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Seasonal variations of the Middle–Upper Paleolithic transition at El Castillo, Cueva Morín and El Pendo (Cantabria, Spain)

With debate escalating in regard to the prolonged contemporaneity of neandertal and modern human groups in the Franco-Cantabrian region on the one hand, and the late persistence of neandertals (until ca. 28–30,000 B.P.) and Mousterian industries in southern Iberia on the other; sites with Mousterian–Upper Paleolithic sequences from northern Spain play a pivotal role in the ongoing investigation of the Middle–Upper Paleolithic transition in western Europe. An important line of inquiry into the nature of social and economic change from the Middle to Upper Paleolithic is the monitoring of shifts in land use and resource procurement patterns. The recognition of short-term, seasonal patterning in settlement and resource provisioning may provide insights into changes in mobility, territoriality, and social organization that might otherwise be missed. This paper presents results of a seasonality study of fauna from archaeological levels spanning the Middle–Upper Paleolithic transition from the sites of El Castillo, El Pendo, and Cueva Morín in Cantabrian Spain. Data concerning season of death and age at death of prey animals presented here are derived from dental growth mark (increment, annuli) analysis. These data, along with other artifactual and faunal evidence suggest to us that: (1) economic strategies and technologies pervasive in the Upper Paleolithic are rooted in the Cantabrian Middle Paleolithic; and, (2) the apparent increase in deposits from the Middle through Upper Paleolithic may be the signature of a gradual increase in logistical economic strategies including the heightened level of social organization required for their implementation.

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Introduction

The nature of biocultural change from the Middle to Upper Paleolithic in western Eurasia, characterized either as an abrupt event with intrusive Aurignacian industries replacing resident Mousterian technologies, or, as a gradual, “more complex mosaic scenario” (Straus, 1995: p.7) with *in situ* technological innovations, has been a source of controversy for over four decades (e.g.,

Jordá Cerda, 1955; de Sonneville-Bordes, 1966; Bordes, 1968; Mellars, 1973; White, 1982; contributors to Mellars & Stringer, 1989; Cabrera Valdés, 1993; Knecht *et al.*, 1993; D’Errico *et al.*, 1998). Most recently, debate has escalated in regard to the punitive prolonged contemporaneity and “acculturation” of neandertal and modern human groups in the Franco-Cantabrian region along with the contested chronology of the Aurignacian and Châtelperronian

industries on the one hand (D'Errico *et al.*, 1998; respondents to D'Errico *et al.*, 1998), and the late persistence of neandertals (until ca. 28–30,000 B.P.) and Mousterian industries in Portugal and southern Spain on the other (Antunes *et al.*, 1989; Vega Toscano, 1990; Villaverde & Fumanal, 1990; Antunes, 1990–91; Raposo, 1993; Zihlão, 1993; Hublin *et al.*, 1995). AMS ^{14}C dates of ca. 40,000 B.P. from El Castillo in Cantabria and 38,000 B.P. from L'Arbreda and the Abric Romani in Catalunya represent the earliest unequivocal Aurignacian appearances in western Europe¹ (Bischoff *et al.*, 1989, 1994; Cabrera Valdés and Bischoff, 1989). These, along with the young dates from Portuguese and southern Spanish Mousterian sites, have inspired the controversial “Ebro Frontier” hypothesis (Zihlão, 1993, 1995; cf. Vega Toscano, 1998). At present then, sites with Middle–Upper Paleolithic sequences from northern Spain play a pivotal role in the ongoing investigation of the nature of the Middle–Upper Paleolithic transition.

At the core of debates surrounding the Middle–Upper Paleolithic transition in southwestern Europe are the movements/migrations, cultural, and perhaps biological interactions of peoples—peoples generating Mousterian, Châtelperronian, and Aurignacian tool assemblages (contrary to investigations of other regions, we do not find sufficient evidence in Cantabria to attribute these assemblages to particular human types). Therefore the uncovering of changes in land use, resource procurement patterns, and group mobility patterns are expected to throw light on the nature of social and economic change from the

Middle to Upper Paleolithic in this region (cf., Mellars, 1973; Bailey, 1983; Clark & Straus, 1983; White, 1985; Marks, 1988; Bernaldo de Quirós, 1992; Cabrera Valdés & Bernaldo de Quirós, 1992, 1996; Straus, 1992; Scheer, 1993; Svoboda *et al.*, 1996).

In addition to the detection of long-term shifts, the recognition of short-term, seasonal patterning in settlement and resource provisioning can provide behavioral information that might otherwise be missed (see e.g., Speth, 1987, 1990). For example, recent evidence for seasonal patterning in economic strategies has suggested behavioral differences between neandertals and early modern humans in the Levantine Middle Paleolithic (Lieberman, 1993a), as well as alterations of both resource base and procurement strategies during various phases of the French Middle and Upper Paleolithic (Pike-Tay, 1991a; Brugal & David, 1993; Enloe, 1994; Burke, 1995). One of the first settlement models of the Upper Paleolithic employing seasonality as a key variable was Jochim's (1983, 1987) for southwest France. Jochim proposed that ecological pressure during the glacial maximum exerted human range restriction and population pressure which in turn led to economic specialization on salmon and intensification of big game hunting (1983: p. 217; 1987: pp. 321–327). Although there is no evidence for intensive salmon fishing in Upper Paleolithic southwest France, the apparent increase in sites which led to Jochim's notion of a population increase may instead indicate a shift in settlement pattern (Pike-Tay, 1991a: p. 15; Burke, 1995: p. 69). Jochim's predictions of changes in degree of mobility, territoriality, and seasonal group aggregations as a result of population/settlement shifts offer working hypotheses for a seasonality study of Cantabrian sites.

This paper presents results of a seasonality study of fauna from archaeological levels spanning the Middle–Upper Paleolithic transition (from ca. 50 kya to 30 kya)

¹At Trou Magritte (Straus, 1995b), Aurignacian stratum 3 was AMS-dated to $41,300 \pm 1690$ B.P., but underlying stratum 4 was AMS-dated to $30,890 \pm 660$ B.P. and $21,550 \pm 190$ B.P. Straus proposes that the discrepancy is attributed to significant protein leaching from bones in stratum 4, a plausible explanation since all three dates were measured on the aspartic-acid fraction of bone collagen.

from the sites of El Castillo, El Pendo, and Cueva Morín in Cantabrian Spain. Faunal samples are from Mousterian, Châtelperronian, Aurignacian and Gravettian levels (Table 1). Data concerning season of death and age at death of prey animals presented here are derived from analysis of the dental microstructure of their teeth [i.e., dental growth mark (increment, annuli) or skeletochronological analysis]. Table 1 shows samples sizes for this study in their culture-stratigraphic sequence.

The study is preliminary in that: (1) results of other faunal analyses are not available for all assemblages. For example, faunal assemblages from El Castillo's recent excavations are currently under study by Dr Jesús Altuna and NISP/MNI counts and taphonomic studies are not yet completed; and (2) while dental annuli analysis can provide sound indications of seasonal hunting, additional seasonal indicators should be sought for a definitive picture of site seasonality (for a range of indicators see Monks, 1981; Pike-Tay, 1991a; Stiner, 1994: pp. 343–351). Therefore, interpretations offered here may require modification in light of future work.

Materials

There are only two Lower Périgordian (Châtelperronian) contexts in Cantabria, those from Cueva Morín and El Pendo. Early Aurignacian deposits in the region come from Cueva Morín, El Pendo, El Castillo (all in Cantabria Province, Figure 1), El Conde (in Asturias) and Lezetxiki (in Guipúzcoa); all of which were previously occupied during the Mousterian. However, other sites (such as Cueto de la Mina and Amalda) had either never before been intensively used by humans, or had experienced an occupational hiatus around the time of the “transition.” Such sites saw their first early Upper Paleolithic occupation late

in time than Cueva Morín, El Pendo, and El Castillo (Straus, 1992, p. 75; Cabrera Valdés & Bernaldo de Quirós, 1996). Known site location for the early Upper Paleolithic appears to mirror that of the Mousterian (Freeman, 1973b), occurring along the narrow Cantabrian coastal plain from the Bay of Biscay and into the low hills stretching before the Cordillera Cantabrica. Although based on approximations, available data indicate a very low population density during the Mousterian of Cantabria (Butzer, 1986). Expansion from Mousterian sites is local, consisting of radii from 5 to 10 km in the wide valleys of the low-altitude hilly region (Cabrera Valdés & Bernaldo de Quirós, 1992). Deposits also appear along rivers in the interior valleys at altitudes between 30 and 100 m. These sites are in the minority and are where evidence suggesting more specialized subsistence strategies such as ibex hunting is found. Butzer (1986) observed that the proportions of two settlement types were similar for both the Upper and Middle Paleolithic; in each case one-third of the sites are interior settlements (nine of 27 known Upper Paleolithic sites and three of nine Mousterian sites). On the other hand, calculations by Straus (1983) and Clark (1986) of tool density (per volume of sediment) and site frequency suggest settlement changes over time. They concluded that the Mousterian corresponds to a low site frequency of 0.2 (14 deposits and 75,000 years), with a progressive increase until the Austurian/Azilian (end of the Upper Paleolithic), where this measure reaches an average of 25.7 (77 deposits in an average of 3000 years). However, as Butzer (1986) noted, erosion and removal of sediments may have biased the number of known deposits. It is also important to consider the more intensive investigations of Upper Paleolithic sites, the difficulty of detecting intact open-air sites, and the need for intensive systematic survey of the north plateau—all of which may be contributing to

Table 1 Sample sizes for dental growth mark analysis in culture-stratigraphic succession

Industry, level	No. of "readable" teeth/level	Modified dental MNI	Depth of level	Available dates (AMS) (Cabrera Valdés & Bischoff, 1989; Cabrera Valdés <i>et al.</i> , 1996)
El Castillo				
Archaic Aurignacian, 18b1	14	9		38,500 ± 1800
Archaic Aurignacian, 18b2	30	17		37,700 ± 1800
Archaic Aurignacian, 18c	42	31	15–50 cm (18b1,b2,c)	40,000 ± 2100
Sterile, 19	na	na		
Charentian Mousterian (H), 20a,b	29	21		43,300 ± 2900; 39,300 ± 1900
Charentian Mousterian (H), 20c	25	14	35–45 cm (20a,b,c)	
Total no. of teeth sectioned (all species)	159			
Total no. of "readable teeth"	140			
Total no. of "unreadable" teeth (H)=with hendedores [flake cleavers]	19			
Cueva Morin				
Gravettian, 5a	10	7	20–25 cm	
Evolved Aurignacian, 5b and c	7	7	5–10 cm	
Typical Aurignacian, 6	5	4	20–30 cm	32,145 ± 865
Typical Aurignacian, 7	na	na	15 cm	29,515 ± 840
Archaic Aurignacian, 8	na	na		28,435 ± 540
Archaic Aurignacian, 9	1	1	30 cm (levels8and9)	28,515 ± 735; 28,515 ± 1280
Chatelperronian 10	na	na	5 cm	36,950 ± 6580; 28,515 ± 840
Denticulate Mousterian, 11	na	na	10–20 cm	
Denticulate Mousterian, 12	na	na	3–20 cm (12aandb)	
Mousterian, 13	1	1	5 cm	
Mousterian, 14	1	1	4–7 cm	
Typical Mousterian (H), 15	na	na	2–5 cm	
Typical Mousterian (H), 16	na	na	3 cm	
Typical Mousterian (H), 17	2	2	5–2 cm	
Total no. of teeth sectioned (all species)	33			
Total no. of "readable teeth"	27			
Total no. of "unreadable" teeth	6			
El Pendo				
Gravettian, Va	5	4	5 cm	
Evolved Aurignacian, Vb	1	1	20 cm	
Evolved Aurignacian, VI	5	4	15 cm	
Typical Aurignacian, VIIa,b	8	8	10 cm	
Chatelperronian, VIII	1	1	12 cm	
Archaic Aurignacian, VIIIb	3	3	10 cm	
Mousterian, IX	na	na	25 cm	
Mousterian, X	na	na	7 cm	
Mousterian, XI, XII, XIII(H)	4	4	7 cm,10 cm,7 cm	
Typical Mousterian (H), XIV	na	na	9 cm	
Mousterian, XV	na	na	40 cm	
Typical Mousterian (H), XVIa	3	3	22 cm	
Total no. of teeth sectioned (all species)	31			
Total no. of "readable teeth"	30			
Total no. of "unreadable" teeth	1			



Figure 1. Map of Cantabrian Spain showing the sites of El Castillo, Cueva Morin, and El Pendo and the provincial capital of Santander.

the current picture of Middle Paleolithic niche exploitation of Cantabria's littoral fringe, with selective exploitation of the wide valleys in the foothills, and with the high mountains and central plateau utilized only sporadically if at all. This problem is further complicated by the fact that dates pertaining to the Middle–Upper Paleolithic transition in Cantabria are few and often lacking in precision given the present maximum limit of the radiocarbon method. Therefore,

the AMS ^{14}C dates of $40,000 \pm 2100$, $38,500 \pm 800$, and $37,700 \pm 1800$ B.P., furnished by charcoal samples from the Basal Aurignacian Level 18 at El Castillo (Cabrera Valdés & Bischoff, 1989) are especially important.

