Chapter 9

Mammalian biostratigraphy

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INTRODUCTION

One of the key lines of evidence for dating the Clactonian archaeology at Southfleet Road is the associated mammalian fauna. Mammalian remains from Pleistocene deposits have long been widely employed for correlation and dating of Palaeolithic sites (Schreve and Thomas 2001). More recently, attempts have been made to combine biostratigraphical information from palynology, molluscs and mammal remains with amino acid geochronology to establish a more robust chronology for the British Quaternary (Penkman *et al.* 2011). For the British late Middle and Late Pleistocene, the most complete sequence of stratified molluscan and vertebrate faunas is associated with ancient fluvial deposits in the lower Thames Valley. In this area a flight of terraces reflects the aggradation by the river following its diversion by Anglian ice into its present-day course through central London. The major aggradations are believed to have formed in response to uplift and major cyclical climatic fluctuations between glacial and interglacial stages (Bridgland 2000; Bridgland and Maddy 2002). In this model, downcutting between terraces occurred during cold stages, and temperate sediments in each terrace represent different interglacials. Four pre-Holocene interglacials are recognised within the staircase of terraces in the Lower Thames:

1. The oldest occurs at Swanscombe in the highest (Boyn Hill/Orsett Heath Gravel) terrace and was clearly formed immediately after the southward diversion of the Thames to its present course during the Anglian glacial stage (Gibbard 1979). The interglacial associated with this terrace is widely correlated with the Hoxnian (MIS 11).

2. The second interglacial occurs at a number of sites in the terrace formed by the Lynch Hill/Corbets Tey Gravel. Sites associated with this aggradation include Hackney Downs, Belhus Park, Purfleet and Grays Thurrock (Bridgland 1994).

3. The penultimate interglacial occurs in the terrace formed by the Taplow/Mucking Gravel and has been recognised at Ilford (Uphall Pit), Crayford, Aveley and West Thurrock (Bridgland 1994).

4. The last interglacial (Ipswichian) occurs beneath the Kempton Park terrace and is exemplified by sites with *Hippopotamus* at Trafalgar Square and Brentford (Stuart 1982).

The mammalian faunas from these terrace deposits have been documented extensively (Bridgland 1994; Schreve 2006a; 2006b). This work has identified important differences in mammalian faunal composition between interglacials. These differences reflect fluctuations between glacials and interglacials, with a succession of extinctions and immigration events, as well as morphological changes within taxa. These factors have combined to produce unique combinations of mammalian taxa in the different terraces, which can been used as a basis for differentiating interglacial stages and for making correlations with isolated deposits elsewhere in southern England. The mammalian evidence has also been used to identify shorter duration climatic oscillations within interglacials that have been linked to isotope substages (Schreve 2001b); these attempts at fine-resolution correlation, however, remain highly controversial (Ashton *et al.* 2008; Pettitt and White 2012, 230–1). Work in progress at key British Middle Pleistocene localities, for example at Hoxne, Ebbsfleet Valley, is beginning to challenge the current mammal biozonation of the Middle and Late Pleistocene in Britain (Ashton *et al.* 2008; Preece and Parfitt 2000; 2008). The evidence from the Ebbsfleet Valley (Wenban-Smith *et al.* forthcoming) and the extensive mammalian fauna from Southfleet Road in particular, provide important cornerstones in this revision.

This chapter presents the mammalian biostratigraphical evidence for the age of the Southfleet Road sequence. The climatic implications of the large mammal taxa are discussed, as this evidence is important in establishing an interglacial context. The main focus, however, is a metrical and morphology comparison of the Southfleet Road large mammals with samples from British Middle and Late Pleistocene sites, particularly those from the Lower Thames Valley. At Southfleet Road, the mammalian fauna provides compelling evidence that the sediments containing the Clactonian artefacts were deposited during the early part of the Hoxnian interglacial. The final part of the chapter attempts to integrate this evidence into the emerging picture of a more complex British sequence, which can in turn be related to climatic oscillations and substages of MIS 11.

BIOSTRATIGRAPHICAL AND PALAEO-ECOLOGICAL SIGNIFICANCE OF THE SOUTHFLEET ROAD LARGE MAMMALS

Primates

Macaca sylvanus (L.), Barbary macaque

A notably exotic element of the Southfleet road fauna is macaque, represented by a well-preserved first phalanx (Fig. 9.1) from the tufa channel.

Today, there are small isolated populations of Barbary macaque in the Rif and Atlas Mountains of western Morocco and north-eastern Algeria, but the species was more widespread during the Pleistocene (Delson 1980), extending into northern Europe during interglacials. Remains of macaque have been reported from six other Pleistocene sites in Britain. The earliest record is from the Upper Freshwater Bed at West Runton, Norfolk (Hinton 1908; Stuart 1996) and dates to the early Middle Pleistocene, Cromerian Interglacial Stage. Currently, the youngest known material is from late Middle Pleistocene (MIS 9) deposits at Cudmore Grove (Essex) and Grays Thurrock and Purfleet (Schreve *et al.* 2002) in the Thames Valley. At Swanscombe, Barbary macaque was identified on the basis of a fragmentary ulna from the Lower Loam. Somewhat younger is the material from Hoxne Suffolk (late MIS 11). This sample includes several isolated teeth (Singer *et al.* 1982) from fluvial sediments that overlie the Hoxnian lake muds (Ashton *et al.* 2008). Earlier Pleistocene macaques exhibit morphological and metrical differences from extant Barbary macaque, implying subspecific status (Alba *et al.* 2011); Singer *et al.* (1982) showed that the Hoxne sample is indistinguishable morphologically from extant North African *Macaca sylvanus*.

Currently, the preferred habitat of the Barbary macaque is mountainous slopes in forests of cedar, oak and pine (Fa 1984) with nearby water. Marginal habitats occupied by Barbary macaque include coastal scrub and

Figure 9.1 *Macaca sylvanus*. First phalanx (Δ.50014, context 40070), anterior view

Table 9.1 List of *Oryctolagus cuniculus* specimens with measurements. Measurements (in mm) taken according to the method of von den Driesch 1974

Phase	*Context*	*Sample*	*Element*	*Measurements*
5	40025	40343	Upper cheek-tooth frag	
			Lower cheek-tooth frag	
			2 terminal phalanges	
		40348	2 upper cheek-tooth frags	
			R innominate frag	
			R astragalus	GL 11.7
			R calcaneus frag	
			1st phalanx frag	
			3 terminal phalanges	
		43860	Upper cheek-tooth frag	
		40380	L upper cheek-tooth frag	
			Lower cheek-tooth frag	
			L lower incisor	MD 2.93, BL 1.94
			R ulna (proximal end)	
6a	40039	*	L M_{2-3}	
6b	40070	40329	Upper & lower cheek-teeth (digested)	
		40330	R tibia (distal end)	Bd 10.7; Dd 6.29
	40144	40336	R M_2 (digested)	

Astragalus: GL = greatest length; Tibia: Bd = breadth of distal end, Dd = depth of distal end. Incisor: MD = mesiodistal diameter, BL = buccolingual diameter

* Δ. 41079

rocky slopes with vestigial vegetation. They feed primarily on seeds, fruits, roots and leaves of cedar and oak, with other foods such as insects and other small animals forming a minor component. As well as providing food, trees are also important for sleeping and providing safe refuges from predators.

The environment associated with the Barbary macaque from Hoxne was probably mixed woodland dominated by conifers, during a cooler phase near the end of MIS 11. At Swanscombe, however, macaque occurred during the early temperate part of the interglacial, when the dominant regional vegetation was deciduous woodland. The presence of Barbary macaque at Southfleet Road reinforces other faunal indications of woodland at the site.

Lagomorphs (Lagomorpha)

Oryctolagus cuniculus (L.), rabbit

A total of 24 bones and teeth were identified as rabbit (Table 9.1). These remains represent a minimum of eight individuals (assuming elements from the same individual do not occur in separate samples), with most coming from context 40025 (Phase 5). The morphology of the teeth and postcrania compare closely with modern *Oryctolagus cuniculus*.

The natural range of the rabbit during the early Holocene was confined to Iberia and the southern coastline of France. Very few Pleistocene records are known beyond this region (Donnard 1981; Rogers *et al.* 1994), with the notable exception of southern England, where several Middle Pleistocene sites have yielded rabbit remains. Here, rabbit was first shown to have been a genuine element of the British Pleistocene fauna by its presence in Hoxnian deposits at Ingress Vale and Barnfield Pit (Mayhew 1975). At Swanscombe, rabbit remains are abundant in the Lower Loam, but it is also present at several levels within the underlying gravels. According to Mayhew (ibid.), the rabbit bones and teeth from Swanscombe are indistinguishable skeletally from those of modern rabbits from southern England. More recently, rabbit remains have been found in Hoxnian contexts at East Farm, Barnham (Parfitt 1998b) and Beeches Pit (Preece *et al.* 2006; 2007). Besides these Hoxnian sites, it has been identified at Boxgrove (Currant 1986b; Parfitt 1999) and at Westbury-sub-Mendip (Parfitt unpublished), probably from different temperate stages within the 'Cromerian Complex' (Preece and Parfitt 2000; 2008).

The cluster of Hoxnian sites with rabbit in southern England suggests that optimal conditions for its survival existed during the peak of this interglacial. Important environmental factors may have included a combination of an oceanic climate with mild winters and suitable vegetation of open woodland and expanses of interconnecting grassland (Bjärvall and Ullström 1986; Mitchell-Jones *et al.* 1999). Rabbits may have favoured coastal situations (eg Boxgrove), but its presence at other sites suggests that it made incursions inland, perhaps along the grassy floodplains of large rivers. Ecologically, the presence of rabbit at Southfleet Road is indicative of warm temperate conditions and reinforces other evidence for grassland with nearby cover provided by patchy scrub or from trees along the woodland edge.

