMB	62/63	49G/50	Stem	Sides		On stem	Sides of stem		
AMB	62/63	40B/18	Stem	Left side					Flexion
AMB	62/63	3/72	All surfaces						
AMB*	62/63	12/24	Stem	Point, stem					Flexion, grinding
AMB*	62/63	49G/62	Several locations	Several locations		On stem			
AMB	62/63	40A/6	Stem, shoulder	Side, lower face	On tip				
AMB	62/63	38Z/A52	Stem	Several loc.		Shoulder		Chattermarks on stem	
AMB	62/63	4/36		Preserved areas					
AMB	62/63	3/49	On stem apex						
AMB	62/63	4A/7		Upper face, right side					
AMB*	62/63	44F/79		Several loc.					
AMB	62/63	41C/5	On stem	Sides					
AMB	62/63	7/30							
AMB*	62–63	11/2		Both faces					
AMB*†	62/63	14/3							

Table 2 ***Continued***

Site	Year	Catalog	Location of polish	Location of striations	Faceting	Flaking	Marginal flaking	Grooves, tool marks	Techniques
AMB	80	G100/60	On tip						
AMB	80	H98/13	Tip, stem	Lower face	On tip		Stem		Flexion
AMB	81	K115/1		Tip					
AMB	81	L115/9–10	Stem	Point			Tip		Flexion
AMB	81	L115/63						Tip, upper face	
AMB*	81	K116/6							
AMB*	81	L115/35	On stem						
AMB*	81	I202/3				On tip			
AMB*‡	81	L120/68				On tip, butt			Grinding
TORR	CERR‖	2643		Both sides				Sides	
TORR	CERR	2644							
TORR	CERR	2645		Upper face				Upper face	
TORR	CERR	2647							
TORR	CERR	2648		A few					
TORR	CERR	2650		Split surface					
TORR§	CERR	2651		Tip					Flaking, grinding
TORR	CERR	Unnumbered		Left side					
TORR	61	Q1258	Tip, stem	Right side				Stem	
TORR	62/63	K12/B1	On tip, stem						Flexion

*Missing from the Soria museum.
†Described as a medial segment.
‡Described as a juvenile tusk tip with flaked butt.
§Described as a hollow-ground point.
‖CERR=Cerralbo excavation.

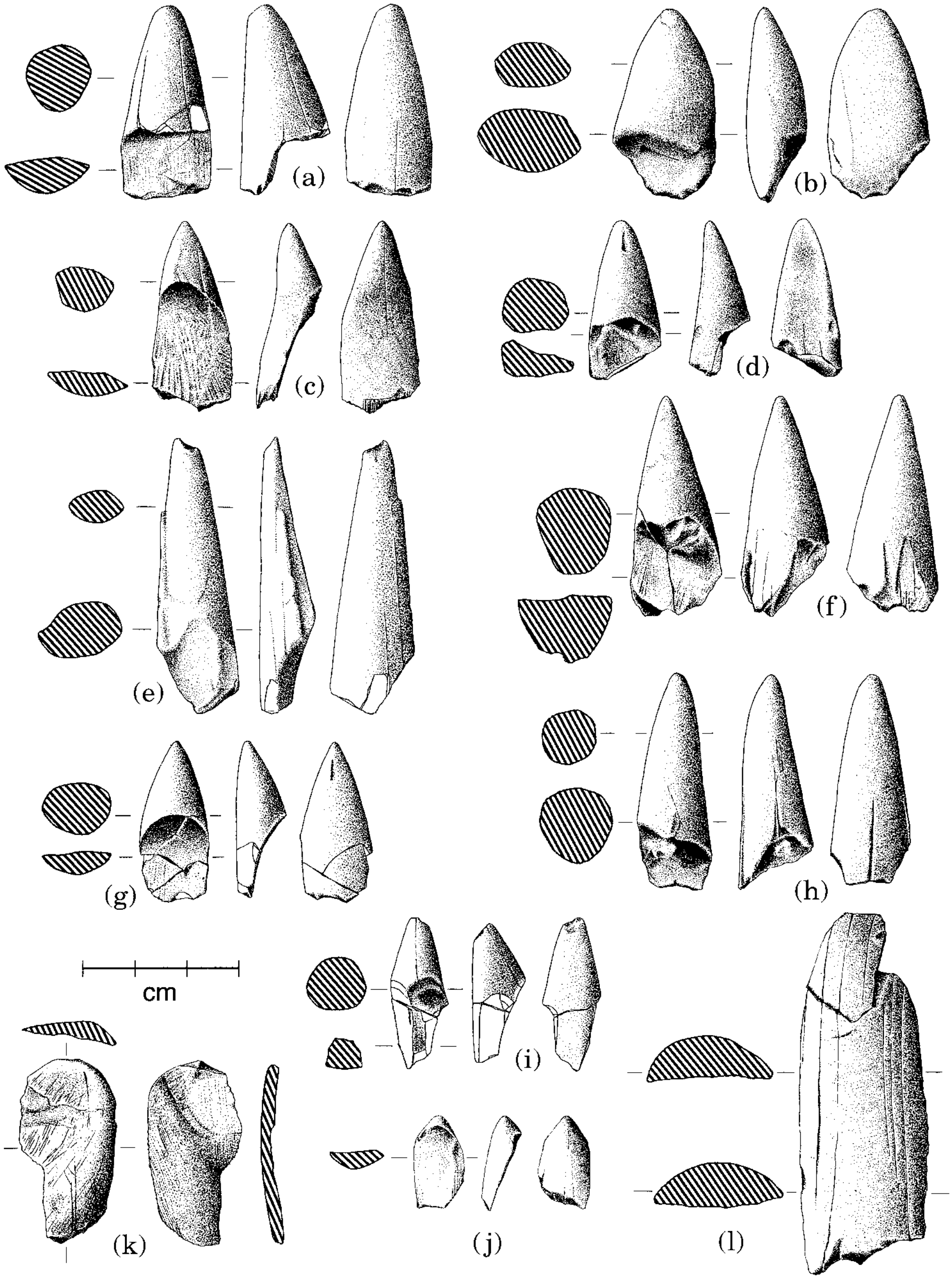

Figure 5. Drawings of a sample of ivory points (a–j) and ivory flakes (k–l) from the 1993–1999 Santonja and Pérez-González excavations. (d) and (h) are from stratigraphic unit AS3; all others are from unit AS 4. (a)–(c) AS4 745, 888, 608; (d) AS3 587; (e)–(g) AS4 892, 149/531, 896; (h) AS3 596; (i)–(l) AS4 654, 734, 546, 537. Drawings by A. Sanz Aragonés.

Figure 6. Partial skeleton of an adult male *Elephas antiquus* from Ambrona (1995 excavations by Santonja and Pérez-González).

Size variation. Morphometric analysis shows great variability. The frequency distributions of total, stem and apical lengths (Figure 10) show very dispersed values. The length of intact ivory points ranges between 1·8 and 23·2 cm; that of the apical portion of the point (its supposedly active part) varies between 0·4 and 16·1 cm; stem length is between 1·2 and 10·5 cm. Some of the smaller pieces have extremely short points, the smallest is 0·4 mm long [Figure 5(j)]. Comparably small sizes can be found only in some classes of Upper Paleolithic and Mesolithic microliths hafted to form the tips and barbs of arrows but the width and rounded tip of these ivory pieces makes difficult to imagine their functional value as elements of composite tools. These ivory points have exactly the same general morphology as the much larger pieces (Figure 11). The recent excavations have added to the impression of a great dimensional variability through the recovery of several points smaller than 4 cm, missing from the older series. Thus, we agree with Haynes' suggestion that the morphology of these pieces is natural and accidental; their variability makes them weak candidates for being human-made artefacts of a specialized nature.

It could be argued that other kinds of Paleolithic artefacts show significant dimensional variability and similarly dispersed frequency distributions. Acheulian bifaces, for instance, can be quite variable in length. The frequency distribution for length of the Ambrona bifaces from Howell & Freeman's excavations show an irregular, dispersed pattern with a wide range of values (Villa, 1983: Figure 55; cf. also Figure 54 with length of bifaces at Lazaret and Terra Amata). However, hafted pieces tend to have more clustered distributions because the functional requirements of hafting limit the possibility of morphological variation. Figure 12 illustrates the variation in length and breadth in a sample of Magdalenian bone and antler points and in the ivory points from Ambrona. The Upper Paleolithic sample is deliberately heterogeneous, as it includes three kinds of bone points (72