On the basis of the existing site location and tool density data, Mousterian groups in the region have generally come to be viewed as few in number and dispersed. Butzer (1986) also predicted that Mousterian

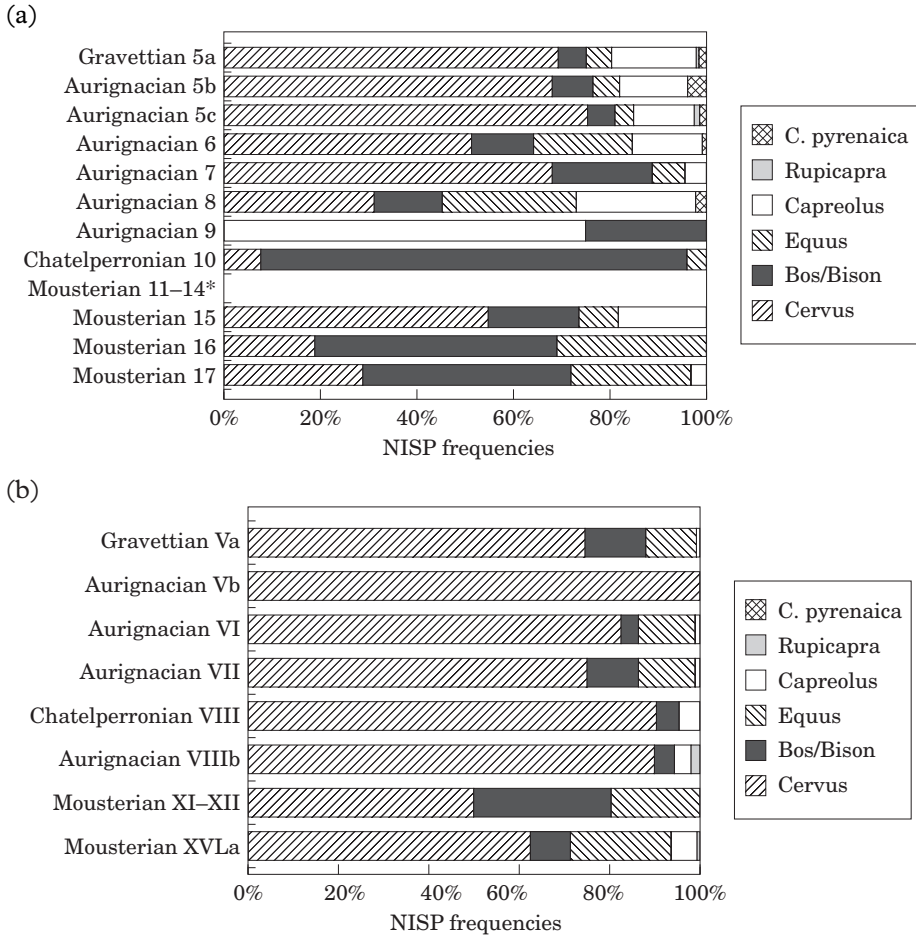


Figure 2. (a) Species abundance as measured by relative NISP frequencies. Cueva Morin counts from Altuna (1970, 1973); (b) El Pendo counts from Fuentes Vidarte (1980). *Data not available.

occupations would not overlap seasonally. The apparent increase in deposits from the Middle through Upper Paleolithic may be the artefact of taphonomic disturbances and inadequate archaeological reconnaissance or it may be a true reflection of population increase, in the sense of either an increase in the number of groups or an increase in group size. It may also be the signature of a shift in settlement strategies with a progressive increase in group mobility, logistical economic strategies (*sensu* Binford, 1980), and in the level of social organization required for territorial control. It is our contention that

seasonality data will help clarify or discount the roles played by these variables.

El Castillo

El Castillo cave is located some 30 km from Cantabria’s coastal capital of Santander on a steep hillside above the Pas river, one of many relatively short north–south rivers running from the Cordillera Cantabrica through the narrow stretch of coastal plain to the Bay of Biscay (Figure 1). From 1910–15, Obermaier excavated an archaeologically-rich 18 m deep section at the center of the large entrance chamber of the cave, leaving a

Table 2 El Castillo faunal lists of levels 18 and 20 from 1910–15 excavations

Taxon in probable order of abundance (descriptions of Vaufrey, Newton & Fischer, 1910–15)	Aurignacian Delta (level 18)	Mousterian A (level 20)
<i>Cervus elaphus</i> , red deer	“Numerous, 216 individuals”	“Very abundant, 184 individuals”
<i>Bos sp.</i> [and/or <i>Bison sp.</i>], large bovines	“Numerous, 29 individuals”	“133 individuals”
<i>Equus caballus</i> , horse	“Numerous”	“Very abundant”
<i>Rhinoceros mercki</i> [= <i>Dicerorhinus kirchbergensis</i>], Merck’s rhino, or more likely <i>D. hemitoechus</i> [Altuna, 1971:397]	“Fairly numerous”	“Present”
<i>Capreolus capreolus</i> , roe deer	“Fairly rare”	“Very rare”
<i>Rupicapra rupicapra</i> , chamois	“Fairly rare”	“rare”
<i>Capra ibex</i> [or <i>C. pyrenaica</i> [Altuna, 1971:389]], ibex	“Very rare”	“One molar”
<i>Elephas antiquus</i> , straight-tusked elephant	“Fragments”	
<i>Sus scrofa</i> , wild boar	“Very rare”	“One molar”

relatively large intact section near the entrance itself (Obermaier, 1924). In 1980, Cabrera Valdés began excavating an approximately 8 by 6 m area of the intact section (referred to here as the recent excavations) and those excavations continue today. El Castillo’s long stratigraphic sequence [26 levels of cultural remains span the “Acheulean”, Mousterian, Aurignacian, Périgordian (Gravettian), Solutrean, Magdalenian, Mesolithic (Azilian), and Bronze Age] has been studied from a range of perspectives (Obermaier, 1924; Freeman, 1964; Cabrera Valdés, 1978, 1984; Butzer, 1981; Bernaldo de Quirós, 1982; Cabrera Valdés & Bischoff, 1989; Bischoff *et al.*, 1992; Pumarejo & Cabrera Valdés, 1992; Bernaldo de Quirós & Cabrera Valdés, 1993; Klein & Cruz-Urbe, 1994; Cabrera Valdés & Bernaldo de Quirós, 1996; Pike-Tay, 1998). Sedimentological analyses show that the site’s deep Mousterian and Upper Paleolithic sequence falls within the last glaciation, i.e., within Oxygen Isotope Stages 4, 3, and 2 (Butzer, 1981; Cabrera Valdés & Bischoff, 1989; Cabrera Valdés *et al.*, 1997). Because the faunal sample from El Castillo’s recent excavations is much larger than those from Cueva Morín and El Pendo, El Castillo is

given primary emphasis in the present study (Table 1).

El Pendo

The mouth of the large, downward sloping cave of El Pendo is at the base of a steep bluff at the northern end of a long dry valley. It is 12 km from Santander (Figure 1). El Pendo’s stratigraphic sequence furnished 18 levels spanning the Middle and Upper Paleolithic and Azilian. It is one of the three sites in western Europe (along with Le Piage and Roc-de-Combe in southwest France) where, according to the excavators, a Lower Périgordian assemblage overlies an early Aurignacian level (Carballo, 1960; González Echeagaray, 1980; for a contrasting interpretation of the stratigraphy at El Pendo see Hoyos Gómez & Laville, 1983; for that of Le Piage, and Roc-de-Combe see D’Errico *et al.*, 1998).

Cueva Morín

Cueva Morín is located at the base of a low lying hill some 15 km from Santander (Figure 1). Morín, too, furnished a deep archaeological sequence of 22 levels that span the Middle Paleolithic to the

Table 3 NISP/MNI of herbivore prey from Cueva Morín

Industry, level	<i>Cervus elaphus</i>	<i>Bos/Bison</i>	<i>Equus</i>	<i>Capreolus</i>	<i>Rupicapra</i>	<i>Capra pyrenaica</i>
Gravettian 5a	373/9	29/3	30/4	94/5	3/1	8/3
Aurignacian 5b	143/7	17/3	12/2	30/4	0/0	8/1
Aurignacian 5c	120/6	9/1	6/1	20/4	1/1	3/1
Aurignacian 6	77/4	19/4	31/2	22/4	0/0	1/1
Aurignacian 7	86/5	26/2	8/1	6/1	0/0	0/0
Aurignacian 8	14/1	6/1	13/3	11/1	0/0	1/1
Aurignacian 9	0/0	3/1	1/1	0/0	0/0	0/0
Châtelperronian 10	2/1	23/1	1/1	0/0	0/0	0/0
Mousterian 11–14*	na	na	na	na	na	na
Mousterian 15	6/1	2/1	1/1	2/2	0/0	0/0
Mousterian 16	3/1	8/1	5/1	0/0	0/0	0/0
Mousterian 17	142/5	215/6	124/7	15/1	0/0	1/1

Measures of taxonomic abundance of major ungulate prey for levels sampled for dental annuli analysis. From Altuna (1970, 1973).

*NISP/MNI data for levels 11 through 14 not available.

Epipaleolithic (Freeman, 1971, 1973a, 1973b, 1981, 1992; González Echegaray & Freeman, 1971, 1973, 1978; Stuckenrath, 1978; Laville & Hoyos, 1994). Rare evidence for Mousterian structures (wind breaks, post holes) comes from level 17; as well as unusual and controversial burial evidence from Morín's Aurignacian level 8, dated to ca. 28,000 B.P. (González Echegaray & Freeman, 1973, 1978; Madariaga, 1973; González Morales, 1997: p. 65).

Lithic assemblages

Lithic raw material use in the Mousterian and early Upper Paleolithic (EUP) at El Castillo, El Pendo, and Cueva Morín emphasized local coarse-grained materials such as quartzite and ophite, with percentages of flint increasing from roughly 40–60% in the Mousterian to 90–98% in the Gravettian (Freeman, 1980; González Echegaray, 1980; Bernaldo de Quirós, 1982; Cabrera Valdés, 1988; Cabrera Valdés & Bernaldo de Quirós, 1992; Bernaldo de Quirós & Cabrera Valdés, 1993). At these and other Cantabrian sites, Middle Paleolithic tool types are present in early Upper Paleolithic assemblages, while early Upper Paleolithic tool types appear in

Mousterian assemblages (not as a result of post-depositional mixing, but of *in situ* technological development and continuity). Similarly, Aurignacian tool types are associated with Gravettian assemblages and vice versa (Freeman, 1980; González Echegaray, 1980; Bernaldo de Quirós, 1982; Cabrera Valdés, 1988; Straus, 1992: p. 74 and appendices; Bernaldo de Quirós & Cabrera Valdés, 1993). Therefore, conventional typological distinctions used for Middle and early Upper Paleolithic industries are problematic for this region. Overall, we find the technological transition from the Mousterian to the EUP to be more of a quantitative change than a qualitative one, marked by a progressive decrease in the number of sidescrapers and an increase in the number of endscrapers and burins (Bernaldo de Quirós, 1982; Bernaldo de Quirós & Cabrera Valdés, 1993).