Rodents (Rodentia)

Castor fiber (L.), beaver

This species is represented by a single complete upper fourth premolar (Fig. 9.2), which is indistinguishable in size and morphology from modern comparative European beaver.

Figure 9.2 *Castor fiber*. Right P^4 (Δ.40899, context 40100): (a) buccal view; (b) occlusal view

At Swanscombe and Ingress Vale, two species of beaver are represented in the assemblages. The extinct 'giant' beaver *Trogontherium cuvieri* occurs at both sites, but European Beaver is known only from Swanscombe; both are represented by very few remains (Mayhew 1975). The beaver fits well with an interpretation of freshwater habitats bordered by deciduous woodland in the vicinity of these sites.

Carnivores (Carnivora)

Panthera leo (L.), lion

Lion is the only large carnivore represented at Southfleet Road. The identification is based on a complete astragalus from context 40025 (Fig. 9.3). The specimen is indistinguishable from that of modern *P. leo*, but the greatest length indicates a large and robust animal, consistent with other British Pleistocene samples (Table 9.2).

In northern Europe, lion is recorded from interglacials with deciduous woodland and cold stages, in association with more open herbaceous vegetation. Fossil evidence (Burger *et al.* 2004; Turner 1984; 2009) suggests that the lion first colonised Europe about 600,000 years ago. Genetic analysis of Late Pleistocene fossil material suggests that the European populations were isolated from those in Asian and African. European Pleistocene lions include individuals of an exceptionally large size (Ballesio 1980; Parfitt 1998b; Turner 2009), which are often referred to a separate species *P. spelaea* (or subspecies *P. leo fossilis – P. leo spelaea*). However, as Turner (1984) has shown, they are indistinguishable osteologically from the modern species, to which they are now referred (Lister and Brandon 1991; Turner 2009).

Remains of lion occur in small numbers in Hoxnian assemblages from Clacton, Swanscombe (Sutcliffe 1964) and Barnham (Parfitt 1998b). The somewhat younger large proximal humerus from Hoxne (Stuart *et al.* 1993) is from fluvial sediments that overly the Hoxnian lake beds. In terms of size, all of the Hoxnian specimens (including the astragalus from Southfleet Road) are larger and more robust on average than those of modern African lions (Parfitt 1998b).

Figure 9.3 *Panthera leo.* Astragalus (Δ.43845, context 40025), dorsal view

At Southfleet Road, lions would have hunted in grassland amongst scattered trees in open parkland. Their principal prey would have included herbivores, such as fallow and red deer as well as bovids.

Elephants (Elephantidae)

Palaeoloxodon antiquus Falconer and Cautley, straight-tusked elephant

Straight-tusked elephant is represented by parts of a dispersed skeleton from context 40078, Phase 6, and a

Table 9.2 Greatest length (in mm) of the astragalus in Recent African and European Pleistocene *Panthera leo*

	n	*Mean ± SD*	*Observed range*
Recent			
Africa[a]	8	53.1 ± 3.59	47.5–59.2
Africa[b]	22	53.8 ± 4.3	46.5–61.5
Last Cold Stage			
Gailenreuth, Germany	2		67.1, 67.4
Jaurens, France[c]	5	60.9 ± 5.18	56.0–67.0
Middle Pleistocene			
Southfleet Road	1	64.7	
Barnham, Suffolk (Hoxnian)	1	70.1	
Westbury-sub-Mendip, Somerset (early Middle Pleistocene)	1	73.5	

[a] Modern comparative sample (Natural History Museum, London) comprising four males and four females
[b] Modern comparative sample (Gross 1992) comprising 22 males and eight females
[c] Ballesio 1980
Other measurements, Parfitt (unpublished)

Figure 9.4 *Palaeoloxodon antiquus*. Tusk (Δ.43788, context 40025). The relatively small size of the tusk (which is almost complete) suggests that it is from either a female or young individual

tusk from context 40025, Phase 5 (Fig. 9.4). Most of the bones from the dispersed skeleton are poorly preserved, but identifiable pieces include both (badly crushed) tusks, the third upper molars, several vertebrae, ribs and carpal bones (see Chapter 8). An isolated cuneiform (Δ.43378) from context 40144 probably belongs to the partial skeleton from context 40078.

At Swanscombe, straight-tusked elephant remains occur throughout the fossiliferous sequence. These include numerous isolated teeth, but also post-cranial bones and a complete tusk from the Middle Gravel (Sutcliffe 1964). Straight-tusked elephant has also been reported from Hoxnian Thames-Medway deposits at Clacton and in the lake muds at Hoxne (Stuart 1982). As with most records from Britain, these finds are from interglacial contexts associated with palaeobotanical evidence for temperate deciduous woodland. Its appearance in at least two horizons at Southfleet Road is not unexpected given other faunal evidence of parkland and forested environments at the site.

Rhinoceroses (Rhinocerotidae)

Rhinoceroses were an important part of the fauna of Britain during the Pleistocene. Several species have been identified in the early Middle Pleistocene, most of which are assigned to the genus *Stephanorhinus*. These include *S. hundeshemensis*, two un-named but closely related forms (*Stephanorhinus* sp. A and *Stephanorhinus* sp. B, of Breda *et al.* 2010), and *S.* cf. *megarhinus*, the latter currently known only from Boxgrove (Breda *et al.* 2010). A major phase of faunal turnover occurred during the Anglian Glacial Stage with the extinction *S. hundesheimensis* and its allies and their replacement by narrow-nosed rhinoceros *S. hemitoechus* and Merck's rhinoceros *S. kirchbergensis*. These were the dominant rhinoceroses in northern Europe during temperate stages in western Europe. At present, the earliest known entry of the woolly rhinoceros (*Coelodonta antiquitatis*) into Britain was in the late Middle Pleistocene. This is attested by a skull and a humerus from the Ebbsfleet Valley, which were found in cold stage deposits attributed to MIS 8. In central Europe it has been found in securely dated and well-stratified interglacial contexts. One such site is Neumark-Nord in Germany, where the remarkable association of three rhinoceros species (*S. hemitoechus*, *S. kirchbergensis*, *Coelodonta antiquitatis*) has been found in lake sediments containing a wealth of palaeobotanical evidence. The lake appears to have been infilled during the Last Interglacial MIS 5e (Sier *et al.* 2011, but see Van der Made 2010 for an alternative view) and the rhinoceros fossils are associated with open steppe forest, interspersed with steppe meadows, heath and shrub (Van der Made and Grube 2010).

Currant (1996) has raised the possibility that three rhinoceros species were present at Swanscombe during the early part of the Hoxnian. He identifies three associated upper cheek teeth from the Lower Gravel, which he ascribes to the Early Pleistocene rhinoceros species *S. etruscus*. Although this identification is contested (see below), another 'archaic' rhinoceros, *S. megarhinus*, is present in even younger contexts in Europe, thus adding a further level of complexity to the history of European Pleistocene rhinoceroses (Breda *et al.* 2010).

***Stephanorhinus hemitoechus* (Falconer), narrow-nosed rhinoceros**

Narrow-nosed rhinoceros is represented by a badly crushed skull, with most of the upper dentition, from context 40039 (Phase 6a). The teeth (Fig. 9.5) are identified as *S. hemitoechus* on the basis of size (Fig. 9.6; Table 9.3), their high crowns, reduced anterior and enlarged posterior teeth, and rough enamel. A further 18 specimens are tentatively assigned to this species, including fragmentary teeth and skull fragments assigned to this taxon based on their close proximity to the skull (Table 9.4).

In northern Europe, narrow-skulled rhinoceros has been recorded in the early Middle Pleistocene (Fortelius *et al.* 1993), but it is unknown from deposits of this age in Britain (Breda *et al.* 2010). The material from Clacton and Swanscombe (eg Basal Gravel) are currently the oldest records from Britain (Breda *et al.* 2010). The dentition of *S. hemitoechus* is relatively high-crowned, suggesting that it fed mainly on abrasive herbaceous vegetation. Climatically, it encompassed both peak interglacials and interstadials in Britain (Lister and Brandon 1991).