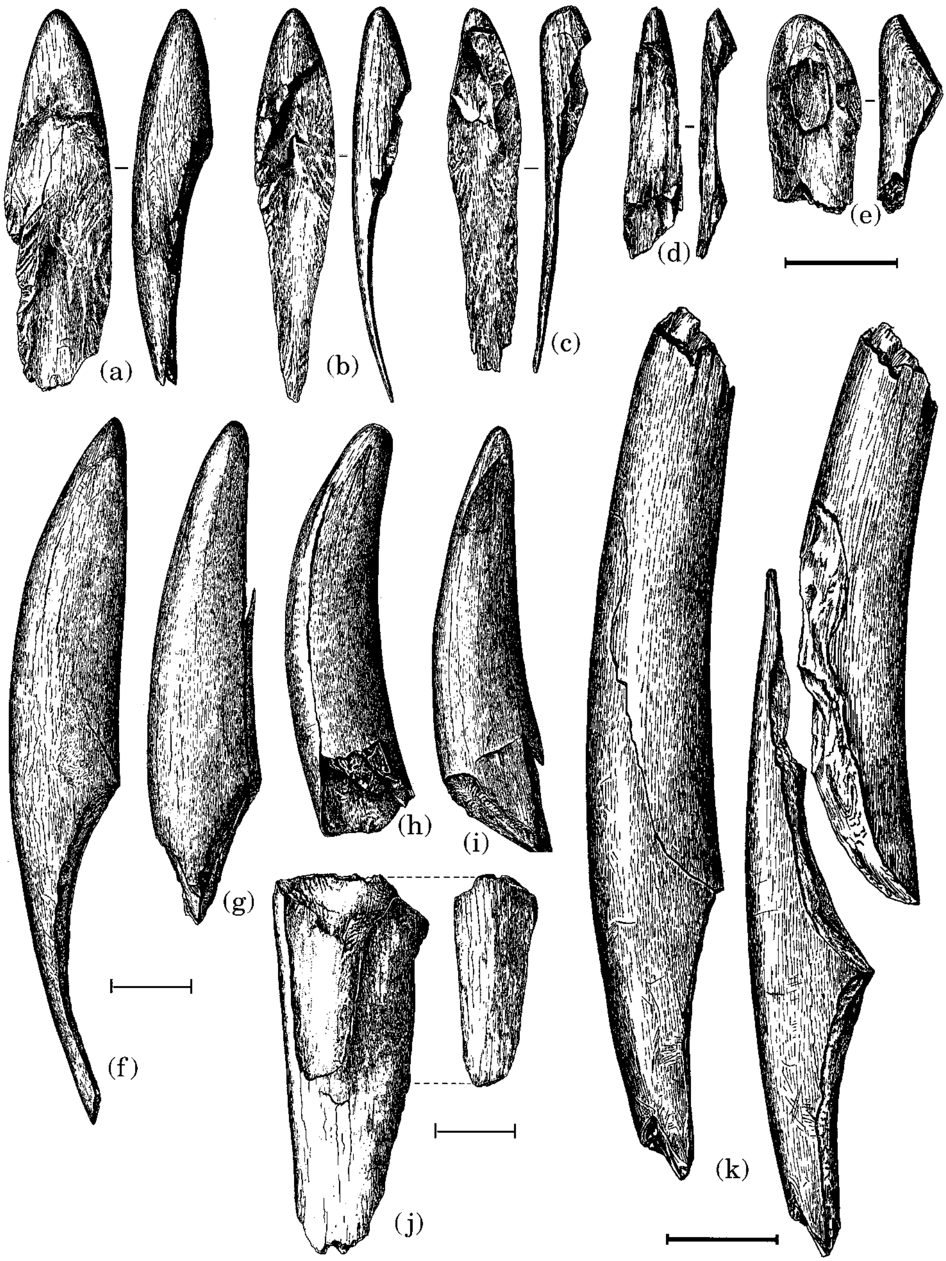

Figure 7. Morphology of tusk fragments collected by Haynes; (a)–(d), (f) long stems, (e) short stems; (g), (i) dihedral ends, (h) fracture without a stem, (j) ivory flakes, (k) medial segment. All scales = 3 cm. After Haynes, 1991: Figures 4.4–4.7, reproduced by permission of the author and of Cambridge University Press.

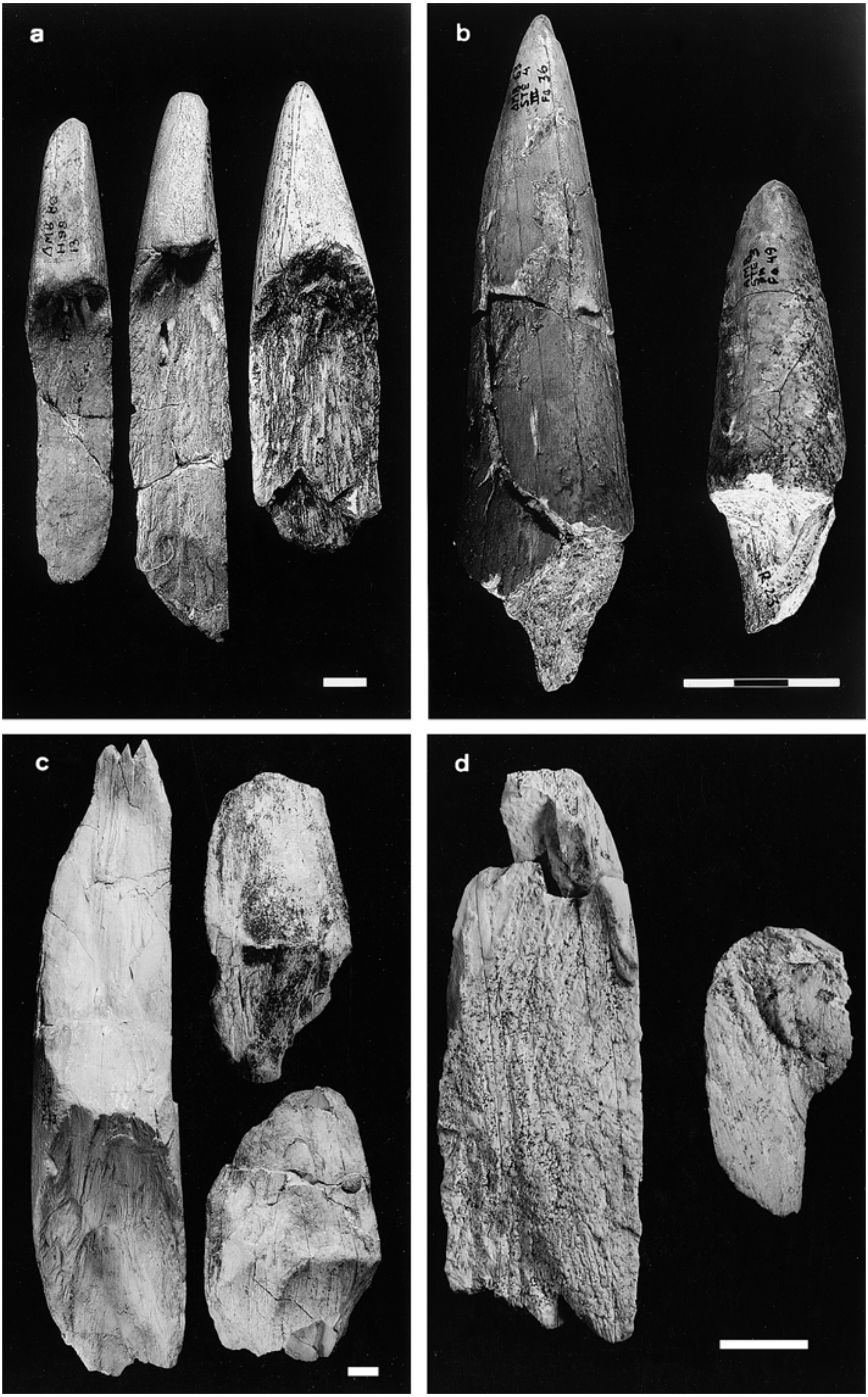

Figure 8. Ivory pieces from Ambrona (a), (b), (d) and Torralba (c); (a) points with long and medium-length stems, Ambrona H98/13, 41C/62 and 49G/50; (b) points with dihedral stems, Ambrona 4/36 and 3/49; (c) medial segments, Torralba Q 9003, K9 B1/69, Q 2778; (d) two ivory flakes, ventral face, AS4 546 and 537. All scales=1 cm.

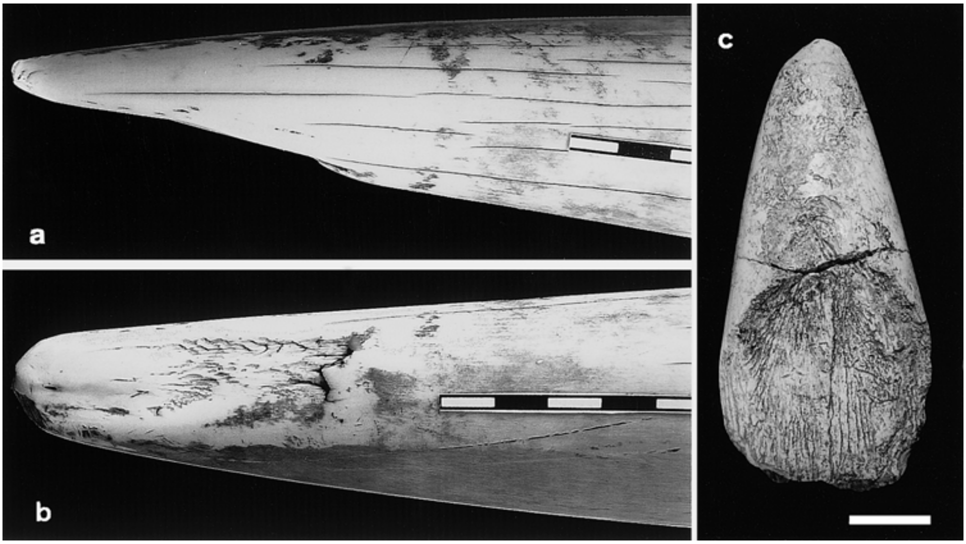

Figure 9. (a), (b) Modern tusk with tip fracture showing ridges (equivalent to hackle marks on stone flakes or cores) smoothed by subsequent use, scale in cm. Museum d'Histoire Naturelle of Bordeaux; (c) ivory point from Torralba (Cerralbo 2645) with hackle marks, scale=1 cm.

with a single-beveled, 76 with a double-beveled and 88 with a forked base) from 12 sites in the Pyrenees region (Bertrand, 1999). It is worth noting that the Magdalenian sample is a collection of morphological, not necessarily functionally identical, types, just like the sample of ivory points from Torralba and Ambrona. Yet the distribution of Magdalenian points is definitely more clustered and less irregular than that of the ivory points; clustering of values is especially evident in the breadth histogram. This is to be expected in hafted points since the breadth of a point controls the breadth of its shaft. The irregular and dispersed distribution of the ivory points does not appear to conform to a hypothesis of hafting.

Traces of manufacture and utilization. Howell & Freeman (1983) and Howell *et al.* (1995) have suggested that, although the production of some of these pieces may be a natural phenomenon, humans have used and modified them, stressing the presence of manufacturing and utilization traces, such as striations, polish, grooves and tool marks, and marginal flaking. These traces were not discussed by Haynes. In their analysis, however, Howell and colleagues do not address the problem of the state of preservation of the surfaces and do not discuss alternative interpretations. To assess the anthropic origin of these traces it is necessary to evaluate the taphonomic processes which may have produced them. The new excavations and assemblage analysis provide data on the sedimentary context (Pérez-González *et al.*, 1997*a*,*b*) and the degree of preservation of the bone, ivory and lithic remains.