At Cueva Morín, however, Freeman (1993) sees a rupture between the Châtelperronian and preceding Mousterian, with greater continuity existing between the former and the Aurignacian. To Freeman, the Mousterian is technologically monotonous, of long duration, with few

Table 4 NISP/MNI of herbivore prey from El Pendo

Industry, level	<i>Cervus elaphus</i>	<i>Bos/Bison</i>	<i>Equus</i>	<i>Capreolus</i>	<i>Rupicapra</i>	<i>Capra pyrenaica</i>
Gravettian Va	109/4	18/1	18/1	1/1	0/0	0/0
Aurignacian Vb	18/1	0/1	0/0	0/0	0/0	0/0
Aurignacian VI	232/7	9/0*	37/1	2/1	0/0	1/1
Aurignacian VII	167/5	23/1	30/3	2/1	0/0	0/0
Chatelperronian VIII	19/1	1/0*	0/1*	1/0*	0/0	0/0
Aurignacian VIIIb	46/2	2/1	0/0	2/1	0/0	1/0
Mousterian XI–XIII	10/2	6/2	4/1	0/0	0/0	0/0
Mousterian XVIa	185/10	25/12*	67/3	17/0*	0/0	1/1

Measures of taxonomic abundance of major ungulate prey for levels sampled for dental annuli analysis. From Fuentes Vidarte (1980).

*Discrepancies in data reporting (compare Cuadro 34 and Cuadro 35: pp. 218 and 234; Fuentes Vidarte, 1980).

Table 5 Percentage completeness of final growth zone stages of dental cementum of 216 adult *Rangifer tarandus* individuals of the Kaminuriak herd*

Month	Mean	Standard deviation	Most commonly observed	Total range	Predicted growth†
April	6.5%	4	4–9%	0–17%	11%
May	—	—	—	—	22%
June	15%	10	16–25%	0–32%	33%
July	—	—	—	—	44%
August	—	—	—	—	55%
September	68%	8	60–78%	53–86%	66%
October	—	—	—	—	77%
November	93%	7.5	84–100%	78–100%	88%
December	94%	6	94–100%	85–100%	99%
January			In winter annuli		
February			In winter annuli		
March			In winter annuli		

*Data from Pike-Tay, 1995.

†Predicted growth=if rate of growth is constant from April through December.

innovations and much formal variation. In contrast, Châtelperronian, Aurignacian and Gravettian assemblages show rapid successions of new forms, the introduction of osseous materials and a much higher degree of regularization in production and use than seen in the Mousterian assemblages (in spite of the persistence of Mousterian types throughout the EUP levels). In addition, he observes an easily recognizable regional character in the EUP assemblages, something not found in the Mousterian (Freeman, 1993: p. 175).

Geographically, the three sites form a triangle between the Bay of Santander and the valley of the Pas river, with no side of the triangle more than 25 km long. Raw material selection appears to be primarily a function of local accessibility in both Mousterian and EUP assemblages. At El Castillo, for example, a typological distinction occurs between quartzite and flint, where the use of flint in the Mousterian levels appears reserved for the manufacture of tools that vary in size between 4.5 and 7 cm. This is probably due both to the size

of available flint nodules as well as to the fact that flint sources are more distant than those of ophite and quartzite. Flint comes from diverse sources in Cueva Morín and El Pendo, sites situated closer to coastal outcrops than El Castillo is. At Morín, the proportion of flint is very high, in both the retouched and unretouched material. The only exception to this is in Mousterian level 15 where the proportion of quartzite is equal to that of flint. At Pendo, flint is also well represented. The high quality of Cantabrian quartzite, which is very fine grained, leads to its frequent utilization throughout the Paleolithic. Quartzite's presence overall is low to moderate in Morín and El Pendo, and high in Castillo (e.g. 45% in the Mousterian). It usually occurs as water-rolled pebbles at the sites.

Ophite is also widely used at the three sites, with outcrops occurring within a 2 km radius of Morín and El Pendo, suggesting expedient use of the nearest sources. It is used primarily in the manufacture of Mousterian flake cleavers (*hendedores*) at the two sites, but is also represented among other flake tools, as in level 17 of Morín. At El Castillo, ophite and coarse-grained quartzite, which are rarely utilized in other pieces, were employed in the production of the flake cleavers from level 20.

The presence of flake cleavers in classic Würmian Middle Paleolithic cave deposits of the Pyrenees and the Cantabrian shelf [which originally inspired Bordes's (1953) attribution of "Vasconian" to assemblages containing them] is probably related to both the expediency of their production in lower quality, available local raw material and to particular activities (we will return to this idea later). At El Castillo, El Pendo and Cueva Morín, Mousterian *hendedores* are always made on ophite and coarse-grained quartzites but never on flint. The stratigraphic position of these sites' Mousterian levels has been correlated to the final fluctuations of the Wurm II (Butzer, 1981). At

El Castillo, these fluctuations occur at the end of the Mousterian sequence with level 20, which contains flake cleavers and was previously assigned to the Hengelo by Butzer (1981), who has been proved correct by the dates of 43,300±2900 B.P. and 39,300±1900 B.P. recently obtained through ¹⁴C mass spectrometry (Cabrera Valdés *et al.*, 1996). Level 20 is separated from the lower levels of the EUP (level 18) by a thick stratum of sterile silts designated level 19. Level 19, which marks the Middle to Upper Paleolithic transition may then be broadly contemporary with the last levels of the Mousterian occupation of Cueva Morín and El Pendo, which are attributed to the Denticulate Mousterian. Thus, the older Mousterian occupations that yielded flake cleavers in the three caves could have been contemporary members of the same settlement system. These points will be clarified when our current program of dating of the site is completed.

Paleoenvironment and Fauna

Current evidence suggests that from the close of Oxygen Isotope Stage 4 through I.O. Stage 3 (corresponding broadly with Würm II and Würm II/III Interstadial of traditional terminology), Cantabria experienced an interpleniglacial climate with widely fluctuating, but primarily moderate conditions. Palynological, paleontological, and sedimentological evidence from the Santander caves is consistent with a variably cool, moist/humid parkland environment of pine, birch, juniper, and hazel, as well as grasses and ferns (Altuna, 1971, 1972, 1973, 1990; Leroi-Gourhan, 1971, 1980; Butzer, 1981, 1986). Forest cover expanded and receded in response to long term temperature, precipitation and soil conditions.

Middle Paleolithic-aged levels from Cantabrian sites show that large carnivores, such as cave bear, lion, hyaena, wolf, wild dog, and leopard, alternated cave tenancy

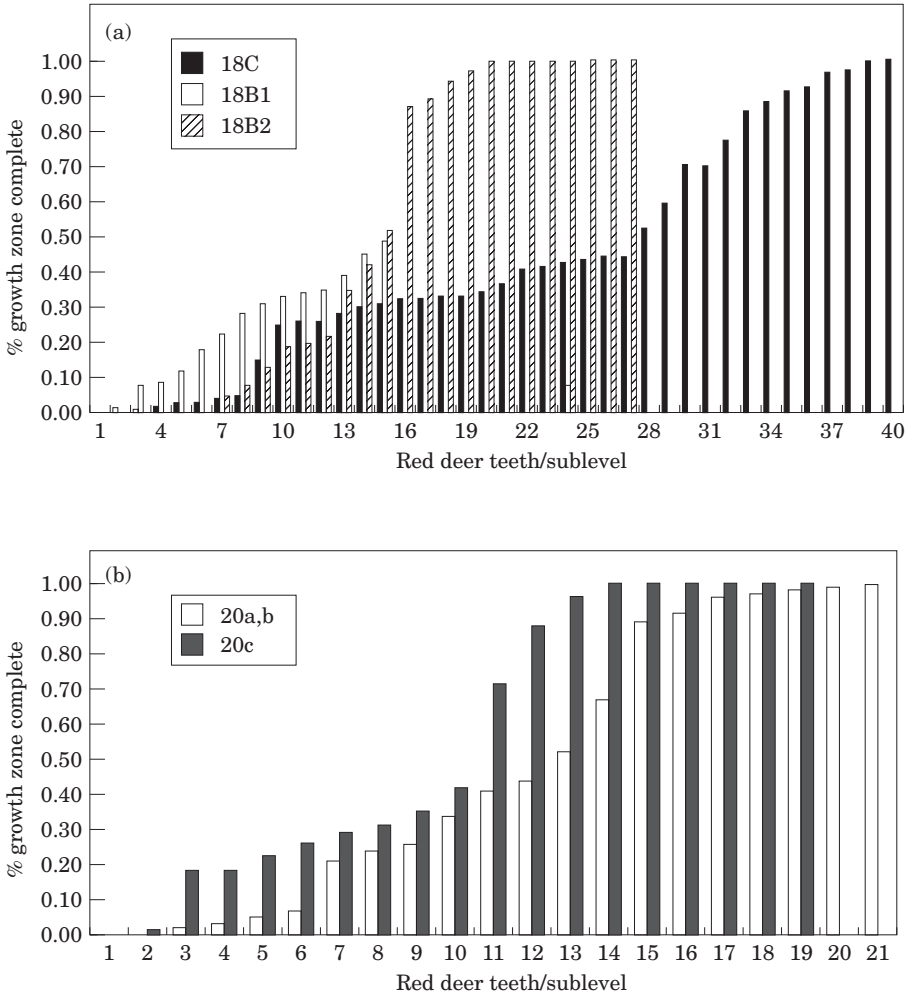


Figure 3. (a, b) Percentages of completeness of growth of the final cementum band of red deer teeth from El Castillo’s levels 18 and 20. Growth increments in most teeth from 18c and 18b2 are either <40% or >80% complete (=“spring” through “early summer” or “late fall” through “winter”); while most in 18b1 are <40% (“spring” through “early summer”). Growth stages in sublevels 20a,b vary little from those in 20c, with approximately half of the teeth <40% and half >70% (“spring” through “early summer” and “fall” through “winter” complete). Modern reference samples from Pike-Tay (1991a: pp. 41–64).

with humans and persisted throughout the early Upper Paleolithic, albeit in diminished numbers. While faunal analyses of El Pendo and Cueva Morín are generally complete (Altuna, 1971, 1973; Fuentes Vidarte, 1980), at El Castillo only level 18 of the recent excavations has been examined specifically to determine the primary agents of bone accumulation (Pumarejo & Cabrera

Valdés, 1992). That study indicates that humans were the principal bone accumulators in level 18. The same appears to be true for El Castillo’s level 20, although formal analyses are not yet completed. In this Mousterian level we have noticed many cut marks, but no carnivore marks on recovered bone. Therefore, we feel confident that humans, not large carnivores, were the

Table 6 Sample means and standard deviations of cementum growth stages of El Castillo's *Cervus* sample*

Archaeological strata	Mean	Standard deviation
18b1	0.24	0.16
18b2	0.58	0.41
18c	0.43	0.32
20a,b	0.47	0.39
20c	0.57	0.39
Aurignacian 18b1,b2,c	0.42	0.35
Mousterian 20a,b,c	0.52	0.39

*See text for sample details.

accumulators of the herbivore dental samples from this level.

Cantabrian grasslands supported herds of red deer, horse, bison, aurochs, and the occasional rhino (usually the steppe rhino, *Dicerorhinus hemitoechus* in the vicinity of the sites concerned here, particularly in Mousterian times), while chamois and ibex populated cliff and steep mountain sides and roe deer and wild boar could be found in localized stands of forest or scrub (Altuna, 1971, 1972, 1973, 1979, 1989, 1990; Fuentes Vidarte, 1980; Bernaldo de Quirós, 1982; Cabrera Valdés, 1984). Reindeer is only rarely encountered in Cantabrian sites but is present in El Castillo's Gravettian level 14 (Cabrera Valdés, 1984).