***Stephanorhinus kirchbergensis* (Jäeger), Merck's rhinoceros**

This rhinoceros is present in the assemblage from context 40100, where it is represented by a poorly-

Table 9.3 List of rhinoceros bones and teeth from Southfleet Road

Taxon	*Phase*	*Context*	*Find no.* Δ	*Element*
S. hemitoechus	6a	40039	41812	R P^3
			42047	R P^4
			41845	R M^1 frag (ectoloph)
			42048	R M^2
			41785	R M^3
			41786, 41875, 42939	L P^4 (refitting frags)
			41691[a], 41843, 41874	L M^1 (refitting frags)
			42491	L M^2
			42492	L M^3
S. cf. *hemitoechus*[b]	6a	40039	41921	L upper premolar frag
			41780	Cheek tooth frag
			41817	Cheek tooth frag
			42335	Tooth frag
			41690	Tooth frag
			41839	Tooth frag
			42238	L occipital condyle & skull frag
			41920	Petrosal
			42420/42421	Petrosal
			43833	R lunar
	6	40078	42003	L scapula frag (part of glenoid and neck)
			40632	L humerus (distal and shaft, distal fused)
			40629	L femur (proximal end, fused)
	6	40100	41475	L radius frag (proximal & shaft)
			41588	L radius frag (distal end)
			41589	L radius frag (distal end)
	6b	40144	43652	R innominate frag (acetabulum and pubis)
			43672a	L innominate frag (pubis)
S. kirchbergensis	6	40078?	43712	L ulna (distal end)
	6	40100	40844	R M_3
S. cf. *kirchbergensis*[b]			41007	Cheek tooth frags
			41026	R lower cheek tooth (crushed)
			40857	Tooth frag
			40861	Mandible frag
			41028	Mandible frag

[a] Associated with crushed skull [b] In the absence of diagnostic characters, identifications are based on size or close spatial association with the skull (context 40039) and mandible (context 40100)

Table 9.4 Measurements (in mm) of rhinoceros bones and teeth from Southfleet Road, taken according to the method of Fortelius *et al.* 1993

Taxon	*Phase*	*Context*	*Find no.* Δ	*Element*				
S. hemitoechus					BL	LL	MB	DB
	6a	40039	41812	P^3	37.6	32.8	48.4	48.6
			42047	P^4	41.2	37.1	56.0	52.6
			42048	M^2	57.9	47.8	62.0	
			41785	M^3	59.1		55.9	
S. cf. *hemitoechus*	6	40100	41475	Radius	Dpr	Bsr		
					c 54.5	*c* 52.0		
	6	40078	40629	Femur	LC			
					80.6			
S. kirchbergensis					BL	LL	MB	DB
	6	40100	40844	M^3	53.0	52.6	30.2	32.5
	6	40078?	43712	Ulna	BDu	BDau		
					77.3	73.5		

Teeth: BL = buccal length, LL = lingual length, MB = mesial width, DB = distal width; Radius: Dpr = proximal depth, Bsr = smallest breadth of the shaft of the radius; Femur: LC = length of caput femoralis; Ulna: BDu = distal breadth; BDau = breadth of distal articular surface

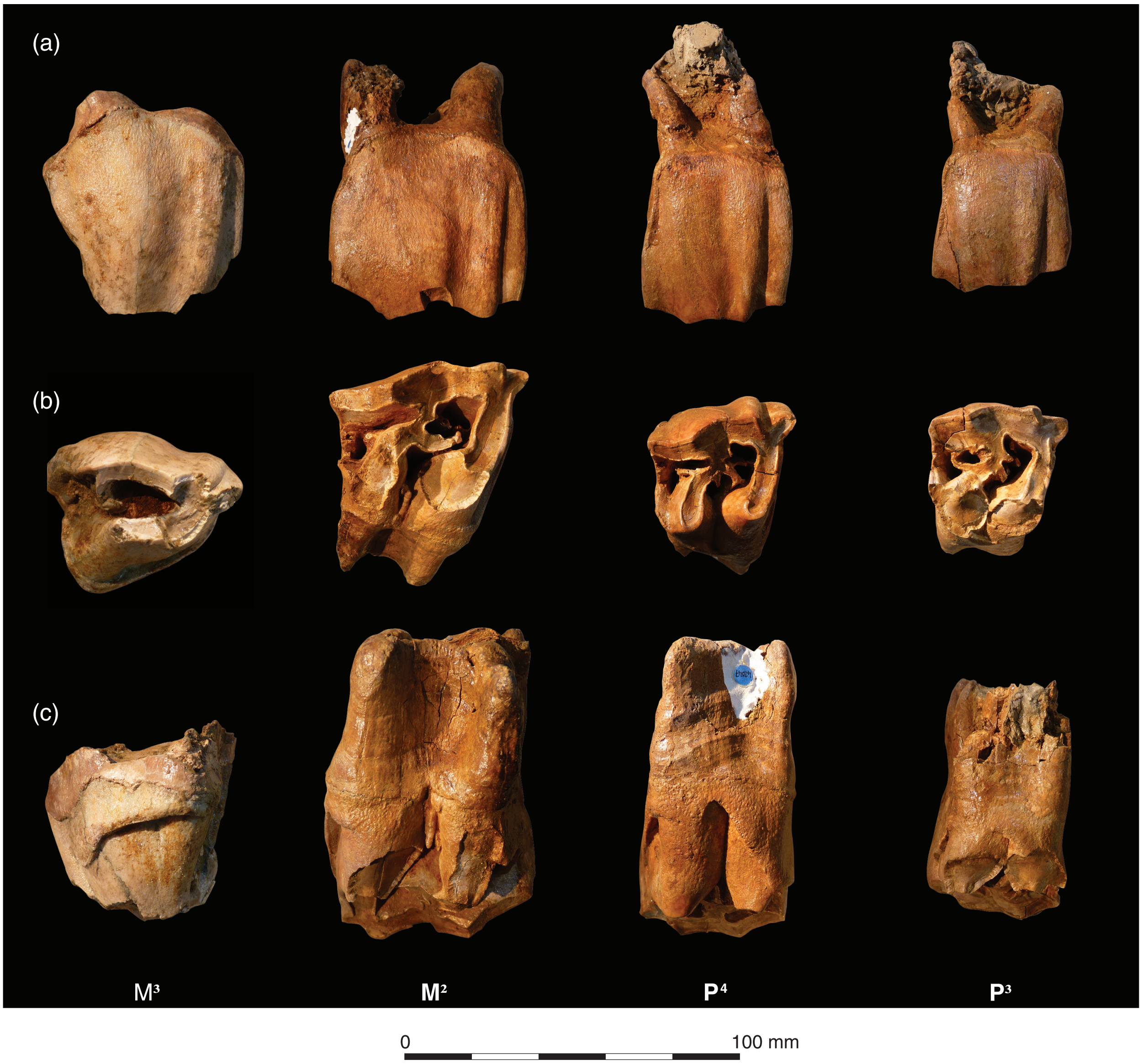


Figure 9.5 Associated right upper cheek teeth P^3-M^3 of *Stephanorhinus hemitoechus*: (a) labial view; (b) occlusal view; (c) lingual view

preserved mandible with the associated lower third molar (Fig. 9.7) and second badly crushed molar. A distal ulna from context 40078 is the only postcranial element that can be ascribed with certainty to Merck's rhinoceros (Fig. 9.8). The identification is based on its exceptionally large size compared to the ulna of *S. hemitoechus* (Table 9.5); woolly rhinoceros (*Coelodonta*) can be excluded on the basis of morphology.

At present, the earliest well-dated records of Merck's rhinoceros in Britain are from the Hoxnian at Clacton and Swanscombe. It may have appeared earlier in other parts of western Europe (eg Mosbach, Germany), but these finds should now be reassessed given the morphological similarities between teeth of *S. kirchbergenis* and *S. megarhinus* (Breda *et al.* 2010). Merck's rhinoceros was characteristic of temperate, wooded interglacials in the European Middle and Late Pleistocene, and has not been recorded from any securely dated cold stage mammalian assemblages in Europe (Van der Made 2010; Billia 2011). During cold stages, its range contracted to refugia in Asia, from where it repeatedly recolonised Europe at the start of successive interglacials (Van der Made 2010).

Table 9.5 Dimensions of the *S. kirchbergensis* distal ulna from Southfleet Road, and comparison with German and British samples of *S. kirchbergensis* and *S. hemitoechus* (Fortelius *et al.* 1993).

	BDu (mm)	*BDau (mm)*
S. kirchbergensis		
Southfleet Road	77.3	73.5
Stockstadt, Rhineland	75.5	65.0
S. hemitoechus		
Ilford		40.0
Maastricht-Belvédère, The Netherlands	36.0	33.0