Points from the new excavations derive from four stratigraphic units. Two have been found in unit AS1 (limestone gravels and sands representing alluvial fan deposits) at the base of the sequence, one in the overlying fluvial clayey sands of AS1/2, four in AS3 (lacustrine marls with lateral increase in gravels) and 12 in AS4 (channel and overbank deposits). Although the degree of abrasion of all archaeological materials varies from one unit to another, 70–90% of all bones, stone artefacts and ivory points show some degree of abrasion. Lithic

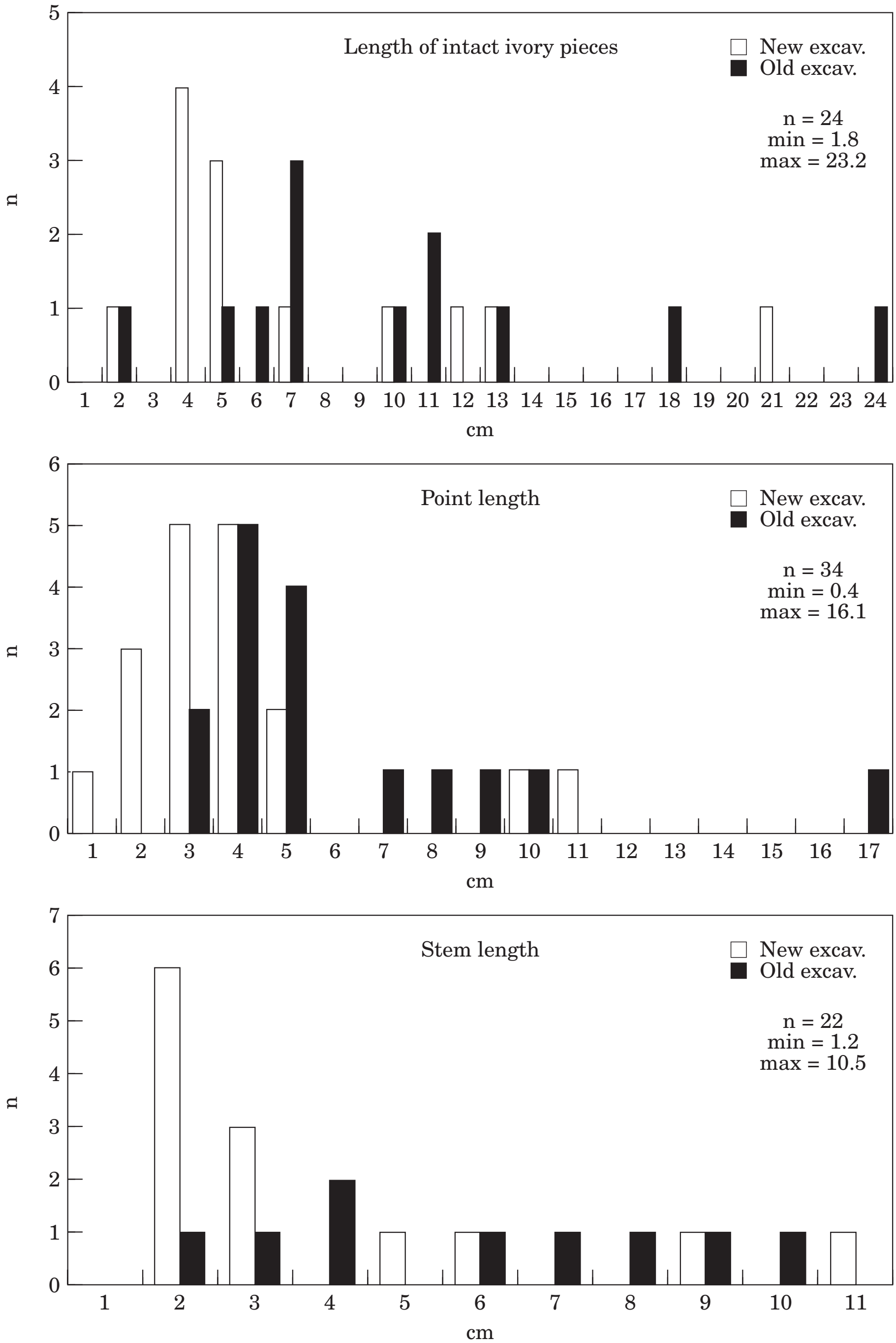

Figure 10. Frequencies distributions of total, stem and point length of intact ivory pieces from Howell and Freeman's excavations (old) and the 1993–1999 excavations (new). 1=0–1 cm; 2=1–2 cm; etc.

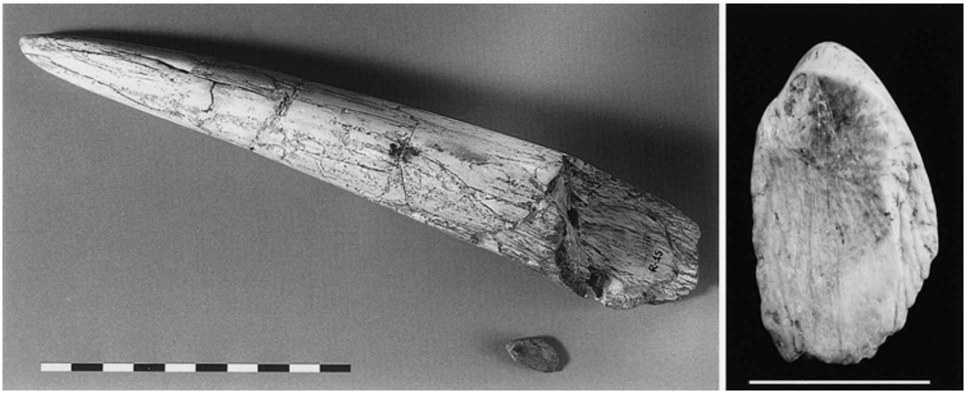

Figure 11. The longest and the shortest points found at Torralba and Ambrona (Torralba Q 1258, 1961 excavations, L=23·2 cm; Ambrona AS4 734, 1997 excavations, L=1·8 cm).

artefacts with fresh edges are abundant only in unit AS3, although even there about half of the sample is slightly abraded (Pérez-González *et al.*, 1997*a*). On a total of 40 pieces that could be analyzed from the old and new excavations, only six are fresh; 34 (i.e., 85%) are either slightly or very abraded. In some cases points are so rolled that they have almost completely lost their original shape. Frequency distributions of degrees of abrasion for different materials (Figure 13) indicate that ivory points and bones have comparable values; not surprisingly stone artefacts have higher proportions of relatively unabraded pieces. Points found in the old and new excavations show no difference in their degree of abrasion, suggesting similar sedimentary contexts for both series. In the two series there are some points that are heavily rolled [Figure 14(a)] and others that are quite fresh, with no striations on the fracture surfaces of stems [Figure 14(b)–(e)]. Figure 8(a), centre and right, and Figure 11(b) provide examples of slightly abraded pieces.

Microscopic analysis of bone and ivory surfaces confirms that at least some of the surface modifications noted on these pieces are due to taphonomic processes. According to Howell & Freeman (1983), 24 points carry striations of human origin (Table 2). They are described as occurring individually or in sets, on tips or stems, and as being oblique, transverse or more rarely longitudinal, occasionally chaotically oriented. Our analysis of new and old points shows that all of them carry striations. In most cases points are covered with randomly oriented or intersecting sets of striations of variable width and depth [Figures 15 and 16(c)]. These traces extend to the apical portion of the point, where no impact scars can be observed [Figure 15(a), (b), (d)]. That these striations have a nonanthropic origin is strongly suggested by the fact that similar patterns of striations occur on unworked tusks from Ambrona [Figure 15(e)], including on the internal face of annular tusk fragments, on the surfaces of many bones from the same site [Figure 15(f)] and on modern tusks (Figure 17(a), (b)]. It is clear that some of these striations are due to sedimentary abrasion, in particular those on the internal face of tusk annuli which are unexposed during the animal's life. Others were produced by the elephants themselves while using their tusks in a variety of activities, such as digging for tubers and water, scraping soil for salt or stripping bark from trees (Haynes, 1991). We can distinguish between the two agencies in only few cases. We can exclude abrasion as a possible cause

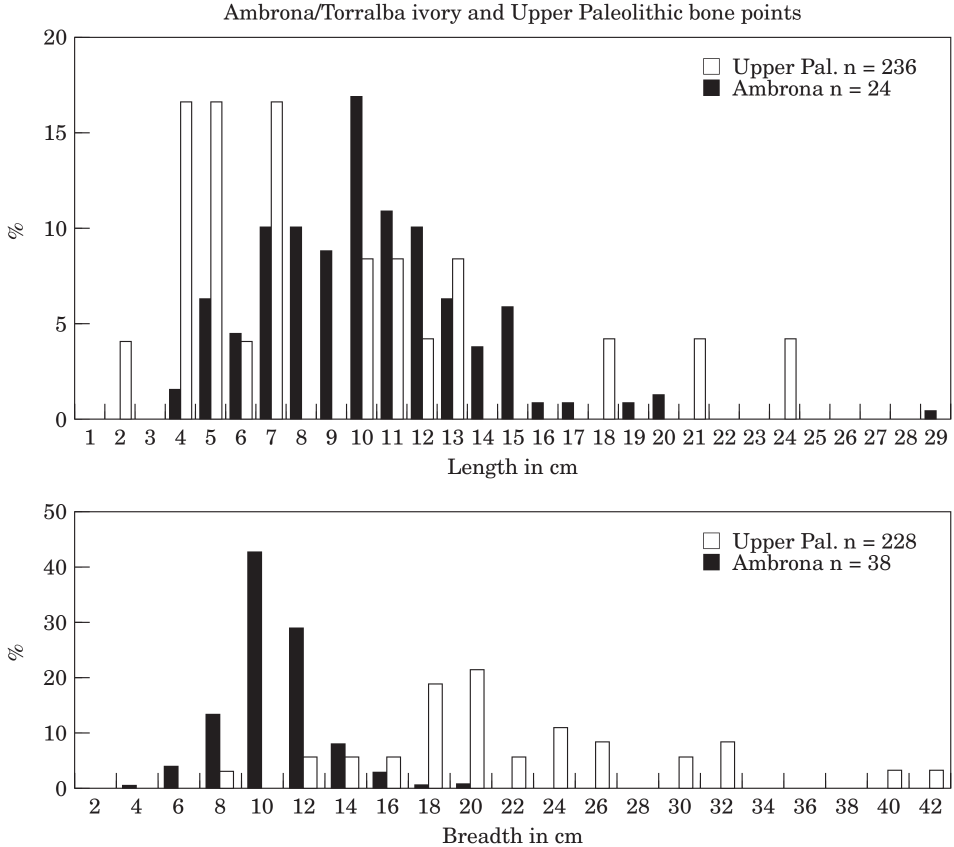

Figure 12. Frequency distributions of length and breadth of ivory pieces and Upper Paleolithic bone points from 12 Magdalenian sites in the Pyrenees region of France and Spain (data from Bertrand, 1999). 1 = 0–1 cm; 2 = 1–2 cm; etc.

of striations on the tip when stems are fresh and carry no striations [Figure 14(c), (e)]. Striations on stems with rounded fracture edges can only be the result of sedimentary abrasion (Figure 18).