Faunal assemblages from El Castillo, El Pendo, and Cueva Morín's Mousterian

and early Upper Paleolithic (EUP) levels generally show red deer as most abundant (by MNI and/or NISP counts), followed closely by the large bovines, the aurochs and bison (*Bos/Bison*), horse, and roe deer, with less frequent occurrences of wild boar, chamois, and ibex (Altuna, 1971, 1973, 1979, 1989; Fuentes Vidarte, 1980; Bernaldo de Quirós, 1982; Cabrera Valdés, 1984). The main exception to this general pattern is seen in the earliest Aurignacian, Châtelperronian, and the Mousterian assemblages from Cueva Morín where large bovines and horse have higher bone counts than red deer (Altuna, 1971, 1973). Figure 2 shows ungulate species abundance by way of NISP frequencies from Cueva Morín and El Pendo (as noted above, such data are not yet available for El Castillo). While marine molluscs are encountered in both Mousterian and EUP contexts at the sites, they do not occur in the large quantities found in later Upper Paleolithic and Epipaleolithic levels [but see Cabrera Valdés (1984) on the molluscan fauna from El Castillo's Gravettian level 14].

The study samples

El Castillo's faunal assemblages. Samples selected from El Castillo's fauna for the seasonality study presented here come from the recent excavations. As noted above, the faunal analyses of the Mousterian and EUP assemblages [with an estimated total

Table 7 Dental cementum growth stages of temperature zone herbivores* recovered at Cantabrian sites

Late Growth†=late summer→late fall; growth zone band >1/2
Complete Growth=late fall or early winter; complete growth zone
Slow Growth=winter; in slow growth "annulus"
Early Growth=spring (end of winter→early summer); early growth zone band <1/2
Growth†=summer or fall; growth zone band ca. 1/2

*Red deer, wild cattle/bison, roe deer, and caprids (see text for details); modern reference samples from Grue & Jensen (1979), Klevezal' & Pucek (1987); Pike-Tay (1991a,b) and (Burke, 1993, 1995).

†The cementum bands from transects of these teeth are less visually distinct than some others, thereby necessitating broader seasonal designations.

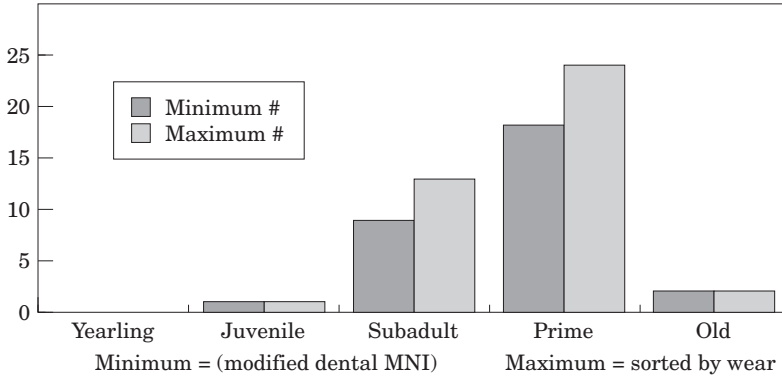


Figure 4. Minimum and maximum estimates of numbers of red deer from El Castillo level 18c. See text and Pike-Tay, 1991a, Appendix C for method details.

bone count of greater than 20,000 for level 18 (Pumarejo & Cabrera Valdés, 1992, p. 142)] are not yet complete. Overall, the assemblages recovered during the recent excavations appear to maintain the character of the faunal inventory of the 1910–15 excavations (Table 2). The summary of ungulates shown in Table 2 from Aurignacian Delta (level 18) and Mousterian A (level 20) is derived from the 1910–15 lists of Vaufray, Newton and Fischer (Cabrera Valdés, 1984: pp. 195, 235–236).

The sample selected for assessment of season of death and age at death of major prey species by dental growth mark analysis consists of 159 teeth from levels 18b1, 18b2, 18c, and 20a, 20b, and 20c. Basal Aurignacian level 18 is thick (15 to 30 cm) and its subdivisions are difficult to distinguish, especially in areas of large fallen blocks. On the basis of skeletal element representation and cut mark analysis, we believe that the dental samples from 18b1 and 18b2 come from a primary butchering area (Pumarejo & Cabrera Valdés, 1992). The dental samples from 18c come from a concentration of hearth sweepings, where much charcoal is interspersed with faunal and lithic remains. Mousterian level 20, characterized as a Charentian Mousterian with cleaver flakes (Cabrera Valdés, 1984), furnished evidence of two hearths with concentrations of char-

coal appearing in 20c1 and 20c3.² It now seems that 20a and 20b are probably a single archaeological stratum with materials coming from hearth sweepings. The 1998 summer excavations recovered a hominid premolar from level 20, but whether it belonged to a neandertal or an anatomically modern human has not yet been determined.

Cueva Morin's faunal assemblage. Table 3 shows Altuna's (1970, 1973) NISP and MNI counts for the major ungulate prey species for levels from Cueva Morin that were sampled for this study. Thirty-three teeth were selected for dental growth mark analysis.

El Pendo's faunal assemblage. Table 4 shows Fuentes Vidarte's (1980) NISP and MNI counts for the major ungulate prey species for levels from El Pendo that were sampled for dental growth mark analysis. Thirty-one teeth were selected.

²Although Obermaier noted the presence of continuous "hearths" in the early excavation, we initially assumed he inferred this from the sheer denseness of the occupation levels rather than the presence of actual structures related to combustion. However, the new excavations have caused us to rethink this assumption as large areas of combustion, probably indicating the presence of real hearths, are found within distinct tracts of the Mousterian strata.

Table 8 Summary of seasonality and age results from dental growth mark analysis of El Castillo's samples according to species and level

No. of teeth sectioned=159, no. unreadable=19						
<i>Aurignacian</i>						
<i>Level 18c</i>						
	<i>Cervus</i>	Juvenile/subadult/prime/old			Total mod. MNI	
Late Growth	0/2/3/0	<i>Bos/Bison</i>	0		5	
Complete Growth	0/1/0/0	0			1	
Slow Growth	0/1/1/0	0			2	
Early Growth	0/5/12/0	0/0/1/0			18	
Growth	1/0/2/1	0			4	
Other=in 18c, 1 <i>Cervus</i> NOT in winter					1	
<i>Aurignacian</i>						
<i>Level 18b1</i>						
	<i>Cervus</i>	Juvenile/subadult/prime/old			Total mod. MNI	
Late Growth	0	<i>Capreolus</i>	0		0	
Complete Growth	0	0			0	
Slow Growth	0	0			0	
Early Growth	0/2/4/1	0/0/1/0			8	
Growth	0/0/1/0	0			1	
<i>Aurignacian</i>						
<i>Level 18b2</i>						
	<i>Cervus</i>	<i>Capreolus</i>	<i>Rupicapra</i>		Total mod. MNI	
Late Growth	0/0/2/0	0	0		2	
Complete Growth	0/0/1/1	0	0		2	
Slow Growth	0/2/4/1	0/0/1/0	0/1/0/0		9	
Early Growth	0/1/3/0	0	0		4	
Growth	0/0/1/0	0	0		1	
<i>Mousterian</i>						
<i>Level 20a,20b</i>						
	<i>Cervus</i>	Yearling/juvenile/subadult/prime/old			Total mod. MNI	
Late Growth	1/1/0/0/0	<i>Bos/Bison</i>	0		2	
Complete Growth	0/0/1/4/0	0/0/0/1/0			6	
Slow Growth	0/0/0/1/1	0			2	
Early Growth	0/0/1/7/0	0/0/0/0/1			9	
Growth	0/0/0/2/0	0			2	
Other=in 20a and b, 1 prime <i>Cervus</i> NOT in winter					1	
<i>Mousterian</i>						
<i>Level 20c</i>						
	<i>Cervus</i>	Juvenile/subadult/prime/old			<i>C. pyrenaica</i>	Total mod. MNI
Late Growth	0	<i>Bos/Bison</i>	<i>Capreolus</i>	<i>Rupicapra</i>	0	0
Complete Growth	0/0/3/1	0/1/0/0	0	0/0/1/0	0/0/0/1	7
Slow Growth	0	0	0	0	0	0
Early Growth	0/0/3/1	0/1/0/0	0/0/1/0	0	0/0/1/0	7
Growth	0	0	0	0	0	0
Other=in 20c, 2 prime <i>Cervus</i> and 1 prime <i>Capreolus</i> NOT in winter and in 20c1, a prime <i>Cervus</i> and 1 prime <i>Bos/Bis</i> NOT in winter					5	

Late Growth=late summer to late fall (growth >1/2).

Complete Growth=late fall/winter, complete growth ZONE.

Slow Growth=winter, slow growing ANNULUS.

Early Growth="spring", end of winter through early summer (growth <1/2).

Growth=summer or fall (ca. 1/2).

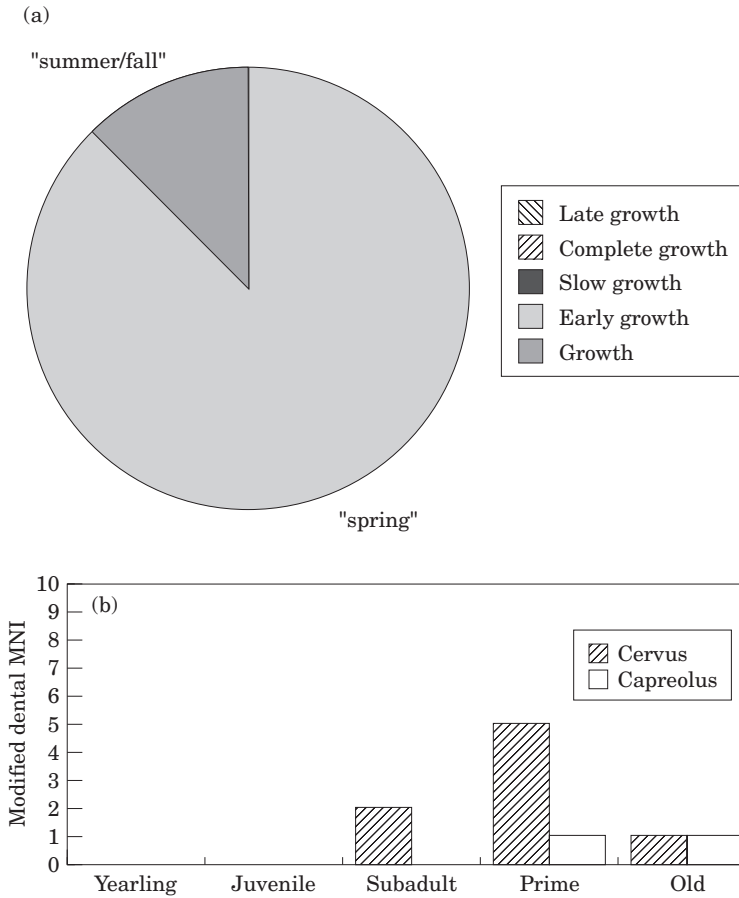


Figure 5. (a) Season of death and (b) age at death of prey animals from El Castillo level 18b1. Numbers=Modified dental MNI.