BDu = distal breadth; BDau = breadth of distal articular surface

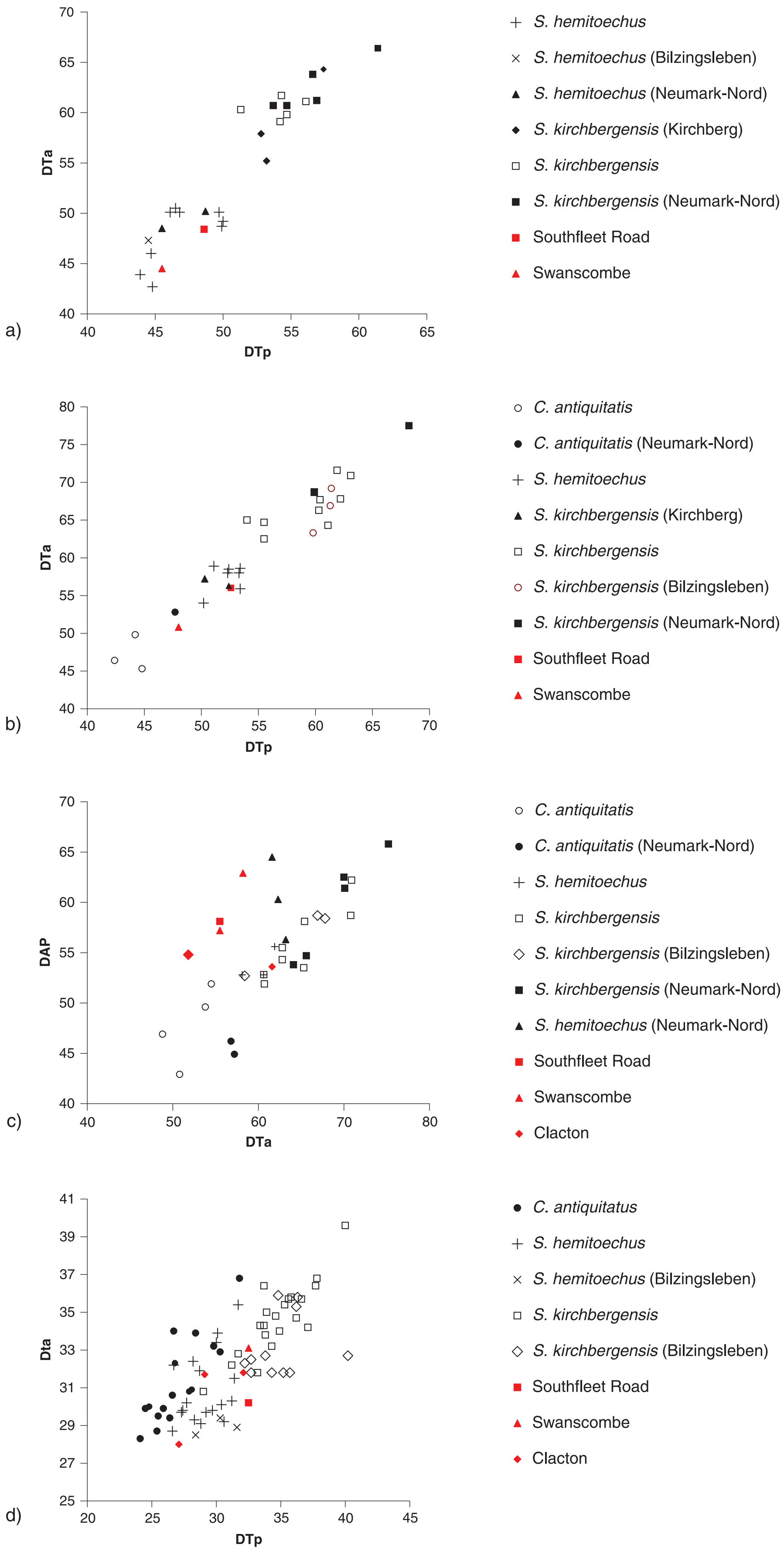
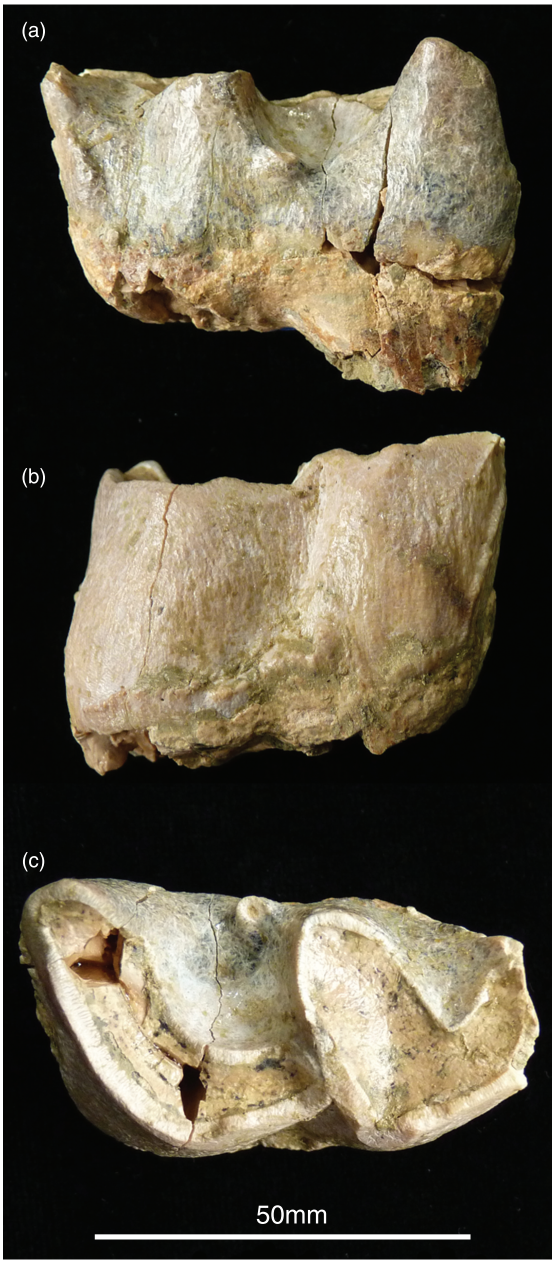


Figure 9.6 Biometric comparisons of rhinoceros cheek teeth. (a) P^3, (b) P^4, (c) M^3, (d) M_3. Comparative samples and measurement abbreviations from Van der Made (2010)



Morphological adaptations (such as low-crowned molars, horizontal carriage of the skull) suggest that Merck's rhinoceros fed on bushes and other browse in woodland. This conclusion is supported by the remarkable preservation of a diverse assemblage of non-grass taxa and woody plant remains in fossas of upper cheek teeth of this species from Neumark-Nord, Germany (Van der Made and Grube 2010). Environmental reconstructions of Neumark-Nord suggest extensive forest, broken by patchy open habitats of meadows, heath and shrub; a similar environment can be envisaged at Southfleet Road.

Pigs (Suidae)

***Sus scrofa* L., wild boar**

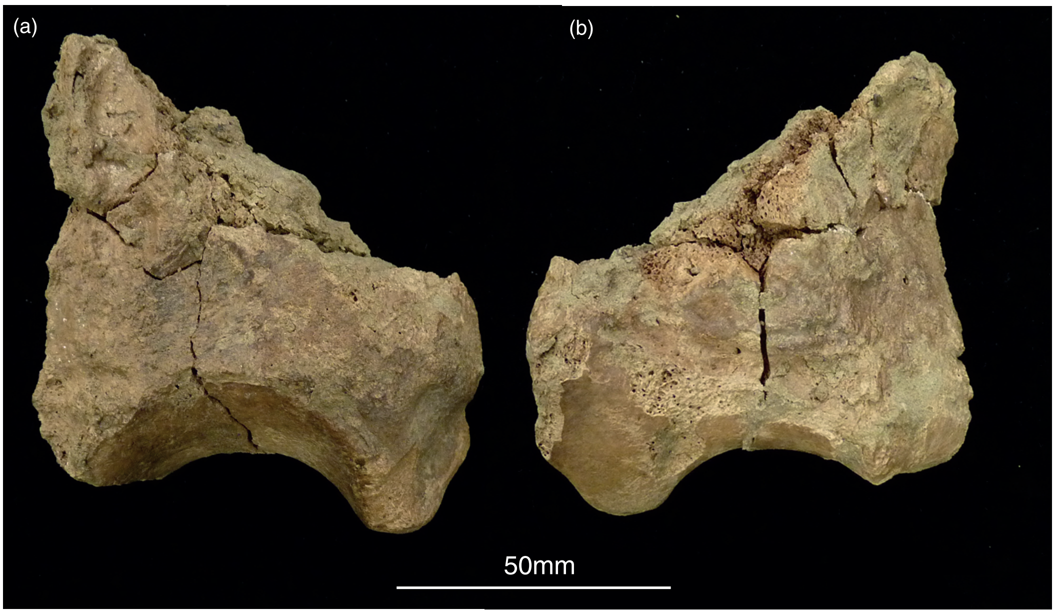
Only two elements could be ascribed with certainty to boar (Fig. 9.9). The specimens are an unworn tip of an upper canine from context 40039 (Phase 6a) and a worn upper second incisor from context 40100 (Phase 6).

The fossil history of British Pleistocene wild boar has been reviewed by Parfitt (in Lister *et al.* 2010). Measurements show an interesting pattern of size change during the Middle Pleistocene, with a marked reduction in body size after the Anglian Glacial Stage (Lister *et al.* 2010, figure 20). Hoxnian wild boar from Swanscombe and Ingress Vale seem to have been of unusually small body size, matching those living in northern Europe at the present day. Unfortunately, the sample from Southfleet Road does not include measurable specimens.

In terms of ecology, Pleistocene wild boar was

Figure 9.7 *(left)* *Stephanorhinus kirchbergensis*. Right M_3 (Δ.40884, context 40100): (a) lingual view; (b) buccal view; (c) occlusal view

Figure 9.8 *(below)* Ulna of *Stephanorhinus kirchbergensis* from Southfleet Road (Δ.43712, context 40078)



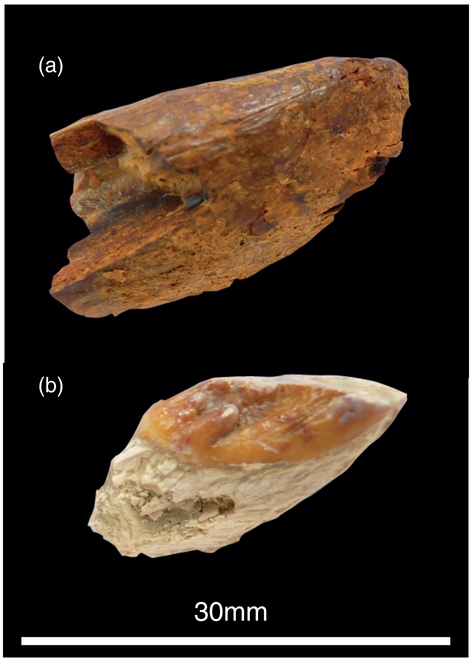


Figure 9.9 *Sus scrofa* : (a) canine (Δ.41876, context 40039); (b) incisor (Δ.41207, context 40100) from Southfleet Road

strongly associated with temperate woodland. They were absent from cold stage mammalian assemblages, with only rare occurrences during interstadials. The occurrence of wild boar at Southfleet Road is consistent with temperate conditions inferred from other faunal indicators. Local habitats must have included substantial woodland and dense thickets with close proximity to marsh and reed-beds (Bjärvall and Ullström 1986; Mitchell-Jones *et al.* 1999).