Parallel striations interpreted by Howell & Freeman as the result of anthropic grinding are also present on a specimen from the new excavation [Figure 16(a)]. These traces are morphologically similar to ground bone surfaces yet their nonanthropic origin is strongly suggested by identical striations on modern tusks due to the use of the tusk during the life of the animal [Figure 16(b)].

On a few specimens one can observe deep and short grooves (Table 2) which can be found also on modern tusks and are therefore consistent with a natural, not anthropic, origin [Figure 17(c), (d)].

Polish on tip or stem, interpreted as due to use or rubbing against the haft, was observed by Howell & Freeman (1983) on 18 pieces (Table 2). Our SEM analysis of surfaces described as polished shows that they are covered by intersecting striations (Figure 18) comparable to those present on other points with varying degree of surface and edge abrasion [Figure 15(c), (d)] indicating that areas considered as polished do

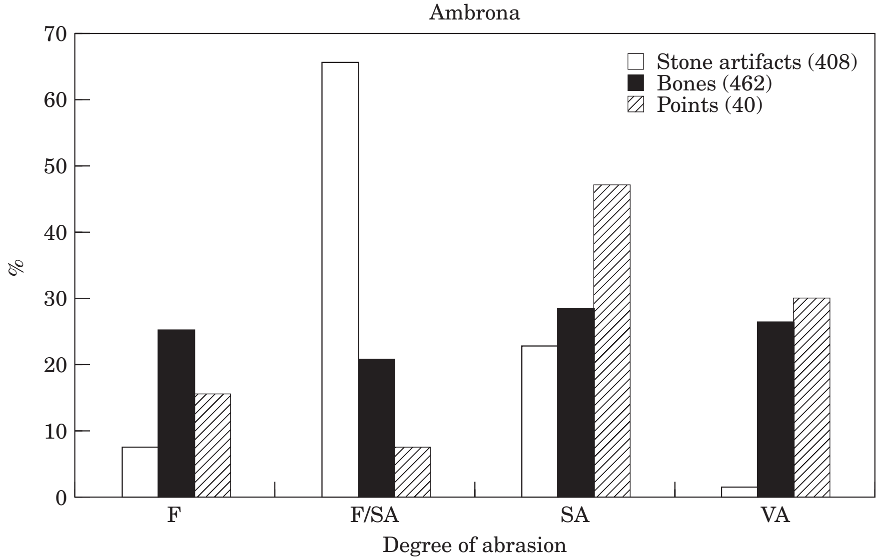

Figure 13. Degree of abrasion of the ivory points and of a sample of animal bones and stone artefacts from the corresponding stratigraphic units (AS1, AS1/2, AS3, AS4) in Ambrona. F=fresh; F/SA=fresh to slightly abraded; SA=slightly abraded; VA=very abraded.

not differ microscopically from naturally abraded surfaces.

Several stems present small flake scars on the sides or at the proximal end [i.e., Figure 8(a), Ambrona 49G/50] described as traces of intentional retouch or chipping by use. In fact such scars occur also on naturally broken tips collected by Haynes [Figure 7(d)] who considers them as damage occurring at the time of breakage. Facets described as an indication of deliberate shaping should also be considered a result of natural processes [Table 2 and Figure 8(a), Ambrona H98/13]. In fact, during the elephant's life the tusk tip can be broken, creating flattened surfaces that are gradually smoothed and worn down, forming facets with rounded edges and tips with spatulate ends (cf. Figure 9).

We must conclude that all the Torralba and Ambrona pieces are natural and not evidence that mid-Pleistocene hominids made or used ivory points.

The only anthropic modifications that we have been able to detect on the points coming from the old excavations are preparators' marks which occur in the form of wide scraping marks oriented longitudinally along the point sides. The recent origin of these marks is proven by the fact that they run into root marks [Figure 17(e)] or clearly remove the original patinated surface [Figure 17(f)]. These marks were probably made with metal spatulas, as indicated by our replicative experiments.

The ivory point from the site of Castel di Guido (Figure 2) is very similar to those from Torralba and Ambrona. At Castel di Guido elephant remains (NISP=1459) are the most abundant after those of *Bos primigenius* (NISP=2157). All skeletal elements are represented including 81 tusk fragments of which at least 20 are of large size. The ivory piece is listed among the bone tools; the authors note the occurrence of minute flake removals at the base of the stem and of longitudinal striations (Radmilli & Boschian, 1996). Although the processes of accumulation of the faunal assemblage are still to be elucidated and a microscopic

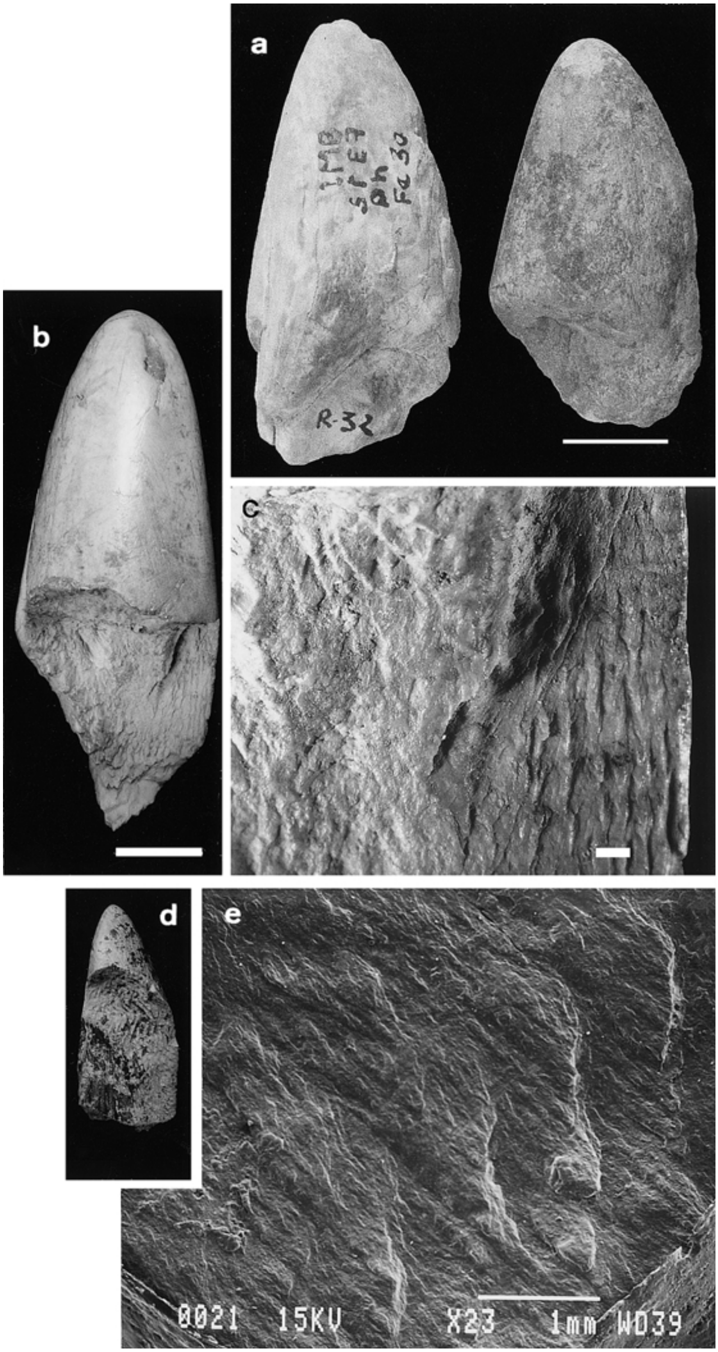

Figure 14. (a) Two heavily rolled points from the old and new Ambrona excavations, Ambrona 7/30 and AS4 888, scale=1 cm; (b) unabraded ivory point from Torralba (Cerralbo 2643; scale=1 cm) with striations on the natural tusk surface, but absent from the stem (c); note on the stem the characteristic fracture marks of fresh ivory, scale=1 mm; (d) AS4 608 with fresh edges, and (e) its unabraded stem, SEM micrographs, scale=1 mm.