Methods

Assessing season of capture and age at death from the recording structures of teeth

Skeletochronology or sclerochronology is the study of recording structures apparent in mineralized vertebrate tissues (Mina & Klevezal', 1970; Castanet, 1980). Recording structures are incremental or layered growth marks that form in response to changes in the physiological condition of an organism. Growth marks occur diurnally, seasonally or annually in such structures as molluscan shells, fish bones, otoliths, and scales; the bones of amphibians, reptiles and

mammals; the keratinous layers of claws and horns of some animals; and the dentine and cementum of mammalian teeth. Growth marks in teeth have been of interest to biologists concerned with aging individual animals (Laws, 1952; Klevezal' & Kleinenberg, 1967; Morris, 1972; Spilage, 1973; Grue & Jensen, 1979; Klevezal', 1996). In the teeth of most temperate, subarctic, and arctic mammals, a yearly cycle is marked by one wide (growth) zone, temporally corresponding to the warmer seasons; in addition to one narrow *annulus* (slow growth) and/or a "line of arrested growth" (LAG), temporally corresponding

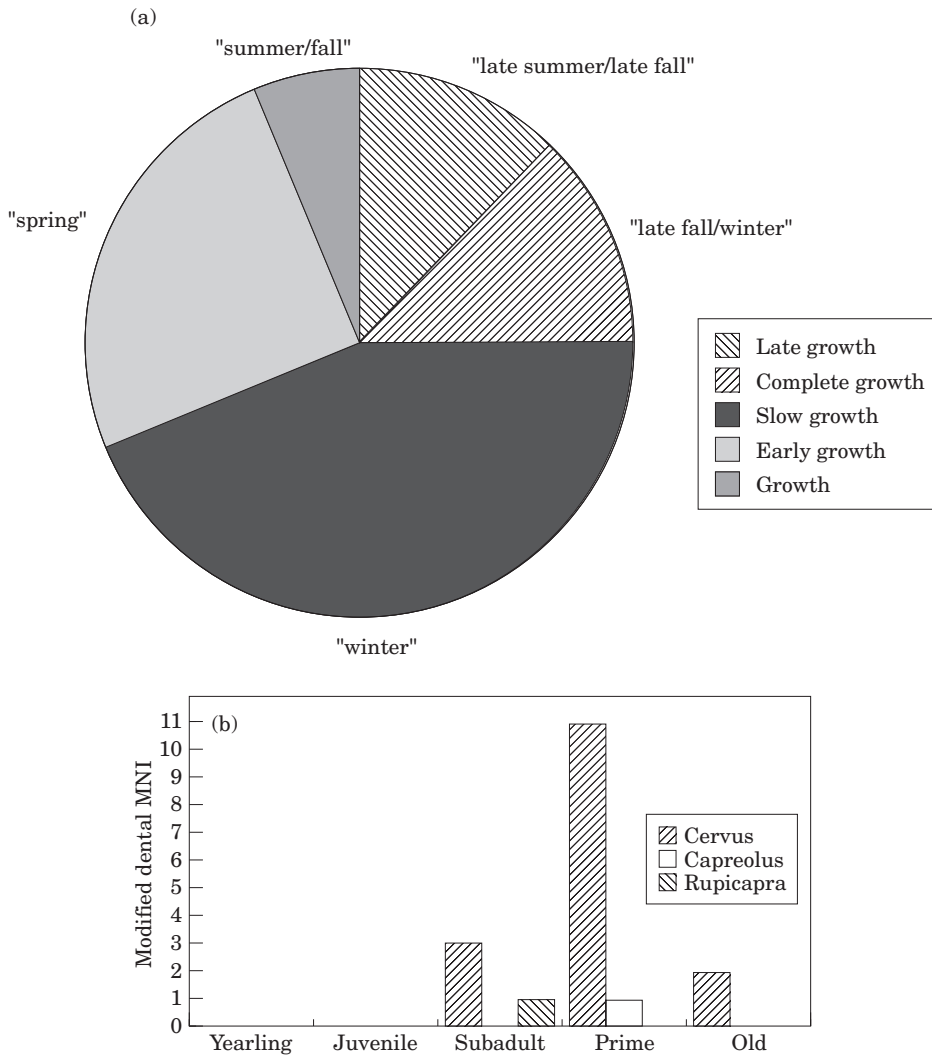


Figure 6. (a) Season of death and (b) age at death of prey animals from El Castillo level 18b2. Numbers=Modified dental MNI.

to "winter", and observable in the dental cementum and/or dentine (Castanet, 1981; Francillon-Vieillot *et al.*, 1990; Klevezal', 1996).

The physical and optical expressions of these growth increments in teeth are due to differing patterns of collagen fiber organization and to cell content/degree of mineralization (Castanet, 1981; Francillon-Vieillot *et al.*, 1990; Lieberman, 1993a,b; Klevezal',

1996). In the case of dental cementum, the differentiation of growth layers is the result of seasonal rhythms of cementoblast activity and quiescence and of occlusal strain (Lieberman, 1993a,b). Lieberman's controlled experiments with goats show that two major causal factors are at work in the formation of dental cementum increments: (1) the nutritional quality of the diet, which accounts for the width

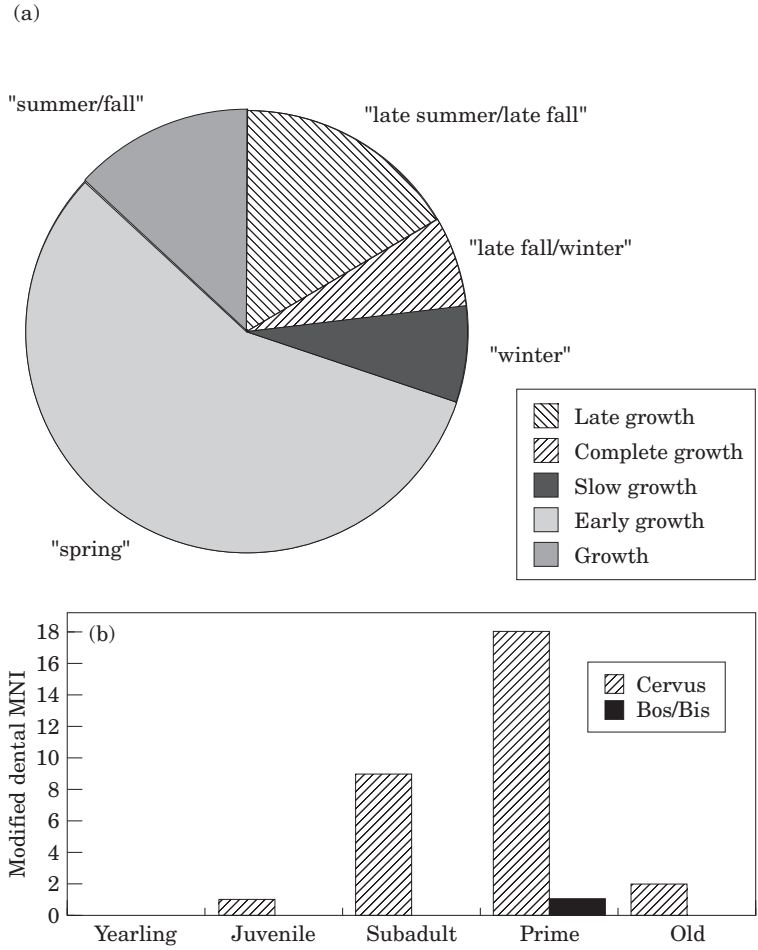


Figure 7. (a) Season of death and (b) age at death of prey animals from El Castillo level 18c. Numbers=Modified dental MNI.

of the band; and (2) food hardness, which affects occlusal strain resulting in the fibrillar angle changes in the extrinsic and intrinsic collagen fibers (which is responsible for the different optical qualities of the growth zone and annulus under the microscope) (Lieberman, 1993a,b). Results of Pike-Tay's (1995) and Weinand's (1997) studies of well-documented *Rangifer* (reindeer/caribou) and *Odocoileus* (white-tailed deer) herds respectively support Lieberman's conclusions. That these microstructural variations in teeth can indi-

cate the season of death of animals has been of particular concern to zooarchaeology (e.g., Saxon & Higham, 1969; Spiess, 1976, 1979; Bourque *et al.*, 1978; Gordon, 1982, 1988; Stallibrass, 1982; Savelle & Beattie, 1983; Koike & Ohtaishi, 1985; Beasley, 1987; Pike-Tay, 1991a,b, 1993, 1998; Burke, 1993, 1995; Lieberman, 1993a,1994; O'Brien, 1994; Weinand, 1997).

Methods and techniques. The methodology employed here for dental growth mark

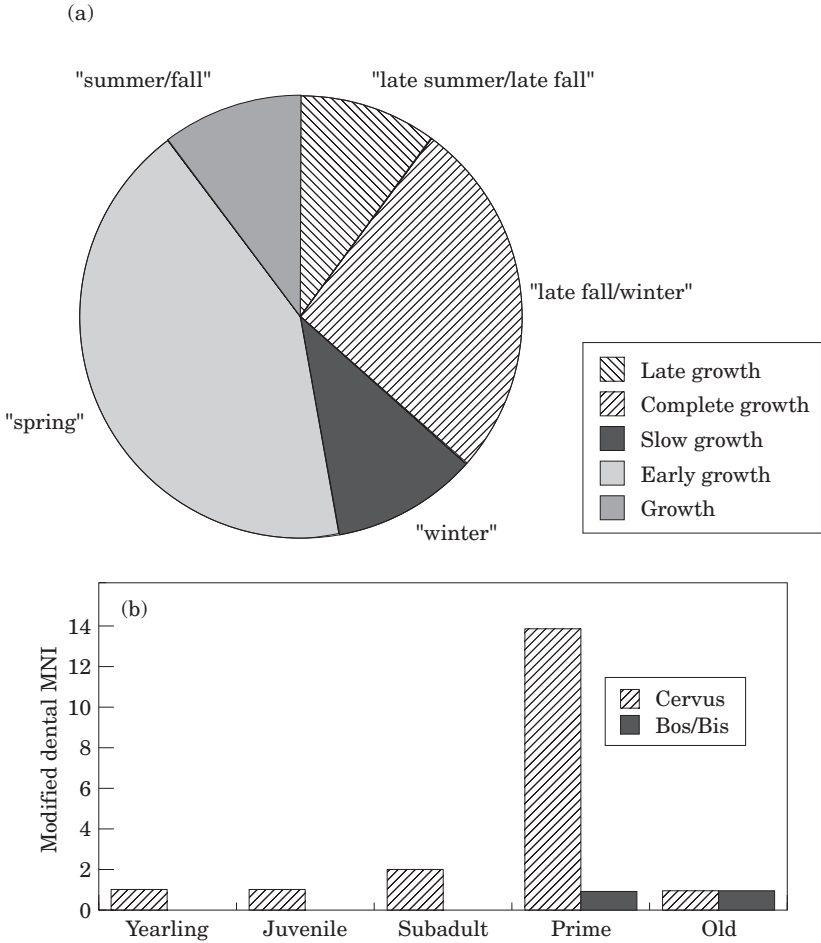


Figure 8. (a) Season of death and (b) age at death of prey animals from El Castillo sublevels 20a and b. Numbers=Modified dental MNI.

analysis of teeth from the Cantabrian sites follows the protocol described in Pike-Tay (1995), which built upon methodological contributions of Gordon (1982), Pike-Tay (1991b), Lieberman *et al.* (1990), and Burke (1993), including: (1) the preparation and use of radial “dry” thin sections (ca. 30 μ) taken at the mesial–distal midline of the tooth; (2) taking of measurements in the areas of acellular cementum near the tooth cervix (root/enamel junction) where, on cervid, bovid and caprid teeth the apposition of growth increments is most

regular; (3) the use of computerized image analysis of digitized scans of slides under polarized transmitted light (common mag.=40 ×, 100 ×, 250 × and 400 ×) for the measurement of consecutive growth zone widths at 2 or 3 cementum transects per tooth; and, finally, (4) the comparison of the “percentage of growth completed” of the final growth zone widths to those from the teeth of known-date-of-death animals of the same species and broadly similar environmental conditions and latitudinal range.

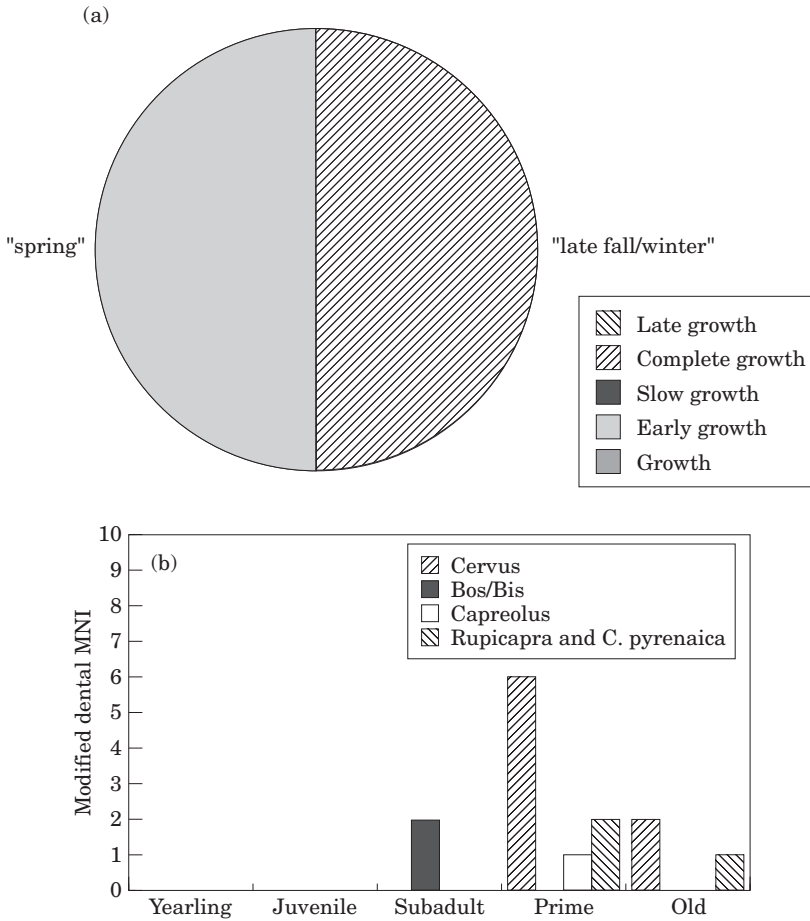


Figure 9. (a) Season of death and (b) age at death of prey animals from El Castillo level 20c. Numbers=Modified dental MNI.