Deer (Cervidae)

Deer were the most numerous of the large mammals in most contexts from Southfleet Road. The sample comprises a total of 349 specimens and includes antlers, some complete postcranial bones and numerous isolated teeth. Of these red deer (*Cervus elaphus*) is represented by 33 specimens, fallow deer (*Dama dama*) by 11 specimens, while only 3 bones were assigned to roe deer (*Capreolus capreolus*). The assemblage includes a high number of indeterminate medium-sized cervid remains. These are likely to represent fallow or red deer, but are too fragmentary or damaged to identify fully. The distinction between Hoxnian fallow deer and red deer is further complicated due the overlap presence of relatively small red deer and exceptionally large fallow deer that occurred together at this time in southern England (Lister 1993; 1996).

At Swanscombe medium-sized cervids are also the most common large mammals in each of the main fossiliferous strata (Sutcliffe 1964; Lister 1986). Giant deer (*Megaloceros giganteus*) and roe deer are also present, but occur in very low numbers (Lister 1986). Lister (1981; 1986; 1994) has shown that Hoxnian deer species are particularly distinctive with a combination of morphological features in their antlers and teeth that make them particularly useful biostratigraphic indicators.

***Cervus elaphus* L., red deer**

A total of 33 bones and teeth are identified to red deer (Table 9.6), making this the most common cervid in the Southfleet Road large mammal assemblage. The sample includes 18 postcranial bones (Fig. 9.10), six cheek teeth, eight shed antlers (Figs 9.11-12) and one portion of antler beam. Two antlers were almost complete, but

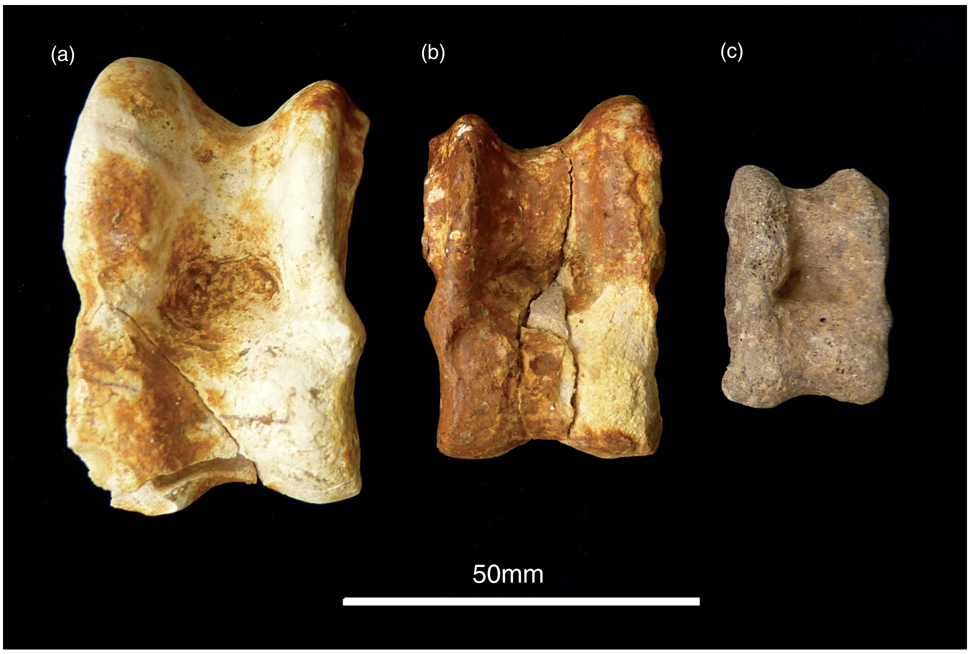


Figure 9.10 Three deer astragali from Southfleet Road: (a) *Cervus elaphus* (Δ.41407, context 40100); (b) *Dama dama* (Δ.41034, context 40039); (c) *Capreolus capreolus* (Δ.5002, context 40070)

Table 9.6 List of *Cervus elaphus* bones and teeth from Southfleet Road

Phase	*Context*	*Find no.* Δ	*Element*	*Comments*
6b	40070	43165	L antler (shed) – basal region with broken brow and bez tines	
6	40078	40741	Antler (shed) – basal region with brow and bez tines, part of beam	
6	40078	42945	R antler (shed) – basal region with brow and bez tines, part of beam	
6	40078	42992	L antler (shed) – basal region with brow and bez tines, part of beam	
6	40078	43848	L antler (shed)	Almost complete, but badly damaged
6	40078(?)	42282	L antler – beam and trez tine	
6	40100	40898	L antler (shed)	Almost complete, but badly damaged. Fig. 9.11
6	40100	41104	L antler base (shed)	
6a	40103	43787	R antler (shed) – basal region with brow tine	
6a	40039	42130	Axis frag	
6b	40070	43076	R P^2	Early-mid wear
6b	40070	43145	R $M^{1\text{ or }2}$	Early wear
6b	40070	43188	L P_2	Early-mid wear
6	40100	41722	L P_3	
6b	40070	43140	L P_4	Mid-late wear
6	40100	41142	R M_3	Early-mid wear
6a	40103/039	43663	L scapula frag	cf. *C. elaphus*
6a	40039	42128	R scapula frag	
6	40100	40626	L scapula frag	
6	40100	41327	L scapula frag	cf. *C. elaphus*
6	40100	40613	L radius frag	Prox. fused
6b	40144	50006	R radius frag	Unfused distal epiphysis
6b	40070	50001	L scaphoid	
6b	40070	50010	R lunate	Juvenile (forming bone)
6	40078	42147	L tibia frag	Dist. fused
6	40100	43917	L tibia frag	Dist. fused
6	40100	41377	R distal fibula	cf. *C. elaphus*
6a	40039	42287	R astragalus	
6a	40039	40076	L astragalus	cf. *C. elaphus*
6	40100	41407	R astragalus	
6a	40103	42476	L metatarsal frag	
6	40100	41305	1st phalanx	
6b	40070	43823a	2nd phalanx	

these proved too fragile to lift intact. The sample includes remains from juveniles as well as adults.

Red deer is one of the most common mammals recorded from the British Pleistocene and also one of the most variable, exhibiting great morphological and size variation through the Middle and Late Pleistocene and Holocene (Lister 1981; 1989; 1995; Grigson and Mellars 1987). The evolution of British Pleistocene red deer was studied in detail by Lister (1981). He noted that the Swanscombe collection includes two antler-tops with several points (Lister 1986, figure 3) that show that the Swanscombe red deer had the capacity to form a 'crown'. This feature is not found in red deer antlers from pre-Anglian/Elsterian contexts, but is dominant in modern adult red deer (Lister 1986; 1993). There is only one antler top from Southfleet Road (Fig. 9.12b). This also has three points forming a simple 'cup', and closely resembles the antler top from the Basal Gravel at Swanscombe (Fig. 9.12a).

The method adopted for assessing the skeletal size of the Southfleet Road red deer was developed by Lister (1993) in his analysis of the red deer from Hoxne. In this percentage method, each fossil specimen is standardised in relation to the corresponding element of a standard skeleton or a sample of individuals from a 'standard population'. An advantage of this approach is that it is particularly well-suited for combined statistical analysis of different bone elements. Table 9.7 gives measurements for the Southfleet Road sample, which are plotted on Figure 9.13 as percentage deviations from the standard Star Carr mean for each bone. From Figure 9.13 it can be seen that the Southfleet Road points are all smaller than the Star Carr mean, with most falling beyond one Standard Deviation of the Star Carr mean. Pooling the different measurements, the mean deviation of the Southfleet Road sample from the Star Carr mean is -9.2% (n = 4). Although the plotted sample is small, other specimens of red from Southfleet Road are

Figure 9.11 Two shed antler bases from Southfleet Road: (a) *Cervus elaphus* (Δ.42992, context 40078); (b) *Dama dama* (Δ..42198, context 40070)

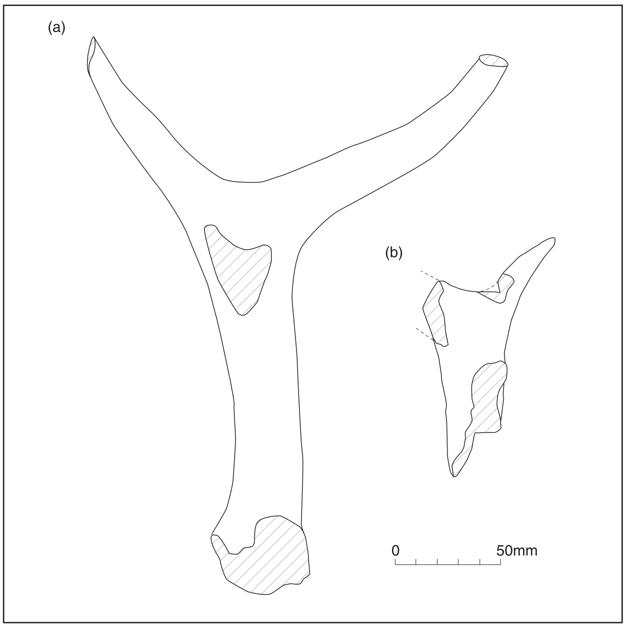


Figure 9.12 Drawing of antler crowns of *Cervus elaphus* from (a) Swanscombe (Natural History Museum (A.S. Kennard collection) M49726, Basal Gravel), and (b) Southfleet Road (Δ. 40898, context 40100)

similarly small, indicating that the mean size of these deer was smaller than that of red deer from Star Carr. Turning to the other Hoxnian samples, it can be seen that the Southfleet Road red deer are similar in size to those from Swanscombe (percentage deviation, -5.6%) and Clacton (percentage deviation, -10.5%), which are all significantly smaller than the larger-bodied animals from Hoxne (Lister 1993). At Hoxne, Lister (1993) has shown that the red deer combined small dental size with somewhat larger body size. This contrasts with the situation at Swanscombe and Clacton animals, where small dental size corresponds to small body size. Unfortunately, it is not possible to test this relationship for the Southfleet sample, where only six measurable teeth are represented. Nevertheless, it may be significant that the length of the single M_3 (L = 29.8 mm) from Southfleet Road is smaller than the Star Carr sample (31.6-39.0, mean 34.55, n = 30).