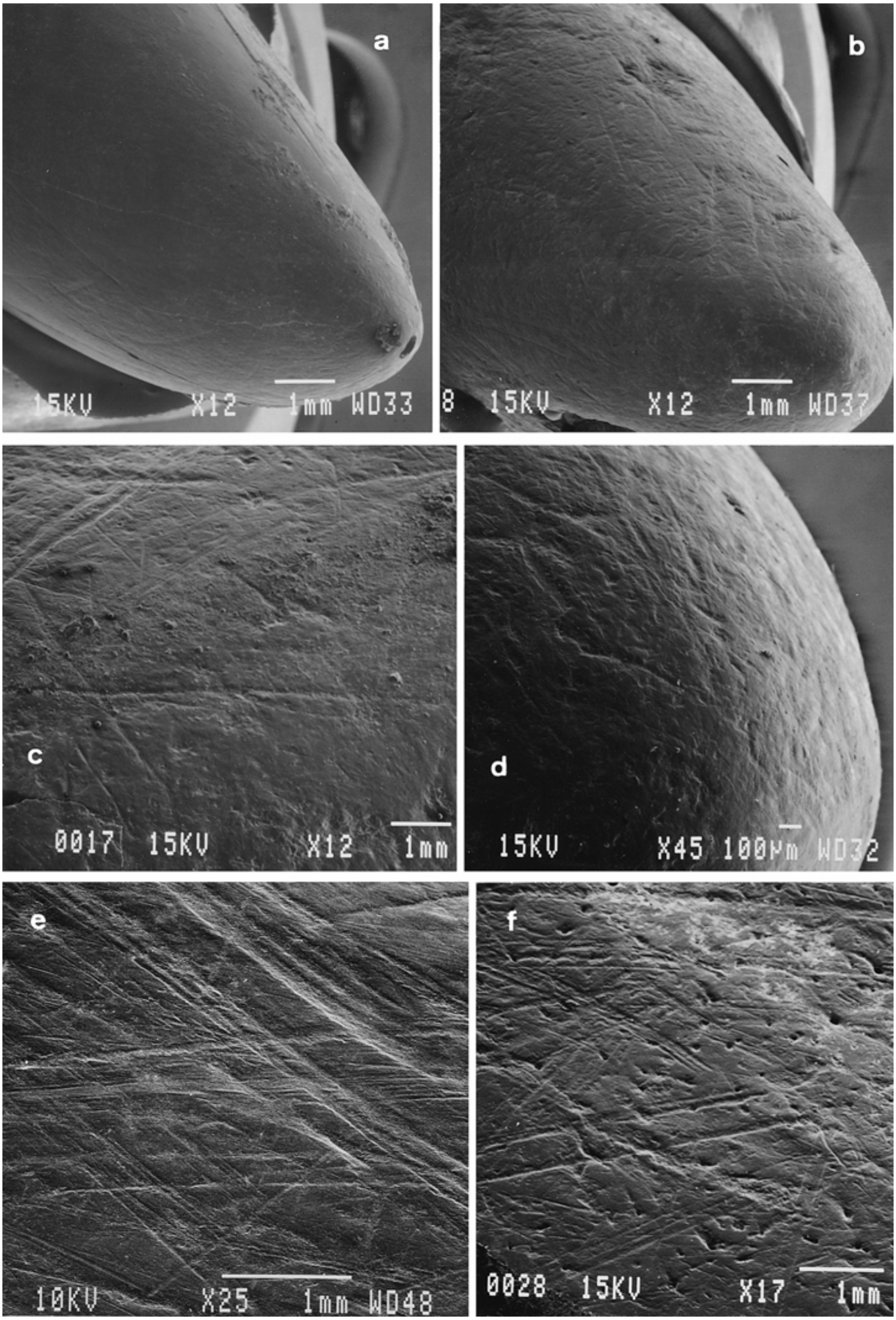

Figure 15. (a), (b) Two ivory points with fresh and slightly abraded surfaces; (c) close-up view of a slightly abraded point showing itersecting striations and small pits; (d) detail of point shown in (b) with short randomly oriented striations and small pits near the apex; (e) detail of the surface of an unworked tusk from Ambrona, old excavations; (f) abrasion striations on a bone fragment from Ambrona, new excavations. (a) AS4 608; (b) and (d) AS4 896; (c) AS1/2 166; (e) tusk H95 1983; (f) bone AS4 731).

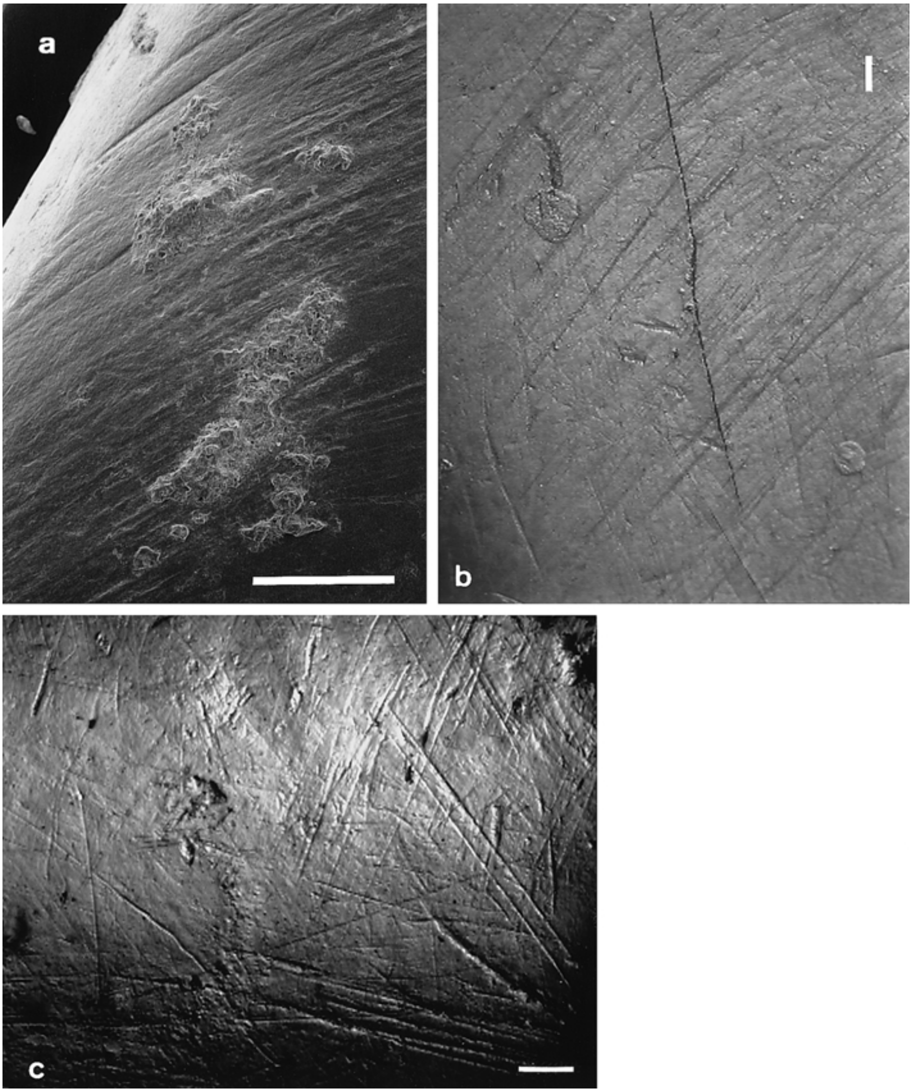

Figure 16. (a) SEM micrograph of parallel striations on point AS4 608. Calcareous concretions prove that the striations are ancient; (b) identical striations on a modern tusk; (c) randomly oriented and some parallel striations on point Cerralbo 2643. (b) and (c) are macrophotos of resin replica seen in transmitted light. Scale=1 mm.

analysis of the object remains to be done, a natural origin of the fragment is suggested to us, as at Torralba and Ambrona, by the available data and the absence of clear anthropic modifications.

Another ivory point, 60 cm long, is reported by Mania (1988) from Bilzingsleben, and described by him as obtained by splitting and sharpening. Since no illustration of these modifications is provided, we cannot assess the validity of Mania's interpretation. Unfortunately we have not been able to gain access to this object.

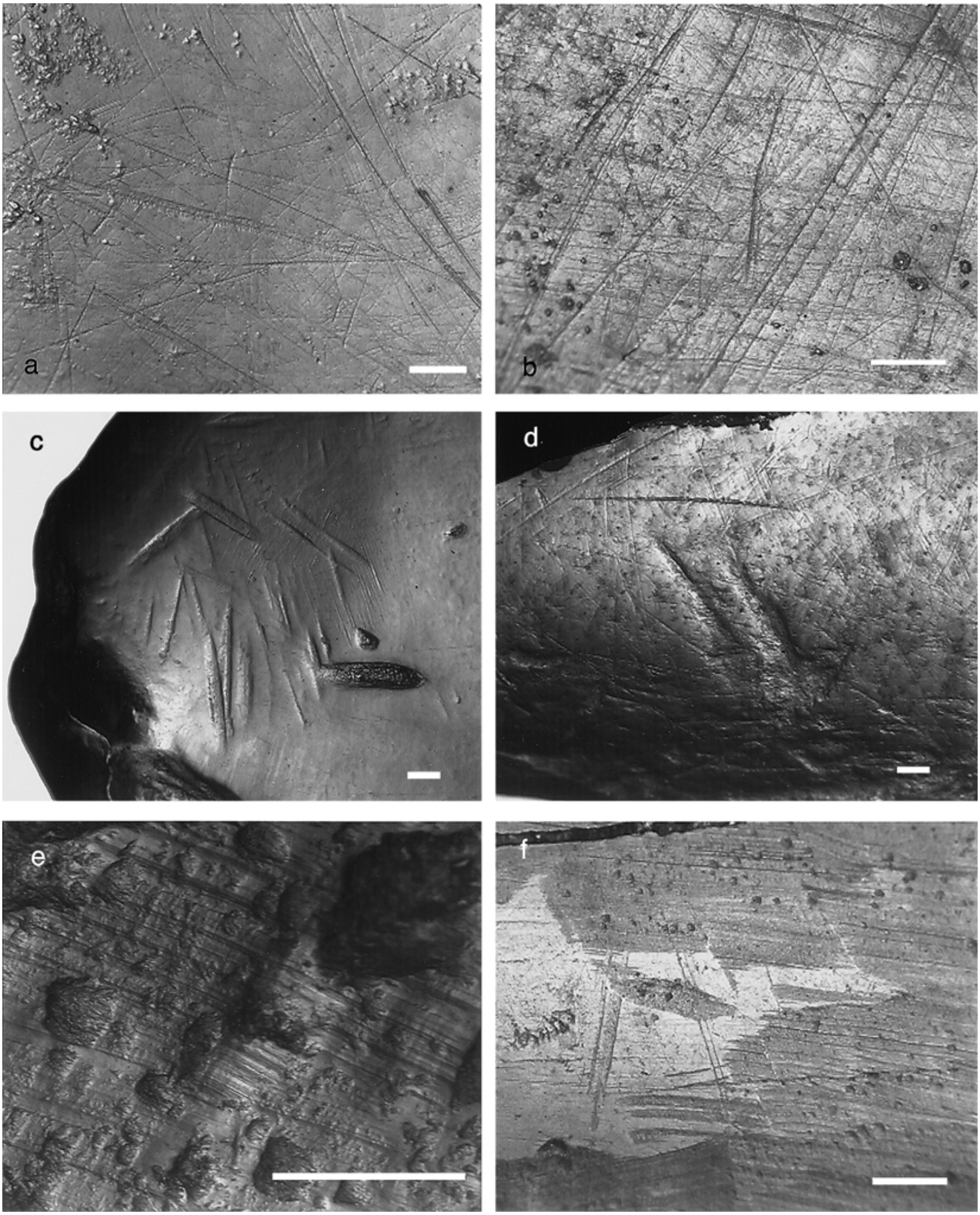

Figure 17. (a) Randomly oriented striations on a modern tusk; (b) groups of intersecting striations of a modern tusk; (c) grooves, pits and short striations on the broken tip of a modern tusk; (d) two deep grooves and some lighter, randomly oriented striations on ivory point Cerralbo 2643 from Torralba; (e) preparators' marks over root marks on point Ambrona 40A/6, note scraping marks running inside root marks; (f) preparators' marks and preserved ivory surface (lighter area to the left of the photo) on point Ambrona 41C/5. All macrophotos of resin replicas seen in transmitted light. Scale=1 mm.