Aging of individual animals. Aging individuals by dental annuli counts also follows the protocol presented in the Pike-Tay (1995) study, where the eruption schedule of each tooth is taken into account. In other words, if the first “winter” annulus forms during the first winter of life as is the case with *Cervus elaphus*, to get the correct age in years, the number of annuli counted on the incisors or M1 is a direct measure of age; 1 year is added to M2; and 2 years are added to P2, P3, P4 and M3 (cf. Mitchell, 1963; Miller, 1974; Grue & Jensen, 1979; Pike-Tay, 1991a). The following age cohorts are

used for all ungulates in the present study: calves (0–11 months), yearlings (12–23 months), juveniles (2–2 years 11 months), subadults (3–4 years 11 months), prime adults (5–10 years 11 months), and post-prime adults (11 years and over).

Attribution of season. Attributions of season of death to temperate zone taxa are temporally broader than attributions possible with subarctic and arctic taxa such as *Rangifer tarandus* (reindeer/caribou), the subject of the Pike-Tay (1995) study. *Rangifer* lives under extreme seasonal

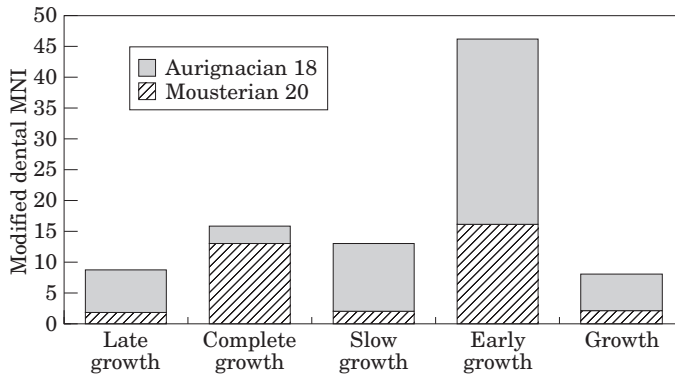


Figure 10. Cementum growth stages of prey animals from level 18 compared to those of level 20. Aurignacian level 18 shows mostly winter through spring growth; Mousterian level 20 shows mostly late fall through spring/early summer growth.

conditions and subsequently exhibits a high degree of regularity in dental cementum growth rates (Pike-Tay, 1995). Table 5 shows the results of the dental mark growth analysis of the right mandibular teeth of 216 known-age *Rangifer tarandus* individuals from the Kaminuriak herd of northern Canada (Pike-Tay, 1995: Table 4). Slightly slower growth is seen early in the warm season with a near constant growth rate (ca. 11% of total cementum zone width per month) attained by mid-summer. Observations indicate: (1) cementum is deposited at a regular rate only in areas of acellular cementum, e.g., nearest the tooth cervix; (2) no overlap exists between the early and late segments of the warm season; (3) initiation of the winter annulus is not as well synchronized as its cessation; and (4) multiple teeth from a given individual provide the same seasonal indications (Pike-Tay, 1995). These four observations hold for the artiodactyl (but not the equid) teeth examined for the present study.

The major difference between *Rangifer* and other high latitude taxa and the temperate zone ungulates (including *Equus*) is that the rate of cemental apposition is less regular in the temperate zone animals. *Rangifer* is a highly seasonal species with extreme

seasonal dietary differences (the key causal factor in dental growth mark patterning, as noted above). The seasonal climate and dietary shifts for Paleolithic prey animals of Cantabrian Spain and for their contemporary temperate zone counterparts were not and are not so extreme. Nonetheless, all of the animal species examined here do exhibit seasonally cyclical growth marks in their dental structures. In particular, red deer, the most abundant species in the study samples, exhibit extremely low variability in the timing of winter annulus formation across wide geographic areas (Mitchell, 1963; Keiss, 1969; Grue & Jensen, 1979, p. 14; Pike-Tay, 1991a,b). Although the dental “growth bands” of the herbivore species examined here cannot be subdivided to the degree possible with *Rangifer*, the early and later, and often, the middle phases of cementum zone growth do not overlap. Therefore, valuable information regarding season of capture may be derived from these animals.

Percentages of completed growth of the final cementum band of all “readable” teeth from red deer—the most abundant, and, in terms of cementum growth mark analysis, the most studied species in our sample—from El Castillo’s levels 18 and 20 are shown in Figure 3. Although there are

no statistically significant differences among the cementum growth data from each sub-level or between Aurignacian level 18 and Mousterian level 20 (see Table 6), visual inspection of Figure 3 shows variation among the sublevels. For example, the growth increments in most *Cervus* teeth in 18c and 18b2 are either <40% [=“spring” through “early summer” (Pike-Tay, 1991a, pp. 41–64)] or >80% [=“late fall” through “winter” (Pike-Tay, 1991a, pp. 41–64)] complete; while most in 18b1 are <40% (“spring” through “early summer”). On the other hand, the distributions of final dental cementum growth stages in sublevels 20a,b vary little from those in 20c, with approximately half of the teeth <40% (“spring” through “early summer”) and half >70% [=“fall” through “winter” (Pike-Tay, 1991a: pp. 41–64)] complete.

Rates of cemental apposition and/or initiation and cessation times of the “winter” annulus of known-aged ungulates (i.e., the control/comparative samples) used as references in the present study of Spanish archaeofaunas (i.e., red deer, horse, aurochs and bison, roe deer, chamois, and ibex) are from the following studies:

- (1) Grue & Jensen’s (1979) summary of their own and other researchers’ results for: roe deer, red deer, bison, equines, *Equus hemionus*, and caprines, *Ovis aries*, *Ovis dalli*, and *Ovis canadensis* (of different genera from Spanish caprines, therefore for general reference only).
- (2) Klevezal’ & Pucek (1987) on European Bison, *Bison bonasus*, hybrids of bison with cattle, and cattle, *Bos taurus*, for the large bovines;
- (3) Pike-Tay (1991a,b) summary of her own and other researchers’ results for red deer;
- (4) Burke (1993, 1995) for horse; and
- (5) in addition to Grue & Jensen’s more generalized data on caprines,

control samples of the same western European caprids recovered in the Spanish sites (ibex and chamois) currently being comprised by Pike-Tay are used as references for the corresponding archaeofaunas in the present study.

Unlike Pike-Tay’s (1995) recent *Rangifer* study, where actual measurements of “% growth zone completeness” were taken with the aid of computer image analysis (the method used in the present analysis) the above studies generally reported growth status of final cementum increments in broader estimates (e.g., fractions) of completed growth. A summary of the cemental growth rates derived from these studies and applied to the Spanish archaeofaunas is provided in Table 7. It is important to note that the cementum growth stages of *Equus* teeth, developmentally unlike those of the above artiodactyls, can rarely be subdivided any more precisely than “slow growth” or “fast growth” stages (Burke, 1993, 1995).

Sampling for the dental growth mark studies: use of a modified dental MNI

All red deer, horse, bovid and caprid teeth in the three archaeological collections were first identified to species and tooth type. Selections were then made for dental annuli analysis. If part of a dental series, only one tooth of the series was taken for analysis, as all members of a tooth row will provide the same information (see Pike-Tay, 1991a,b, 1995); and, if surficial damage to the cementum was obvious to the eye the tooth was rejected. In an attempt to balance both under- and over-representation of individual animals from a given archaeological level, qualitative tooth wear assessments were also given serious consideration in initial sample selection; while teeth showing similar seasonal and age results under the microscope were later linked to one individual. In other words, where a traditional MNI would

Table 9 Summary of seasonality and age results from dental growth mark analysis of Cueva Morin's samples according to species and level

No. of teeth sectioned=33, no. unreadable=6				
<i>Gravettian</i>				
<i>Level 5a</i>	Juvenile/subadult/prime/old			Total mod. MNI
	<i>Cervus</i>	<i>Capreolus</i>	<i>Equus</i>	
Late Growth	0	0	0/0/1/0	1
Complete Growth	0	0	0	0
Slow Growth	0	0	0	0
Early Growth	0/1/1/0	0/0/2/0	0	4
Growth	0/0/2/0	0	0	2
Other=in 5a, a prime <i>Cervus</i> NOT in winter annulus				1
<i>Aurignacian</i>				
<i>Level 5b and c</i>	Juvenile/subadult/prime/old			Total mod. MNI
	<i>Cervus</i>	<i>Capreolus</i>	<i>Rupicapra</i>	
Late Growth	0	0	0	0
Complete Growth	0	0	0	0
Slow Growth	0	0	0	0
Early Growth	0/1/3/0	0/1/0/0	0/0/1/0	6
Growth	0/0/1/0	0	0	1
<i>Aurignacian</i>				
<i>Level 6</i>	Juvenile/subadult/prime/old			Total mod. MNI
	<i>Cervus</i>	<i>Capreolus</i>		
Late Growth	0	0		0
Complete Growth	0	0		0
Slow Growth	0	0/0/1/0		1
Early Growth	0/0/1/0	1/0/1/0		3
Growth	0	0		0
Other=in 6a, <i>Equus</i> NOT in winter annulus				1
Aurignacian levels 7 and 8=no analysis done				
<i>Aurignacian</i>				
<i>Level 9</i>	Juvenile/subadult/prime/old			Total mod. MNI
	<i>Bos/Bison</i>			
Late Growth	0			0
Complete Growth	0/0/1/0			1
Slow Growth	0			0
Early Growth	0			0
Growth	0			0
Chatelperronian level 10=no analysis done				
<i>Mousterian</i>				
<i>Level 13</i>	Juvenile/subadult/prime/old			Total mod. MNI
	<i>Capreolus</i>			
Late Growth	0			0
Complete Growth	0			0
Slow Growth	0/0/1/0			1
Early Growth	0			0
Growth	0			0
<i>Mousterian</i>				
<i>Level 14</i>	Juvenile/subadult/prime/old			Total mod. MNI
	<i>Equus</i>			
Late Growth	0			0
Complete Growth	0			0
Slow Growth	1, age?			1
Early Growth	0			0
Growth	0			0
Mousterian levels 15 and 16=no analysis done				

Table 9 (Continued)

Mousterian Level 17	Juvenile/subadult/prime/old		Total mod. MNI
	<i>Bos/Bison</i>	<i>Rupicapra</i>	
Late Growth	0	0	0
Complete Growth	0/0/1/0	0/0/1/0	2
Slow Growth	0	0	0
Early Growth	0	0	0
Growth	0	0	0

Late Growth=late summer to late fall (growth >1/2).

Complete Growth=late fall/winter, complete growth ZONE.

Slow Growth=winter, slow growing ANNULUS.

Early Growth="spring", end of winter through early summer (growth <1/2).