The red deer is a highly adaptable herbivore with a distribution covering diverse environments and climatic zones. It can subsist on both browse when shrubs and tree shoots are available, but also grazes in open habitats. Optimal red deer habitats include woodland and woodland edge, but it can thrive in open habitats (moors, open mountain areas and steppe), only avoiding taiga with deep winter snow (Bjärvall and Ullström 1986; Mitchell-Jones *et al.* 1999). The relative abundance of red deer at Southfleet Road suggests that the Ebbsfleet Valley may have been better suited to red deer than the nearby floodplain of the Thames, where remains of fallow deer are dominant and red deer are less common in the lower part of the succession.

Dama dama (L.), fallow deer

Only 11 specimens of fallow deer have been recovered (Table 9.8). Of these, four are shed antler bases (Fig. 9.11). The sample includes three isolated teeth, a broken mandible with molars, the distal end of a tibia and two astragali (Fig. 9.10). Table 9.7 gives measurements for the Southfleet Road sample, which are plotted in Figure 9.14 as percentage deviations from a standard sample of modern fallow deer from Richmond Park, London (Lister 1993). From Figure 9.14 it can be seen that the Southfleet Road fallow deer was considerably larger than those in Britain today, and within the size-range of Hoxnian large-bodied fallow deer from Swanscombe and Clacton. In terms of body size, this corresponds to a mean body weight of around 80kg for the Swanscombe

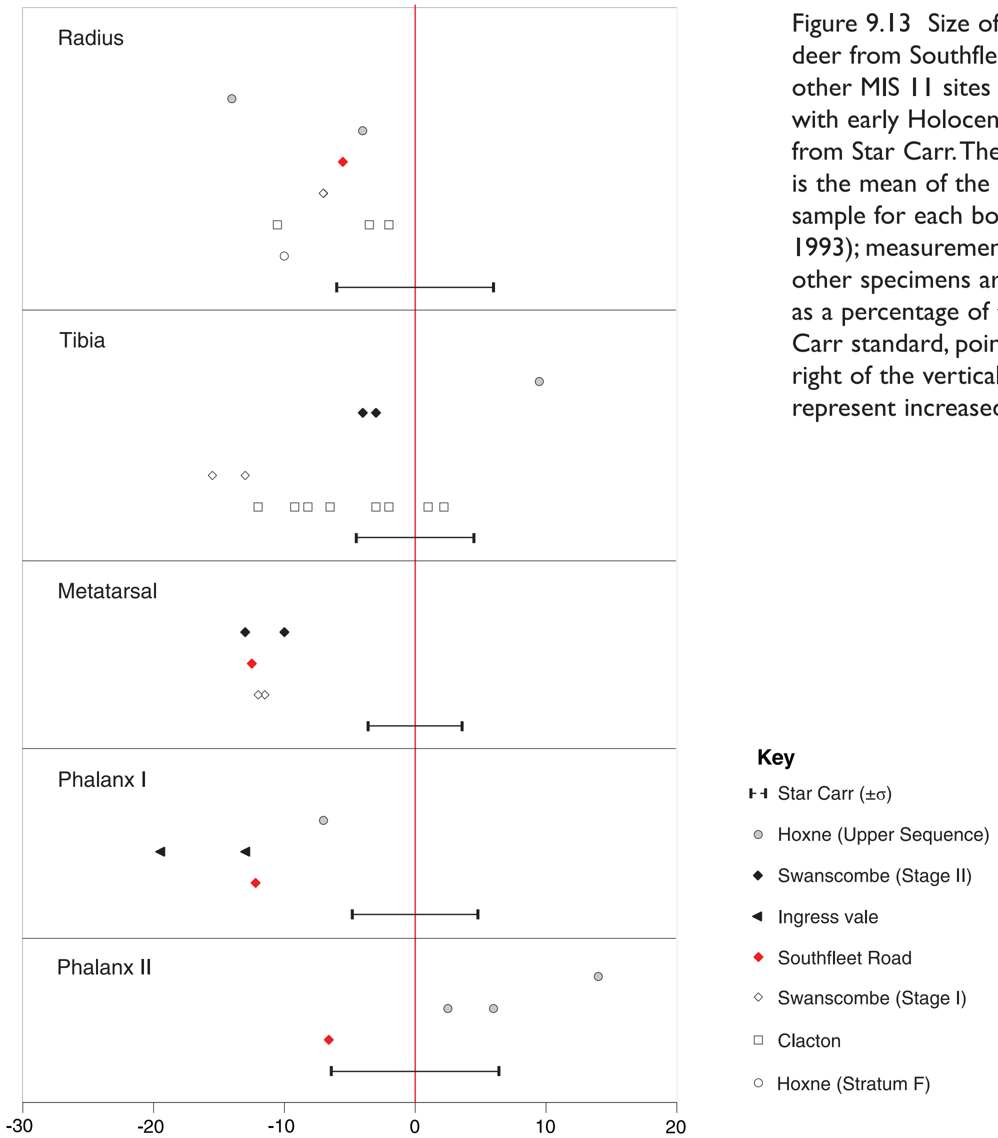


Figure 9.13 Size of the red deer from Southfleet Road and other MIS 11 sites compared with early Holocene material from Star Carr. The zero line is the mean of the Star Carr sample for each bone (Lister 1993); measurements of the other specimens are calculated as a percentage of the Star Carr standard, points to the right of the vertical line represent increased size

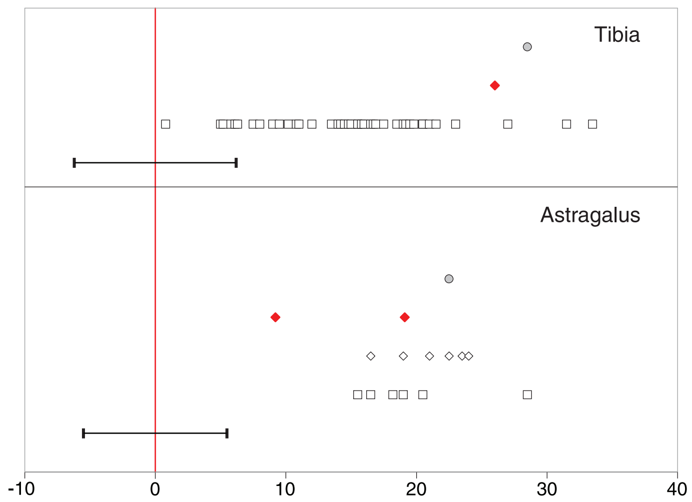


Figure 9.14 Size of the fallow deer from Southfleet Road, Clacton, Swanscombe (Stage I), Hoxne (Upper Sequence), compared with modern fallow deer. The zero line is the mean of a modern sample from Richmond Park, London (Lister 1993); measurements of the other specimens are calculated as a percentage of the modern standard. For key to symbols see Fig. 9.13

Table 9.7 Measurements (in mm) of cervid bones and teeth from Southfleet Road. Measurements (in mm) taken according to the method of von den Driesch 1974

Taxon	*Sub-phase*	*Context*	*Find no.* Δ	*Element*					*Comments*
Cervus elephus					Basal circumference				
	6	40078	42945	Antler	93.0				
	6	40078	42992		144.0				
	6	40100	40898		145.0				
					L	W			
	6b	40070	43076	P^2	13.1	-			
	6b	40070	43145	$M^{1\text{ or }2}$	20.1	21.5			
	6b	40070	43188	P_2	10.0	6.6			
	6	40100	41722	P_3	15.7	9.8			
	6b	40070	43140	P_4	15.4	10.8			
	6	40100	41142	M_3	29.8	14.1			
					GLP	LG	BG	SLC	
	6a	40103/039	43663	Scapula	-	-	-	30.3	cf. *C. elaphus*
	6	40100	40626		58.4	45.0	39.9		
					Bp	BFp			
	6	40100	40613	Radius	56.0	53.1			
					Bd	Dap			
	6	40078	42147	Tibia	52.1	38.5			
	6	40100	43917		48.5	35.8			
					GL				
	6a	40039	42287	Astragalus	*c* 59.4				
	6a	40039	40076		*c* 49.1				cf. *C. elaphus*. Minimum dimension due to damage and erosion
	6	40100	41407		56.6				
					Bp				
	6a	40103	42476	Metatarsal	*c* 38.3				
					GL	Bp	SD	Bd	
	6	40100	41305	1st Phalanx	57.2	19.7	16.1	18.5	
	6b	40070	43823a	2nd Phalanx	38.3	19.6	16.3	15.7	
Dama dama					Basal circumference				
	6b	40070	42198	Antler	95.0				
					L	W			
	6a	40039	41665	$M^{1\text{ or }2}$	21.2	20.7			cf. *D. dama*
	6a	40039	42239	M^3	19.6	21.8			cf. *D. dama*
	6	40100	41114	P_3	12.5	8.4			
	6	40100	41341	M_1	17.1	12.1			
				M_3	26.7	12.3			
					Bd				
	6a	40039	41046	Tibia	42.8				cf. *D. dama*
					GL	Bd			
	6a	40039	41034	Astragalus	46.5	28.7			
	6	40100	40727			*c* 26.3			cf. *D. dama*

animals, as compared to 50kg in Recent British fallow deer (Lister 1986).