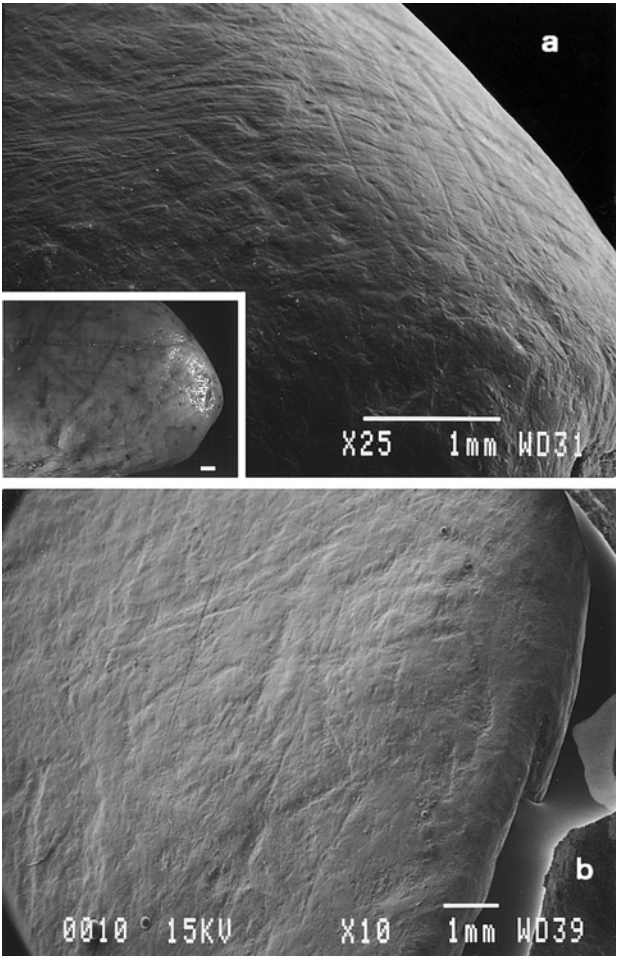

Figure 18. (a) Tip of ivory point Ambrona H98/13 described as polished, showing an abraded surface with sets of intersecting striations and micropits. (b) Stem of the same point with heavily rounded edge (to the right) and intersecting shallow striations on the abraded surface.

Bone and antler points

Vaufrey. This object appears to be a ventral fragment of a rib of a medium-sized mammal. Optical microscopy shows that the surface is altered by chemical action which has removed the bone outer surface and brought to light its porous structure (Figure 19). There is no evidence of grinding or any trace of working by stone tools; the only clearly visible modifications are rodent marks in the central area of the fragment. These marks are lighter in color and appear to have been made some time after the chemical alteration of the piece.

Combe Grenal. This putative broken "sagaie" is a distal fragment of a reindeer antler [Figure 20(a)]. Optical and SEM microscopy shows a well-preserved surface with no evidence of the manufacturing traces commonly found on Upper Paleolithic spear points [Figure 20(b)]. The SEM photo [Figure 20(c), (d)] shows a smoothing of prominent areas, perhaps the result of

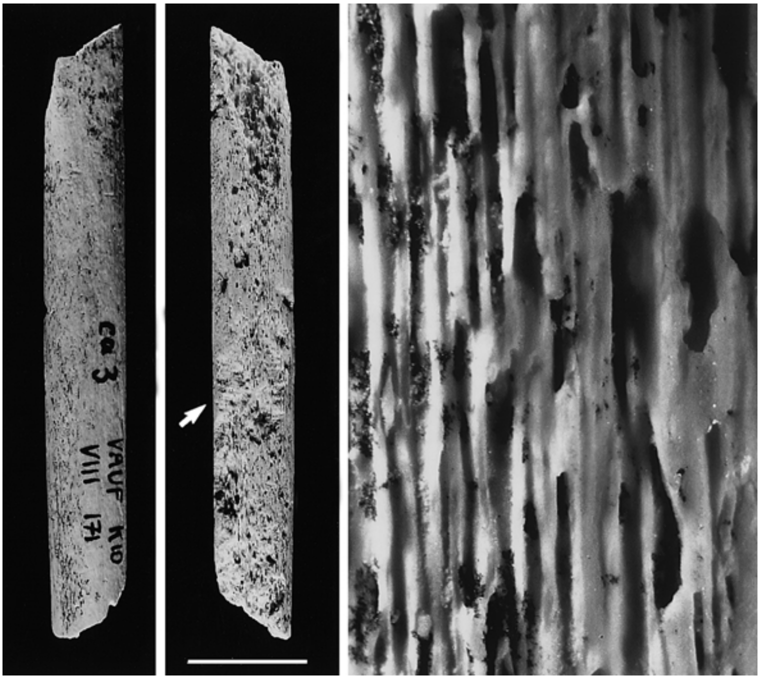

Figure 19. Grotte Vaufrey, layer VIII. Mesial fragment of a possible point described as shaped by grinding. To the right, microscopic view of the bone surface, showing spongy bone exposed by chemical alteration. The arrow indicates recent gnawing by a small rodent.

slight mechanical abrasion in the sediment, but no striations or scraping marks.

The morphology of the point with a sharp tip is not necessarily proof of human manufacture since we know that antlers of small-sized cervids can have sharp tips (Geist, 1999). In sum, there is no evidence that this object is anthropic and its shape should be considered natural.

Camiac. One of the six putative bone tools [Figure 21(a)] is a fragment of an accessory horse metacarpal with scoring by tooth marks at both ends [Figure 21(b)]. The other pieces are heavily abraded long bone fragments. None of the six pieces carries traces of manufacture, as shown by two SEM micrographs [Figure 21(c), (d)] where only the orientation of the bone fibers and a slight smoothing of the surface are visible. The smallest piece shows features (scalloped surface and thin, polished edges) which are typical of hyena-regurgitated bone fragments (Sutcliffe, 1970; d'Errico & Villa, 1997).

Actualistic and archeological evidence indicates that digestion by hyenas can produce pointed fragments mimicking artefactual bone points and perforators. We have found previously undescribed examples of such pseudo-points in the assemblage of hyena-regurgitated bones collected by Sutcliffe in modern African dens. A proximal rib fragment of a small bovid represented in Figure 22(d) provides the most striking case. Similar pseudo-artefacts can be found in Pleistocene hyena dens; as far as we know, they have not been described before. The pseudo-points found at the Upper Pleistocene site of Bois Roche include two specimens on bone [Figure 22(a) 1 and 2] and six specimens which are

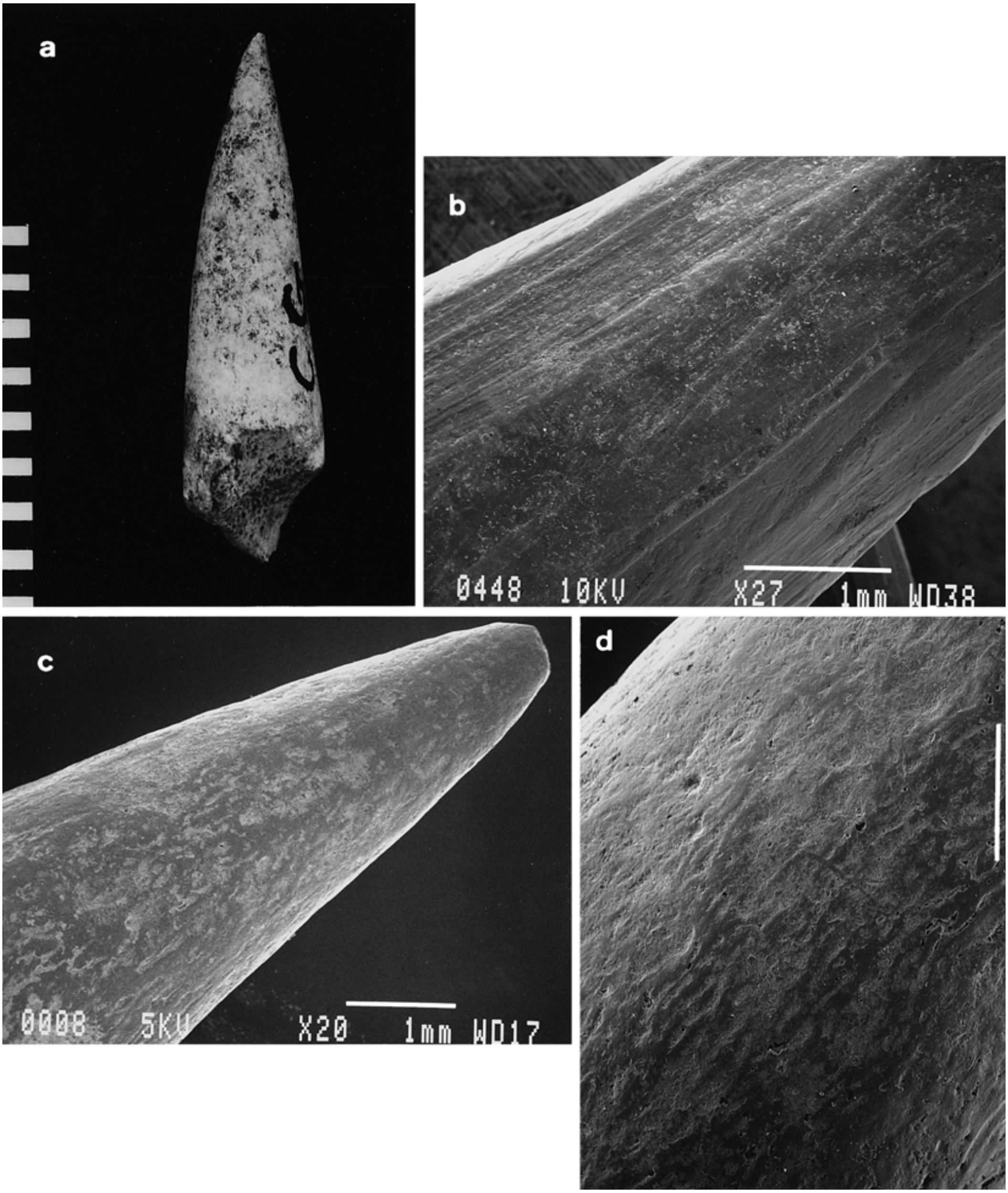

Figure 20. Combe Grenal, layer 16. (a) Antler tip described as a ‘‘sagaie’’. (b) Upper Paleolithic bone point from the site of Aitzbitarte kept in the Museo S. Telmo, San Sebastian (Basque region, Spain) with clear scraping marks due to manufacture. (c)–(d) SEM micrographs of the bone surface showing a slight abrasion and no traces of human manufacture.