Growth=summer or fall (ca. 1/2).

give a count of "1" for a slightly worn right M1 and a very heavily worn right M2 (which may erupt 6 months after the M1) belonging to the same species; both teeth were selected for dental annuli analysis because it is probable that they belonged to two individuals, a younger and an older one. Upon analysis, if different teeth (e.g., *Cervus* P4, M1 and M2), indicated the same age and same season of death according to cementum annuli counts and percentage of growth completed in the final cementum increment, they would be "linked" to one individual (method detailed in Pike-Tay, 1991a, Appendix C). While the initial tooth selection process ultimately contributes to an over-representation of individuals that may not be entirely corrected by "linking" teeth, the latter strategy does reduce the initial numbers; and, as can be seen in Figure 4, the age profiles (and seasonal patterns) of both the "corrected (linked)" and inflated numbers of individuals do not differ in character. Figure 4 shows age profiles of both minimum (=two or more teeth "linked" to an individual) and maximum (each tooth=1 individual) numbers of red deer from El Castillo 18c. All subsequent data presentation and figures in this study use only the minimum ("linked") measures of taxonomic abundance.

Results

El Castillo

Of the 159 teeth selected for analysis from levels 18b1, 18b2, 18c, and 20a, 20b, and 20c, 19 were "unreadable" under the microscope. Results of the dental annuli analysis for the ungulates from these levels are presented in Table 8 and Figures 5–9.

In general, results suggest year round captures throughout the Middle and early Upper Paleolithic occupations of El Castillo. Nonetheless, the seasonal patterning of the Mousterian sample differs somewhat from that of the EUP. The majority of animals were taken from late fall through spring/early summer (i.e. cementum stages of complete growth, slow growth, early growth) in the Mousterian levels and from winter through spring (slow growth and early growth; a slightly more limited seasonal period) in EUP (Figure 10). While all age groups are represented, prime adult animals clearly dominate the assemblages.

Cueva Morin

Of the 33 teeth selected for analysis from levels 5a, b and c, 6a, 9, 13, 14, and 17 (levels 7, 8, 10, 15 and 16 had no usable samples), six were "unreadable" under the microscope. The results of the dental annuli

analysis for the ungulates from these levels are presented in [Table 9](#) and [Figure 11](#).

Results from dental annuli analyses suggest that prey were taken during the late fall and/or winter during the Mousterian and early Aurignacian. The more recent Aurignacian and Gravettian levels show a slightly different and broader seasonality, that of winter/spring/early summer. As in the case of El Castillo, prime adult animals dominate the sample.

El Pendo

Of the 31 teeth selected for analysis from levels Va, Vb, VI, VIIa, VIIb, VIIIa, VIIIb, X–XIII and XVIa, only one was “unreadable” under the microscope. Results of the dental annuli analyses of the ungulates from these levels are presented in [Table 10](#) and [Figure 12](#).

All teeth in El Pendo’s sample exhibit late growth, complete growth, or slow growth stages of cementogenesis. In other words, all throughout the Mousterian and EUP levels kills are limited to the cold season; fall/late fall through early winter (Mousterian) and fall/late fall throughout the winter (EUP). Once again, there is no difference in the mortality patterns from the Mousterian and EUP levels; prime adults dominate the sample.

Discussion

As noted, the three herbivore groups, red deer, large bovines and horse tend to dominate the Mousterian assemblages of Cantabria. With many years of familiarity with Cantabrian faunal assemblages upon which to base his opinion, [Altuna \(1989\)](#) views evidence for Mousterian subsistence strategies as opportunistic in nature. Nonetheless, [Vaufrey’s](#) estimates of the high numbers of red deer at Castillo [level 20: 184 MNI; level 22: 78 ([Cabrera Valdés, 1984: Table 48](#))], along with our own modified dental MNI counts and a dominance of

prime-aged animals at all three sites suggests that Mousterian hunters could effectively exercise certain preferences. However, when we consider the percentages of species from other Mousterian sites such as El Conde where ibex and chamois are the dominant taxa, followed by horse ([Altuna, 1977](#)), it appears that availability of species in the immediate vicinity of the sites, like that of lithic raw material, was an important factor in Middle Paleolithic decision making.

The variable of species availability, including seasonal availability, in the vicinity of the sites, may help explain the appearance of the regionally unique flake cleavers in Mousterian assemblages from El Castillo, El Pendo and Cueva Morín. We have already noted the possible contemporaneity of the levels containing *hendedores* from the three sites. The dental growth mark study shows that these levels have something else in common as well; each yielded the remains of large bovines that were hunted in late autumn as well as horse remains (though seasonality could not always be precisely assigned for the latter). The production and use of a large chopping tool, expediently made from locally abundant ophite or quartzite, would be ideal for the primary butchering, as well as bone smashing, of such large-bodied prey.

Cueva Morín

Seasonal behavioral patterns and range preferences of prey animals may also shed light on why Cueva Morín’s Mousterian, Châtelperronian and early Aurignacian levels with large bovid and horse dominated faunas depart from the pattern of red deer dominated faunas found in nearby sites. Morín level 17, with *hendedores*, shows late autumn kills of large bovines. In fact, *all* bovid and horse kills from Morín are attributed to late autumn and winter. Given the site’s sheltered location at the base of wooded low-lying hills flanking a grassy

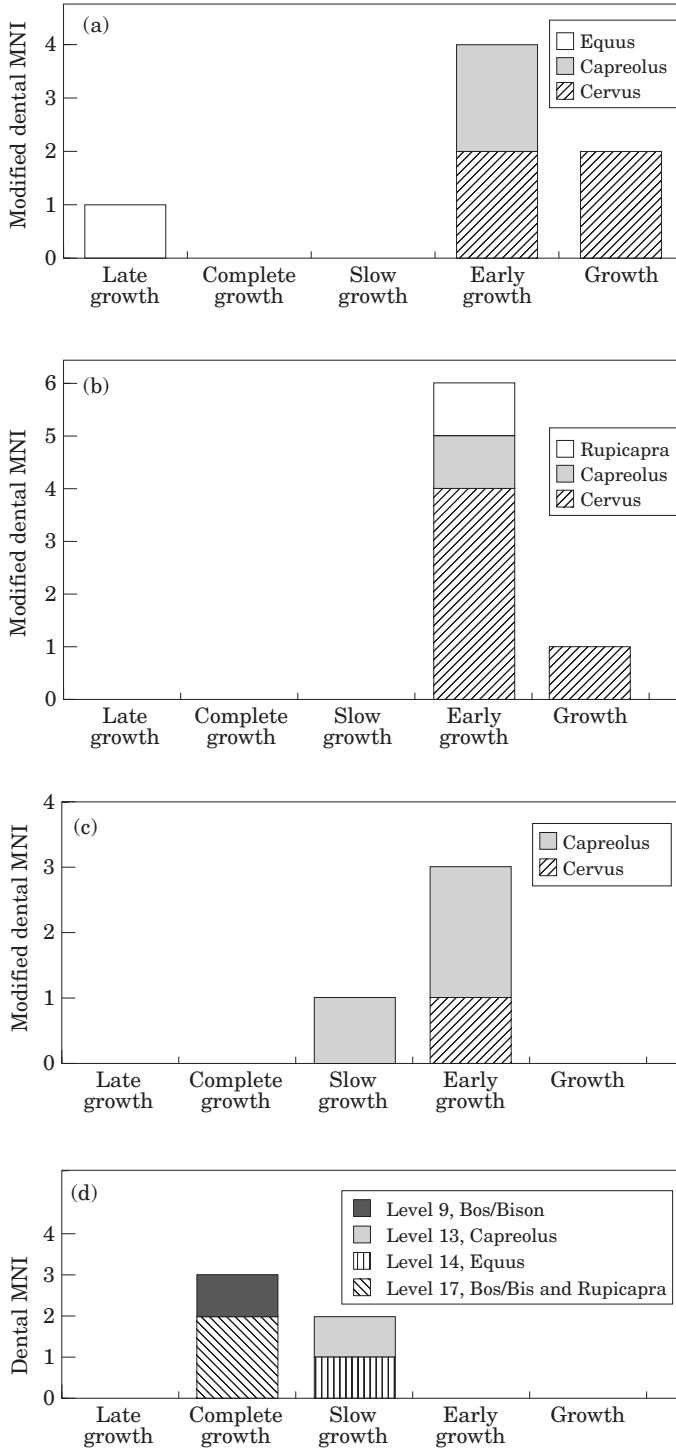


Figure 11. (a, b, c, d) Growth status of final dental cementum increment used to interpret season of death of prey animals from Cueva Morin according to level.

Table 10 Summary of seasonality and age results from dental growth mark analysis of El Pendo's samples according to species and level

No. of teeth sectioned=31, no. unreadable=1			
<i>Gravettian</i>			
<i>Level Va</i>	Juvenile/subadult/prime/old		Total mod. MNI
	<i>Cervus</i>	<i>Equus</i>	
Late Growth	0/0/1/0	0	1
Complete Growth	0	1, age?	1
Slow Growth	0	0	0
Early Growth	0	0	0
Growth	0/0/2/0	0	2
Other=In Va, a prime Cervus NOT in winter annulus			1
<i>Aurignacian</i>			
<i>Level Vb</i>	Juvenile/subadult/prime/old		Total mod. MNI
	<i>Cervus</i>		
Late Growth	0		0
Complete Growth	0/1/0/0		1
Slow Growth	0		0
Early Growth	0		0
Growth	0		0
<i>Aurignacian</i>			
<i>Level VI</i>	Juvenile/subadult/prime/old		Total mod. MNI
	<i>Cervus</i>		
Late Growth	0/0/1/0		1
Complete Growth	0/2/1/0		3
Slow Growth	0		0
Early Growth	0		0
Growth	0		0
Other=In VI, Equus not in winter			1
<i>Aurignacian</i>			
<i>Level VIIa</i>	Juvenile/subadult/prime/old		Total mod. MNI
	<i>Cervus</i>		
Late Growth	0/1/0/0		1
Complete Growth	0/2/0/0		2
Slow Growth	0		0
Early Growth	0		0
Growth	0		0
<i>Aurignacian</i>			
<i>Level VIIb</i>	Juvenile/subadult/prime/old		Total mod. MNI
	<i>Cervus</i>		
Late Growth	0/0/1/0		1
Complete Growth	0/0/1/0		1
Slow Growth	0/1/2/0		3
Early Growth	0		0
Growth	0		0
<i>Chatelperronian</i>			
<i>Level VIIIa</i>	Juvenile/subadult/prime/old		Total mod. MNI
	<i>Cervus</i>		
Late Growth	0		0
Complete Growth	0/0/1/0		1
Slow Growth	0		0
Early Growth	0		0
Growth	0		0

Table 10 (*Continued*)

<i>Aurignacian</i>			
<i>Level V111b</i>		Juvenile/subadult/prime/old	Total mod. MNI
		<i>Cervus</i>	
Late Growth		1/0/0/0	1
Complete Growth		0/0/2/0	2
Slow Growth		0	0
Early Growth		0	0
Growth		0	0
<i>Mousterian</i>			
<i>Level V–XIII</i>		Juvenile/subadult/prime/old	Total mod. MNI
		<i>Cervus</i>	<i>Bos/Bison</i>
Late Growth		1/1/0/0	0
Complete Growth		0/0/1/0	0/0/1/0
Slow Growth		0	0
Early Growth		0	0
Growth		0	0
<i>Mousterian</i>			
<i>Level XVIa</i>		Juvenile/subadult/prime/old	Total mod. MNI
		<i>Cervus</i>	<i>Capreolus</i>
Late Growth		0	0
Complete Growth		0/0/2/0	0/0/1/0
Slow Growth		0	0
Early Growth		0	0
Growth		0	0

Late Growth=late summer to late fall (growth >1/2).
 Complete Growth=late fall/winter, complete growth ZONE.
 Slow Growth=winter, slow growing ANNULUS.
 Early Growth="spring", end of winter through early summer (growth <1/2).
 Growth=summer or fall (ca. 1/2).