Hoxnian fallow deer are generally referred to the subspecies *Dama dama clactoniana*. This form is characterised by an unusual morphology of the antlers, which are less palmated than modern fallow deer, with an extra anterior tine between second tine and palmation (Sutcliffe 1964; Leonardi and Petroni 1976; Lister 1986). This form is best known from the Hoxnian and broadly contemporaneous sites in Italy. Unfortunately the distal parts of fallow deer antlers are not preserved in the Southfleet assemblage.

Other distinctive morphological features of Hoxnian fallow deer are found in the dentition. Lister (1981; 1986) has studied the enamel patterns of the lower third premolar of Pleistocene fallow deer and has observed that Hoxnian specimens often have a metaconid that is fused with the entoconid high in the crown (Lister 1986, figure 2). This enamel configuration is not found in Last Interglacial and modern British fallow deer, but is present in the single worn example from Southfleet Road (Fig. 9.15). Although

Table 9.7 (continued)

Taxon	*Sub-phase*	*Context*	*Find no. Δ*	*Element*			*Comments*
Cervid					L	W	
	6b	40070	43007	Upper molar	19.1		
	6	40100	41113	M$^{1 \text{ or } 2}$		21.1	
	6	40100	41126	M$_{1 \text{ or } 2}$	18.0	12.5	
					BT		
	6b	40070	43093	Humerus	50.3		
	6	40100	41391	Humerus	*c* 45.9		
					BPC		
	6	40100	40875	Ulna	33.0		
					Bd		
	6	40078	41908	Metacarpal	37.6		
					LAR		
	5	40025	43827	Innominate	54.8		
					DC		
	6a	40039	41985	Femur	36.4		
					Bd		
	6	40078	41762	Tibia	47.9		

L = length; W = width; Bd = distal breadth; GL = greatest length; GLP = greatest length of glenoid process; LG = length of glenoid cavity; BG = breadth of glenoid cavity; SLC = smallest length of neck of scapula; BP = breadth of proximal end; BFp = breadth of humeral articular surface; Dd= depth of distal end; SD = smallest breadth of diaphysis; BPC = breadth of proximal articular surface of the ulna; LAR = length of the acetabulum on the rim; DC = depth of caput femoralis

Table 9.8 List of *Dama dama* bones and teeth from Southfleet Road

Phase	*Context*	*Find no. Δ*	*Element*	*Comments*
6b	40070	42198	L antler (shed) base and part of brow tine & beam	
6b	40070	50004	Antler base (shed)	
6a	40103	43784	L antler (shed) base and brow tine	
5	40025	43868	Antler (shed) base	cf. *D. dama*
6a	40039	41665	L M$^{1 \text{ or } 2}$	cf. *D. dama*. Mid wear
6a	40039	42239	L M^3	cf. *D. dama*. Mid wear
6	40100	41114	L P$_3$	Late wear (Fig. 9.15)
6	40100	41341	R mandible with M$_{1\text{-}3}$	Late-mid wear
6a	40039	41046	L tibia (distal and shaft)	cf. *D. dama*. Distal fused
6a	40039	41034	L astragalus	
6	40100	40727	R astragalus	cf. *D. dama*

widely used as a 'population marker' for Hoxnian fallow deer, metaconid fusion is also present at high frequency in the post-Hoxnian fallow deer from Grays, Essex. Although the dating of Grays has been contentious, there is now a growing consensus that the Grays deposits date to MIS 9 (Bridgland 1994; Penkman *et al.* 2011). The fallow deer from Grays are also unusually large, with an average percentage deviation of 14.2 % from the modern standard sample (compared with 16.5 % for Swanscombe and 19.5 % for Clacton). The Hoxne fallow deer (late MIS 11) are of comparable size. These data suggest that fallow deer maintained large body size throughout MIS11 and into the succeeding MIS 9 interglacial. Whether the unusual antler form of the Hoxnian fallow deer persisted into the following MIS 9 interglacial is unknown as no antler remains have been found at Grays.

From an ecological perspective, fallow deer is less adaptable than red deer and more closely tied to woodland, favouring parkland with ample herbaceous foods and relatively warm climates (Bjärvall and Ullström 1986; Mitchell-Jones *et al.* 1999). In the British Pleistocene, fallow deer is restricted to interglacials and is one of the most reliable indicators of interglacial conditions in a British Pleistocene fauna (Stuart 1982).

Capreolus capreolus **(L.), roe deer**

Only two bones can be ascribed with certainty to roe deer. These are a complete astragalus (Fig. 9.10, context 40070) and a fragment from the midshaft of a metacarpal (context 40144); both are from the tufa channel. A splinter of a metapodial diaphysis from context 40100 is also probably from roe deer.

Very few Pleistocene sites in Britain have so far produced remains of roe deer (Stuart 1982). To date, the only other Hoxnian specimens come from Swanscombe, where it is represented by a distal end of tibia from the

Basal Gravel (Sutcliffe 1964; Lister 1986). A small number of roe deer remains have been recovered from each of the Middle Pleistocene interglacials (Boxgrove, Ostend, Westbury-sub-Mendip and West Runton – early Middle Pleistocene; Hoxne – late MIS 11, Grays Thurrock – MIS; Selsey – MIS 7). Individual samples are generally too small to allow detailed discussion of body size, although data from Boxgrove clearly indicate that some early Middle Pleistocene roe deer were exceptionally large (Lister 1993).

The length and distal breadth of the astragalus from Southfleet Road are given in Table 9.9 and plotted in Figure 9.16. Here they are compared with measurements of early Holocene roe deer from Star Carr (Legge and Rowley-Conwy 1988) and Cherhill (Grigson, in Evans and Smith 1983) and modern

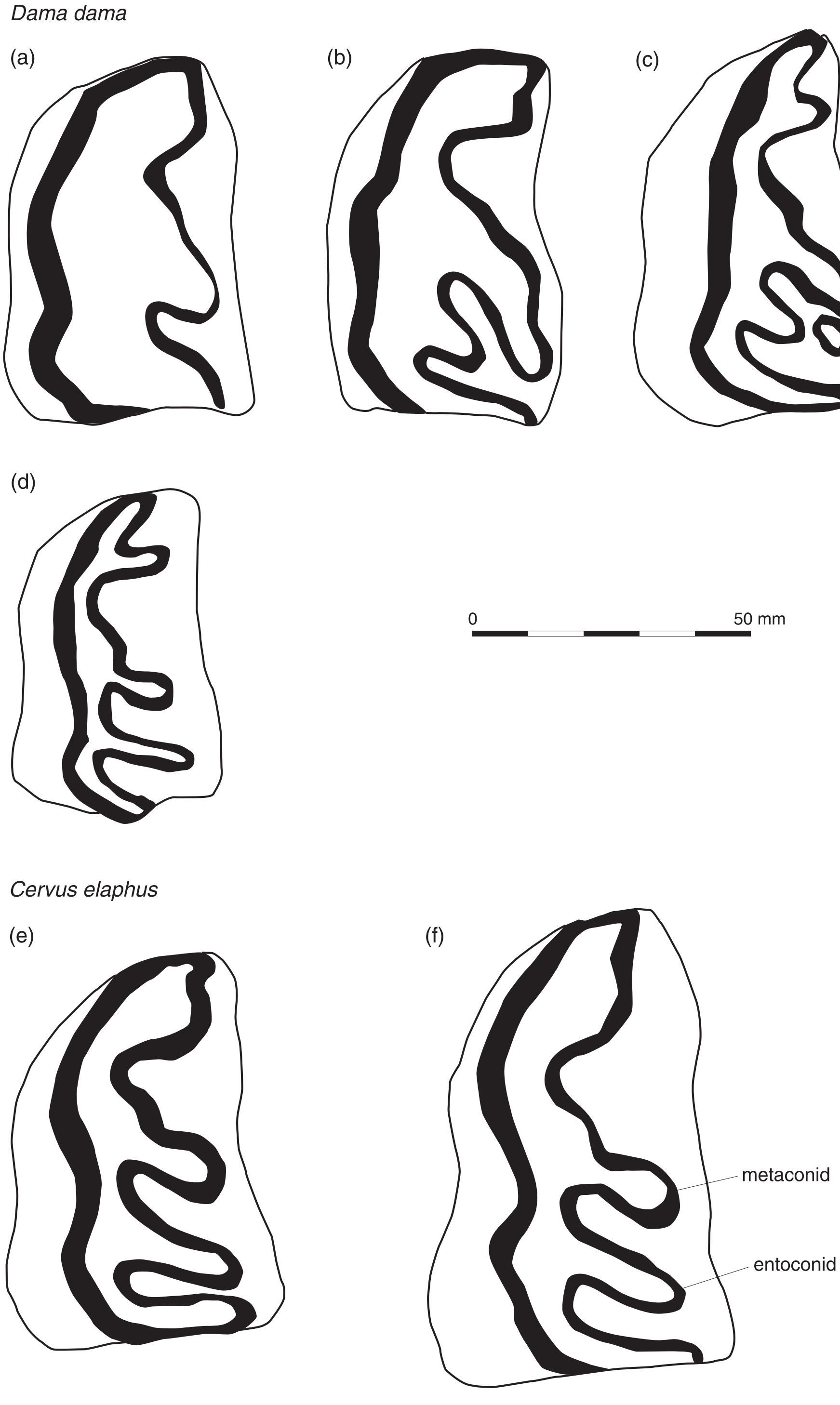


Figure 9.15 Comparison of modern and fossil fallow deer (*Dama dama*) and red deer (*Cervus elaphus*) showing states of metaconid-entoconid fusion in the lower third premolar: (a) Southfleet Road (Δ.41114, context 40100); (b) Swanscombe (M49724. Image inverted); (c) Swanscombe (M49716. Image inverted); (d) England, modern reference specimen (Department of Palaeontology, Natural History Museum, London); (e) Grays, Essex (M21643); (f) Southfleet Road (Δ.41722, context 40100)

comparative material. In these comparisons, the Southfleet astragalus falls within the range of the Star Carr measurements and is slightly larger than the modern west European comparative material. Mesolithic and Neolithic roe deer are large in comparison to modern roe deer from the same region, indicating that roe deer underwent a very marked decrease in size during the Holocene. Similar size reduction in other taxa is thought to be the result of a greater level of human interference and habitat destruction. Lister (1993) has noted that the teeth of late MIS 11 roe deer from Hoxne may have been slightly smaller than from Star Carr, whereas the tibia from Swanscombe is slightly larger than the modern comparative sample. This hints at size change in roe deer during MIS 11, but larger samples are needed to test this hypothesis.