antler tips [four are represented in Figure 22(a) 3 and 4, (b) and (c)]. All show the typical features of digestion (eroded and pitted surfaces with microconcavities and thin, sharp edges) as confirmed by SEM inspection of two antler tips [Figure 23(a),

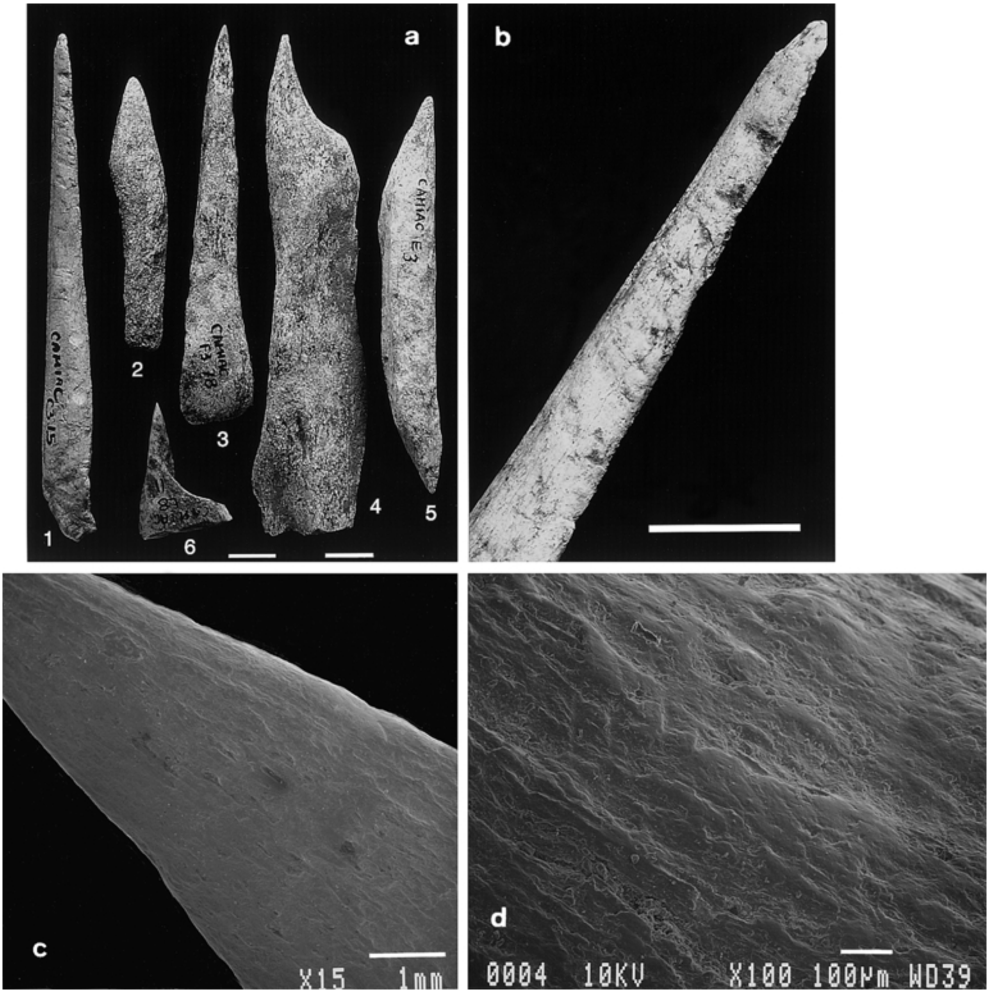

Figure 21. Six bone "points" from the site of Camiac (Gironde, France); (b) detail view of no. 1 with carnivore tooth pits; (c)–(d) SEM micrographs of point no. 4 showing chemically altered and partially abraded surfaces. Scales in (a), (b) = 1 cm.

(b)] and one bone specimen [Figure 23(c)]. The length of the bone specimens is 17 and 20 mm, the length of the antler specimens varies between 17 and 42 mm. Gnaw marks on three of the antler pseudo-points subsequently affected by digestion suggest that these objects result from breakage of antler tips by chewing hyenas. This is also suggested by the fact that all antlers from Bois Roche are heavily grawed. Feeding on antler seems to be a common behavior of Pleistocene hyenas, as noted by Fosse (1999).

The reference material collected by Sutcliffe and the archeological specimens from Bois Roche indicate that at least one of the Camiac specimens is a digested bone. The others are too abraded post-depositionally to be certain to have been digested. The accessory metapodial was gnawed but not digested, since the areas without gnaw marks present no evidence of

Figure 22. (a)–(c) Six pseudo-bone points from the Upper Pleistocene hyena den of Bois Roche (Charente, France). The two specimens on the left of (a) are of bone, all others are of deer antler. Note carnivore tooth pits on (b) and (c); (d) partially digested and regurgitated rib fragment shaped into a point by the gastric acids of a hyena (Ngorongoro Crater, Tanzania, A. Sutcliffe's collection, British Museum, Natural History). Scales = 1 cm.

chemical attack. In conclusion, there is no evidence that any of the Camiac objects are man-made.

It is worth noting that the size, shape and morphology of proximal breakage of the Combe Grenal specimen are similar to some

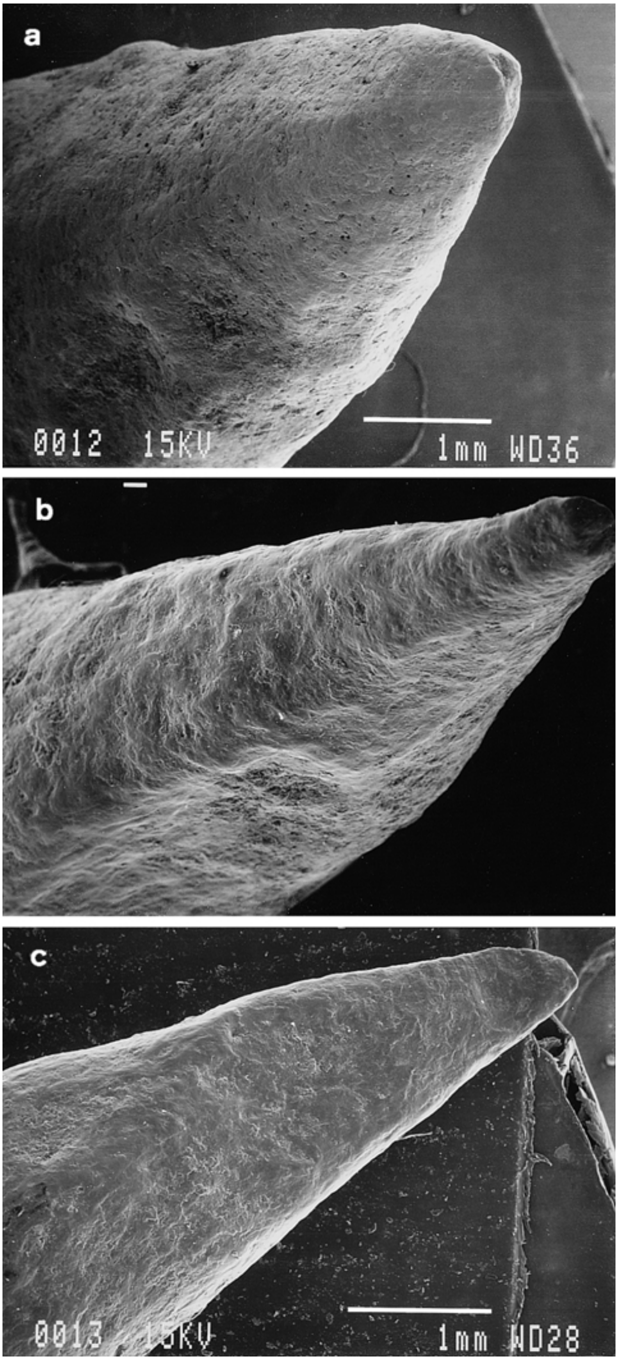

Figure 23. SEM micrographs of three of the Bois Roche pseudo-points. (a) Is a view of no. 4 in Figure 22(a), (b) corresponds to no. 3; (c) corresponds to no. 1. All are characterized by eroded surfaces and microconcavities, especially evident in (a) and (b). Scale in (b) = 100 μm.

of the hyena-produced pseudo-points of Bois Roche. However, the surface of the Combe Grenal specimen shows no evidence of chemical attack by gastric acid; only mechanical breakage seems to be involved. This demonstrates that different taphonomic processes can produce virtually identical pseudo-points.

Pech de l'Azé I. This putative bone awl was examined with the optical microscope. The surface shows no manufacturing traces of any sort. A few striations can be seen on the point; these appear natural, the result of mechanical abrasion in the sediments.

Summary and discussion

In conclusion, none of the objects we have studied can be interpreted as an intentionally shaped bone or ivory point. None carries traces of human manufacture or clear traces of use; all are comparable in shape, size and surface features to pointed pieces of ivory, bone and antler produced by natural processes.