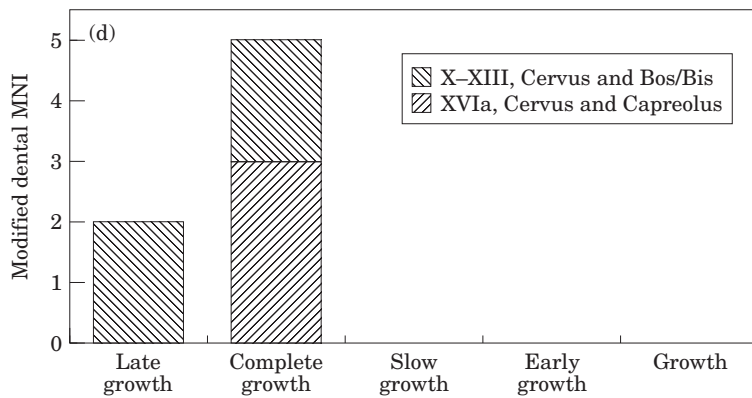
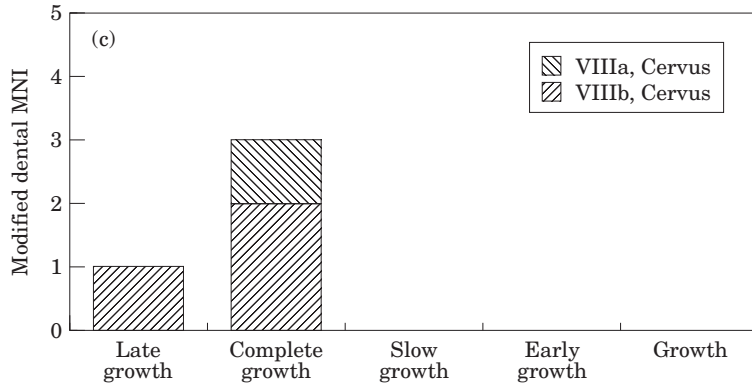
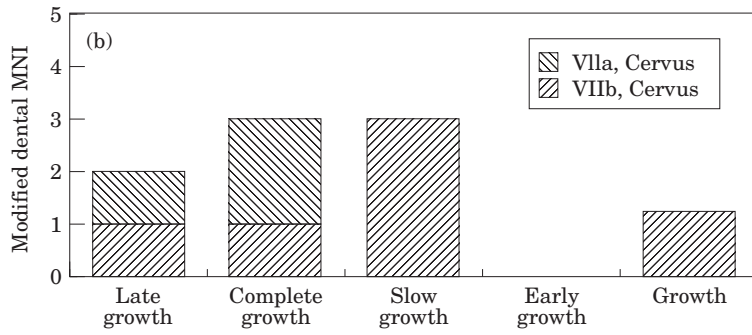
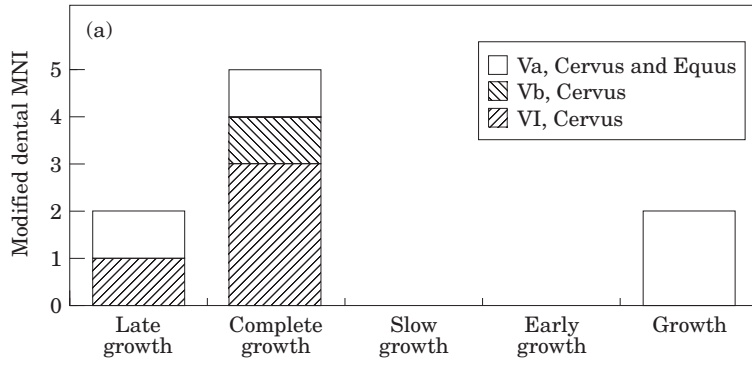
valley floor, cave occupants apparently took advantage of preferred late fall and winter habitats and movements of bison, aurochs and horse through wide valleys with available graze bordered by hills with adjacent tree stands for sheltering from poor weather.

As noted above, on the basis of the existing site location and tool density data, Mousterian groups in the region have come to be viewed as few in number and dispersed with short term, seasonally discrete occupations (e.g., Butzer, 1986). Results from dental annuli analyses from Cueva Morín are consistent with this general characterization in that only late fall/winter kills appear in the Mousterian and early Aurignacian levels while the more recent Aurignacian and Gravettian levels show a different and broader seasonality of winter, spring and

early summer, with red deer hunting emphasized in the spring. We return to the possible implications of this multiple season pattern in the EUP of Morín below.

El Castillo

At El Castillo the majority of animals were taken from late fall through spring (i.e., cementum stages of complete growth, slow growth, early growth) in the Mousterian levels and from winter through spring (slow growth and early growth) in Archaic Aurignacian level 18. Contrary to the pattern seen at Cueva Morín, a slightly more limited seasonal period is seen in the EUP. Level 20, with its clever flakes, two hearths (with concentrations of charcoal appearing in 20c1 and 20c3), and prime and subadult-aged animals may reflect longer term and



repeated use by groups during the cold season with smaller scale, shorter term occupations during the warm season.

We have considered Aurignacian level 18's pattern of spring and winter kills of very large numbers of red deer in light of frequently referred-to archaeological criteria for aggregation sites. Drawing upon the work of archeologists investigating Middle and Upper Paleolithic settlement patterns in the Franco-Cantabrian region (e.g., David, 1973; Freeman, 1973*b*; Spiess, 1979; Clark, 1980; Conkey, 1980; Gamble, 1983; White, 1985), Burke (1995: p. 67) summarizes these criteria as follows:

The identification of Palaeolithic aggregation sites is based on the presence of one or more of the following archaeological features. (1) Evidence for cooperative intercept, or migration hunting of seasonally available game. (2) Relatively high assemblage diversity. (3) Site extension. (4) Evidence of heightened social interaction in the form of stylistic diversity.

At face value, we could argue that the sheer quantity of the faunal and artefactual assemblages (the latter showing high lithic assemblage diversity as well as the presence of organic points with engraved lines and possible personal ornaments) from level 18, the presence of a single species-dominated faunal assemblage, and the wide extent of the deposits within the large cave meet these criteria. However, we realize that such an assertion would be premature for, as Burke (1995: p. 67) cautions, each of these criteria for the identification of aggregation sites is ambiguous [e.g., a single species dominated assemblage is not necessarily equal to cooperative, specialized hunting (Pike-Tay, 1993)]. At present then, the use of El Castillo as an aggregation site for the regional group during the deposition of level 18 remains a hypothesis.

El Pendo

All herbivore teeth in El Pendo's sample exhibit late growth, complete growth or slow growth stages of cementogenesis (i.e., late fall through early winter kills in the Mousterian and early EUP levels; late fall throughout the winter in the more recent EUP levels). In regard to the ages of individual prey, as in the other two sites, all ages are present, but prime-aged animals dominate the Mousterian and EUP assemblages. Three inter-dependent variables explain the exclusively cold season evidence for the occupation of El Pendo during the Middle and early Upper Paleolithic: topography, bone preservation, and small scale occupations. Topography is the most important of these. As noted above, El Pendo is a large downward-sloping cave situated at the base of a steep cliff and the end of a long "dry" valley. Today, as during the Pleistocene, the site and its access is extremely wet and muddy anytime of year *except* late fall and winter. Repeated ground saturation has undoubtedly contributed to the poor bone preservation in the cave (see Butzer, 1980). Like the assemblages from Cueva Morín, the faunal and lithic assemblages from El Pendo come from all phases of the Middle and Upper Paleolithic, but they are of much smaller scale than those from El Castillo. The available evidence suggests to us that El Pendo was used repeatedly throughout the Middle and Upper Paleolithic as a late fall and winter base camp and/or hunting camp.

If, at various times, El Pendo was part of the same settlement system as El Castillo (and Morín), it may have been the fall and winter camp of small groups who then moved to El Castillo in spring. For example, in the case of Castillo's level 18, such a group from Pendo would have joined others

Figure 12. (a, b, c, d) Growth status of final dental cementum increment used to interpret season of death of prey animals from El Pendo according to level.

already wintering at Castillo, where they would hunt red deer, chamois and even ibex, “altitudinal migrators” who moved in the vicinity of the mountain’s relatively low altitude but steep slopes for the new green spring shoots; explaining the higher percentage of spring kills. Similarly, the small groups of late fall/winter hunters of bison and horse known from Cueva Morín’s Mousterian and early Aurignacian levels, may have also moved camp to Castillo in the early spring. Even at El Castillo, where we consider the possibility of such seasonal group aggregations, in early Aurignacian level 18 with its very rich and dense accumulations, we do not believe that group numbers were ever very large (e.g., a couple of tens of people, not hundreds).

Mortality patterns of prey animals

The age distribution of prey animals remains fairly constant throughout the Mousterian and EUP levels at all three sites with all ages being represented, but with prime adults dominating. In this regard, there is no evidence that EUP site occupants were targeting a particular age group of animals any more or less “effectively” than their Mousterian predecessors. Interestingly, this pattern is consistent with Stiner’s findings from twelve southern Italian Mousterian faunal assemblages where those dating to before 55,000 B.P. show essentially non-selective procurement, while the most recent Mousterian assemblages (about 40–35,000 B.P.) are strongly biased toward prime adult prey (Stiner & Kuhn, 1992; Stiner, 1994). Stiner notes that the prime aged/old aged ratio is “very responsive to the relative emphasis on ambush hunting as opposed to scavenging”, where the former as done by modern humans generally results in prime age dominated mortality patterns, while scavenging by any sort of predator often results in a bias toward old animals (1994: p. 355). It would appear that, like the tool forms, the efficient tech-

niques of hunting that became pervasive in the Upper Paleolithic made their first appearances in the Middle Paleolithic of Cantabria.

Conclusions

In conclusion, we examine our findings in light of Jochim’s (1983, 1987) Upper Paleolithic settlement model, with its predictions of changes in degree of mobility, territoriality, and seasonal group aggregations as a result of population/settlement shifts. As noted above, evidence does exist for increasing artefact density and site frequency from the whole of the Middle to the Upper Paleolithic of Cantabria, but we do not know the extent to which this evidence is affected by inadequate preservation and archaeological sampling biases. We find that the data for seasonality, site location, and faunal and industrial assemblages from the levels considered here offer no compelling evidence for a notable or abrupt population or settlement shift across the Middle to Upper Paleolithic transition. On the other hand, various trends appear that are suggestive of change through time. These trends may be the result of gradually increasing logistical (*sensu* Binford, 1980) economic strategies. For example, we have noted: (1) the gradually increasing reliance on flint in the EUP at all three sites, including Castillo, which is most distant from flint sources; (2) qualitative evidence for the use of El Castillo as a relatively large multi-purpose base camp and/or seasonal aggregation site in level 18, its earliest Upper Paleolithic level; (3) expanding niche exploitation by EUP times, with the appearance of special task camps, such as ibex hunting camps situated in rocky areas as are the sites of Lezetxiki or El Conde (specialized camps for the extraction of raw material would fall into the category of special task camps as well, though we have no viable candidates for this latter sort at present); (4) the appearance of the

strategy of seasonal alternation of resource base rather than moving camp (e.g., at Cueva Morín, from the late fall bison and/or horse hunting as seen in the Mousterian and early EUP, to the addition of winter and springtime hunting of red deer and roe deer hunting in the later EUP) and, closely related to this; (5) the fact that the more recent Aurignacian and Gravettian levels at Cueva Morín and El Pendo (to a lesser degree) provide evidence of a broader seasonality than that of the sites' Mousterian and early Aurignacian. This may be the result of an increased degree of mobility and territoriality, i.e., more efficient technological and organizational strategies, resulting in an increase in catchment area and allowing for longer stays at the sites.

The study presented here is inconclusive. In particular, the chronostratigraphic relationships among the sites, made possible when our program of dating and sedimentological analyses are completed, should clarify questions of contemporaneity that are essential to the delineation of settlement systems. Nevertheless, the new data regarding season of death and age at death of prey animals from levels spanning the Middle-Upper Paleolithic transition from El Castillo, El Pendo and Cueva Morín reveal two important things: a dominance of prime-aged prey throughout the Mousterian and EUP, and, subtle shifts in seasonality between and within the sites. These finds, along with evidence for the increasing quantity and diversity of artefactual remains through time at the sites suggest to us that: (1) economic strategies and technologies that became pervasive in the Upper Paleolithic have their roots in the Cantabrian Middle Paleolithic; and, (2) the apparent increase in deposits from the Middle through Upper Paleolithic may indeed be the signature of settlement shifts with a progressive increase in logistical economic strategies including the technological innovations and heightened level

of social organization required for their implementation.

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