It is true that we have not studied all the reported bone points. Some specimens are difficult to locate since they were found long ago (e.g., Grotte de l'Hermitage) but others, from more recent excavations, might be of easier access and could be restudied using procedures and reference materials similar to ours. Interestingly, a recent analysis of the faunal assemblage from the site of Prolom II has indicated that the cave was occupied primarily by hyenas and occasionally by humans. The authors (Enloe *et al.*, 2000) state that the human contribution to the faunal assemblage appears to be minimal. Clearly the pseudo-points we studied from the site of Bois Roche should be useful for interpreting these objects. A similar suggestion can be made for the putative bone point from Grotta del Broion [Figure 3(j)] which has been recently interpreted as a carnivore den used by bears and canids with only sporadic occupation by humans (Cassoli & Tagliacozzo, 1994) and the specimen from the cave of Lunel Viel [Figure 1(f)] which has an important hyena occupation (Fosse, 1994; Fosse *et al.*, 1998). On the other hand, we are not denying the possibility that some of the points we have not seen might be human artefacts [e.g., Gaudzinski, 1999*a*: Figure 4; Figure 3(q) in this paper] and that some bone fragments may actually have been modified to form an awl or short thrusting spears.

To date, however, the available published data are not sufficient to document the existence of hafted bone points and of specialized techniques applied to osseous materials throughout most of the Lower and Middle Paleolithic of Europe. In our view, a correct assessment of these controversial cases can only come from a microscopic analysis of bone surfaces, detailed discussions of contextual data and identification of natural processes mimicking human artefacts.

The first evidence we have of bone points, or more exactly bone awls, manufactured by European early hominids comes from sites dated to the very end of the Neandertal period, specifically from some Châtelperronian sites in France such as Grotte du Renne at Arcy-sur-Cure and Quinçay (Granger & Levêque, 1997; d'Errico *et al.*, 1998*a*,*b*). Traces of manufacture and decoration in the form of parallel striations and regularly shaped notches on the Arcy-sur-Cure awls are documented by macrophotos and by SEM and optical microscopy analyses (d'Errico *et al.*, 2000).

About 50 bone and ivory awls and awl fragments have been found in the Châtelperronian levels of Arcy. They were produced using three different methods. One consisted of modifying, by scraping, naturally pointed bones, such as accessory metapodials or ulnae of small carnivores. Awls could also be made by sharpening with scraping long bone fragments obtained by deliberate breakage. The third method consisted of producing elongated blanks from limb bones with the groove and splinter technique (also called longitudinal debitage; Newcomer, 1977); the blanks were then pointed by scraping. SEM analysis shows that these tools, many of which are decorated with regularly spaced fine incisions, have been used for a long time. Their points were resharpened by abrasion on a stone with a motion perpendicular to the tool axis and the facets resulting from this action of resharpening show subsequent wear traces clearly indicating re-use (d'Errico *et al.*, 1998*a*,*b*, 2000). The variety of manufacturing techniques, the occurrence of awl shapes not found in the Aurignacian and the large number of other bone tools and ornaments (about 150 bone tools and 33 ornaments) lends support to the idea that the Arcy Neandertals had developed autonomous technological traditions or were, at least, able to originally adapt to their needs technologies acquired through cultural exchanges.

Awls have also been reported from Uluzzian sites in Italy, in particular the recently published site of Castelcivita in Southern Italy, where the Uluzzian is dated by radiocarbon to 33–32 ka BP (Gioia, 1990; Gambassini, 1997). The Uluzzian is a Middle to Upper Paleolithic transitional industry with affinities to the Châtelperronian. It is apparently associated with Neandertal remains at Grotta del Cavallo (on the Uluzzo Bay in Southern Italy; Mussi, 1992) where the Uluzzian levels, overlying Denticulate Mousterian levels, have yielded two deciduous molars attributed to this human type (Mallegni, 1992 and personal communication). Among the Castelcivita bone pieces, three at least appear to be deliberately shaped, especially a biconical point, which shows striations due to human manufacture. In sum, on the basis of data from the Châtelperronian and Uluzzian sites, we cannot deny to late Neandertals the technological abilities implied by the use of specialized bone-working techniques; these techniques, applied by Neandertals to the making of awls, are essential for manufacturing projectile bone points. Yet in Eurasia there is no evidence of an organic spear armature technology before the Aurignacian.

Among the basic features of bone projectile technology discussed in detail by Knecht (1997) we should consider three that would seem to be essential prerequisites: hafting techniques, techniques for shaping the point and techniques for producing the blanks. With respect to hafting, we have seen that there is clear evidence of hafting of stone points, both in Africa and in the Near East and probably in Europe prior to the Upper Paleolithic. Although use of a ligature appears to be necessary for organic points (Knecht, 1997) and we have no evidence of this technique in the Middle Paleolithic, making ligatures would hardly seem beyond the capabilities of people who used mastic to haft their points and made Levallois flakes and blades (for a similar point see McBrearty & Brooks, 2000). Techniques such as wedging, whittling, scraping and shaving were used for working wood (Keeley, 1993) and making wooden points (Oakley *et al.*, 1977; Thieme, 2000) already in the middle part of the Middle Pleistocene. Transfer of techniques from one raw material to another is a behavior already apparent in the use of percussion to make flaked bone tools, such the bone bifaces and other tools from several Italian sites (see Introduction). Finally, a crucial aspect of bone projectile technology is the production of blanks. Evidence for the groove and splinter technique only comes from the very end of the Neandertal period (d'Errico *et al.*, 1998*a*,*b*, 2000) but reducing and forming bone can also be achieved by percussion, shaving and abrasion.

Regardless of the position we take concerning the significance of the

Châtelperronian bone tools, we can confidently say that hafting, use of lithic projectile points, hunting with wooden spears and techniques for working organic raw materials were part of the Middle Paleolithic technological repertory and were present already in OIS5 or earlier in Africa and Eurasia. In the Upper Paleolithic, projectile point technology includes not only a variety of specialized lithic forms but also an equally large variety of bone, antler and ivory points. Why is it that Middle Paleolithic hominids that had subsistence strategies which included hunting with hafted stone points did not diversify their tool panoply to include bone points?

On the basis of the evidence as it stands now we can only make some speculative suggestions about the adaptive factors that underlie or limit cultural and technical choices. For instance, the absence of organic spear armatures in the Middle Paleolithic may be due not to a deficiency in the technology of Neandertals but to the organizational strategies of the hunters. According to Ellis (1997) and Knecht (1997), bone points are more durable and can be repaired more easily than stone but require much more time to manufacture. On the other hand, ethnographic evidence suggests that stone points are used for large game while organic tips are used for smaller game; the smaller game (such as birds and small mammals, e.g., lagomorphs) can also be procured using simple equipment such as throwing sticks, slings, snares and traps (Ellis, 1997; for use of projectile points for hunting birds, see Cattelain, 1997). Hunting of birds has been suggested for some Mousterian sites in Spain such as Cova Negra and Gorham's cave (Eastham, 1989) and in Italy but only toward the end of the period, at sites such as Riparo Mochi, Riparo di Fumane and in the Uluzzian levels of Grotta di Castelcivita (Cassoli & Tagliacozzo, 1994, 1997*a*; De Grossi Mazzorin & Tagliacozzo, 1998). Taphonomic observations, such as occurrences of cutmarks and repetitive patterns of localized burning, observed in high frequencies on bird remains from Upper Paleolithic sites such as Grotta Romanelli in Italy and Combe-Saunière and La Vache, in France (Cassoli & Tagliacozzo, 1997*b*; Laroulandie, 2000) would substantiate these interpretations by eliminating hypotheses of natural death for rock-nesting or cliff-roosting birds (such as swallows, doves or choughs) or accumulations by owls and mammalian carnivores. However such studies have not been published and the inference of hunting is based only on the large size and habitat (river-bank and open land, i.e., away from caves) of some species, such as aquatic and galliform birds (but see Andrews, 1990 for a discussion of the nesting and prey habit of diurnal raptors). Older evidence for hunting of rock-nesting birds, corvids and passeriforms at the Lazaret cave is unconvincing (Villa, 1983). At present, concentration on ungulate hunting and foraging of slow-moving small species such as tortoises and littoral shellfish would seem to be the common pattern at Middle Paleolithic sites (Stiner *et al.*, 1999). If so, patterns of game choice and capture may be the reasons for the less diverse hunting equipment of Neandertals.

Given the scarcity of data, we cannot say whether Neandertals simply acquired birds and small mammals with nets or slings or whether they did not include them in their subsistence, thus explaining the absence of organic points. Moreover, some Upper Paleolithic bone and ivory points are so long (up to 40–50 cm; Corchon Rodriguez, 1986; Camps-Fabrer, 1988; Gvozdover, 1995) that they were certainly used for hunting medium to large animals. Thus, we may have to consider some additional factors. Upper Paleolithic bone and stone spear tips differ from Middle Paleolithic stone points hafted or suitable for hafting in aerodynamic properties and in the amount of kinetic energy at impact (Shea, 1997). Middle

Paleolithic stone points, even when carefully and symmetrically shaped by retouch, have often a fairly large and thick base, which implies a fairly large shaft, hence a rather heavy lance or javelin. This kind of weapon, when thrown by hand, will have a low velocity but a high penetration and stopping power at short distance; their cutting edges can cause wide, bleeding, lethal wounds. Robust organic points, launched in a similar way, would be unable to penetrate deeply into the hide and flesh of large mammals because of the softer and more elastic nature of this material and the lack of sharp edges facilitating the initial penetration of the weapon. In spite of the high degree of morphological and technical variability (consider, for instance, the differences between Gravettian and Solutrean lithic points) Upper Paleolithic stone and bone points all have one element in common: they have thin, straight tips and are light, i.e., they are highly aerodynamic and made to travel at high speed. This makes them suitable to be cast from afar. Their morphology and speed will allow them, if not stopped by bones, to go deeper into the animal body and injure internal organs. In general, however, javelins with organic points have less killing force than stone-tipped spears and will produce less lethal wounds in large terrestrial game (Ellis, 1997; Boëda *et al.*, 1999). Their effectiveness and force of impact is increased through the use of spearthrowers which are documented from the Solutrean to the Magdalenian (Cattelain, 1997). The fact that stone points can also be used as butchery knives (as it has been suggested for Paleoindian projectile points; Wheat, 1979; Shea, 1997) may have added a desirable functional versatility to Neandertals' hunting weapons, minimizing the number of tools needed by the hunter. In sum, it is possible that Middle Paleolithic hunting strategies were based on shooting large and medium size game from a close distance and that differences between the Mousterian and the Aurignacian hunting weapons may have more to do with preferred game choices and contexts of use than absence of creative thought or low technological abilities. It is true, however, that our knowledge of hunting strategies in the Paleolithic remains very limited. Therefore our conjectures merit exploration but cannot yet be substantiated.

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