The present-day ecology of the roe deer suggests a mosaic landscape existed in the vicinity of the site, with woodland or thick scrub interspersed with more open areas supporting herbaceous vegetation (Bjärvall and Ullström 1986; Mitchell-Jones *et al.* 1999).

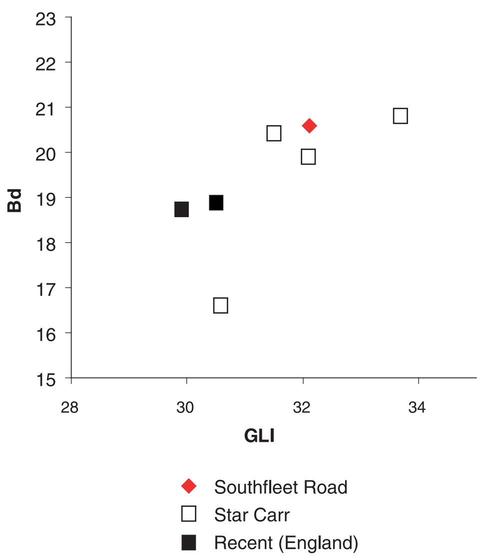


Figure 9.16 Distal breadth (Bd) plotted against greatest length (GLl) of the astragalus to illustrate the proportions of the Southfleet Road astragalus in comparison with samples of modern and early Holocene (Starr Carr) roe deer

Bovids (Bovidae)

***Bos primigenius* Bojanus, aurochs**

A substantial portion of an aurochs skull comprising both frontals with horncores and the basicranium was found in fluvial sands of Phase 3 (Fig. 9.17, Table 9.10). A second individual is represented by part of the nasal and maxillary regions of a skull with most of the cheek teeth from the right side (Fig. 9.18, Table 9.11). In addition to these cranial remains, several fragmentary bones and teeth were recovered from other contexts (Tables 9.10 and 9.12). It is not possible to identify these to species or genus level as they are either incomplete or otherwise poorly preserved.

Several species of large bovid have been recorded from Middle Pleistocene in northern Europe. In the late Middle Pleistocene, these include the ubiquitous *Bison priscus* (steppe bison) and *Bos primigenius*. Also represented is water buffalo (*Bubalus murrensis*), which has been found in deposits correlated with the Hoxnian in Germany (eg Steinheim, Schönebeck). According to Sutcliffe (1964) only *Bos primigenius* was present in the Swanscombe assemblage. However, careful reanalysis of the Swanscombe bovid material by Gee (1991; 1993) has identified a few bones of bison. The genus *Bos*, which arose in Africa at the end of the Early Pleistocene (Martínez-Navarro *et al.* 2007) is first recorded in Europe at Venosa-Notarchirico, Italy (*c* 0.5-0.6 million years ago). The Swanscombe and Clacton aurochs material is significant as they represent the earliest records of this species from north-western Europe. These aurochs are notable for their large size and distinctive horncores, which are less curved, somewhat flatter in cross-section and show less torsion than in more recent populations (Gee 1991).

The Southfleet Road aurochs skull is notable because it is unusually complete. Skulls from Swanscombe and Clacton are generally more fragmentary, but the sample includes a number of horncores and two frontlets from Clacton (one of which is restored). Measurements of the

Table 9.9 Comparison of measurements of the *Capreolus capreolus* astragalus from Southfleet Road and other samples

		GLl (mm)			*Bd (mm)*	
	n	*Observed range*	*Mean ± SD*	*n*	*Observed range*	*Mean ± SD*
Southfleet Road	1		32.1	1		20.4
Holocene						
Starr Carr[a]	4	30.6–33.7	32 ± 1.30	4	18.6–20.8	19.9 ± 0.96
Cherhill[b]	1		32.8			
Recent						
England[c]	2	29.9, 30.5		2	18.8, 18.9	

[a] Legge and Rowley-Conwy 1988
[b] Grigson 1983
[c] Parfitt own data

Table 9.10 List of bovid remains from Southfleet Road. Several of the bones could only be identified as from *Bos* or *Bison* owing to lack of diagnostic features. The proximal metacarpal resembles *Bison*, but the specimen is too incomplete and eroded to provide a firm attribution to this taxon

Taxon	*Phase*	*Context*	*Find no.* Δ	*Element*
Bos primigenius	3	40062	50186	Partial skull (basicranium, frontlet with both horncores)
	5	40025	43298	R premaxilla – maxilla with P^4 (roots), M^{1-3} (mid wear)
	5	40025	43813	L nasal (probably part of *B. primigenius* skull, Δ. 43298)
	6	40078	42561	R metatarsal frag (proximal lateral & medial facets)
Bos or *Bison*	6a	40039	42546	L pisiform & lunate (rearticulates to Δ. 43454)
	6a	40039	43454	L scaphoid (rearticulates to Δ. 42546)
	6	40158	43861	R tibia, shaft & distal end (fused)
	?	40089	40062	R metacarpal frag (part of proximal end & shaft)
Large bovid	5	40025	43842	Skull frag
	6	40078	41909	R metacarpal frag (part of distal end, fused)
	6	40078	40711	Metapodial frag (distal condyle)
	7	40167	50168	Cheek tooth frags

Table 9.11 Measurements (in mm) of *Bos primigenius* teeth from context 40025, Southfleet Road

Phase	*Context*	*Find no.* Δ	*Length of molar row*[a]	M^1L	M^1W	M^2L	M^2W	M^3L	M^3W
5	40025	43298	107	30.2	27.5	34.9	29.1	36.2	26.9

Note: All dental measurements taken at the occlusal surface [a] Length of molar row, measured along alveoli on the buccal side

Table 9.12 Measurements (in mm) of the *Bos primigenius* skull from context 40062, Southfleet Road and two Hoxnian examples from Clacton

	Southfleet Road	*Clacton*	
		M15624	*M2342*
Least breadth between bases of horncores (vdD 31)	340	210	245
Least distance between horncore tips (vdD 42)	-	520	965
Distance between horncore tips (vdD 42a)	-	1970	1890
Greatest tangential distance between the outer curves of the horncores (vdD 43)	*c* 1090	952	1140
Length of outer curvature of horncore (vdD 47)	-	860	805
Horncore basal circumference (vdD 44)	-	475	465
Greatest (oro-basal) diameter of the horncore base (vdD 45)	*c* 164	174	173
Least (dorso-basal) diameter of the horncore base (vdD 46)	-	118	123

VdD = von den Driesch measurement number

Table 9.13 Biometric comparisons of the *B. primigenius* horncores from Southfleet Road with Hoxnian and Holocene samples. Statistics for the Holocene samples are: Minimum-Mean-Maximum (sample size)

	Length (mm)	*Basal circumference (mm)*	*Greatest (oro-basal) diameter (mm)*	*Least (dorso-basal) diameter (mm)*
Holocene (♂& ♀)[a]	335–564.76–845 (90)	180–301.69–395 (100)	-	-
Southfleet Road	-	-	*c* 164	-
Clacton				
M15624	860	475	174	118
M27871	*c* 840	470	173	111
M2342	805	465	173	123
Swanscombe				
M20583, Basal Gravel	730	435	159	104
No number	-	400	138	113
No number	-	485	168	137

[a] from Grigson 1978

Swanscombe and Clacton skull are compared with the Southfleet Road example in Table 9.13. Although somewhat crushed, the Southfleet Road skull displays similar flattening of the horncore base. In addition, the Southfleet Road horncore appear less curved and with less torsion than those of later Pleistocene and Holocene horncores.

Although the aurochs is now extinct, details of its ecology can be reconstructed from its fossil record as well as historical descriptions of the last surviving European populations. It seems to have been a highly adaptable species that was able to shift its diet from grasses to browse, depending on local circumstances. While aurochs was ubiquitous during wooded interglacial conditions in northern Europe, there is ample evidence that it adapted to a variety of ecological conditions, including interstadials during the Last Cold Stage (Currant 1986a).

(a)

(b)

Figure 9.17 *Bos primigenius* skull (Δ.50186, context 40062) from Southfleet Road during conservation: (a) oblique frontal view; (b) basicranium, with occipital condyles at base [Photographs by N. R. Larkin]

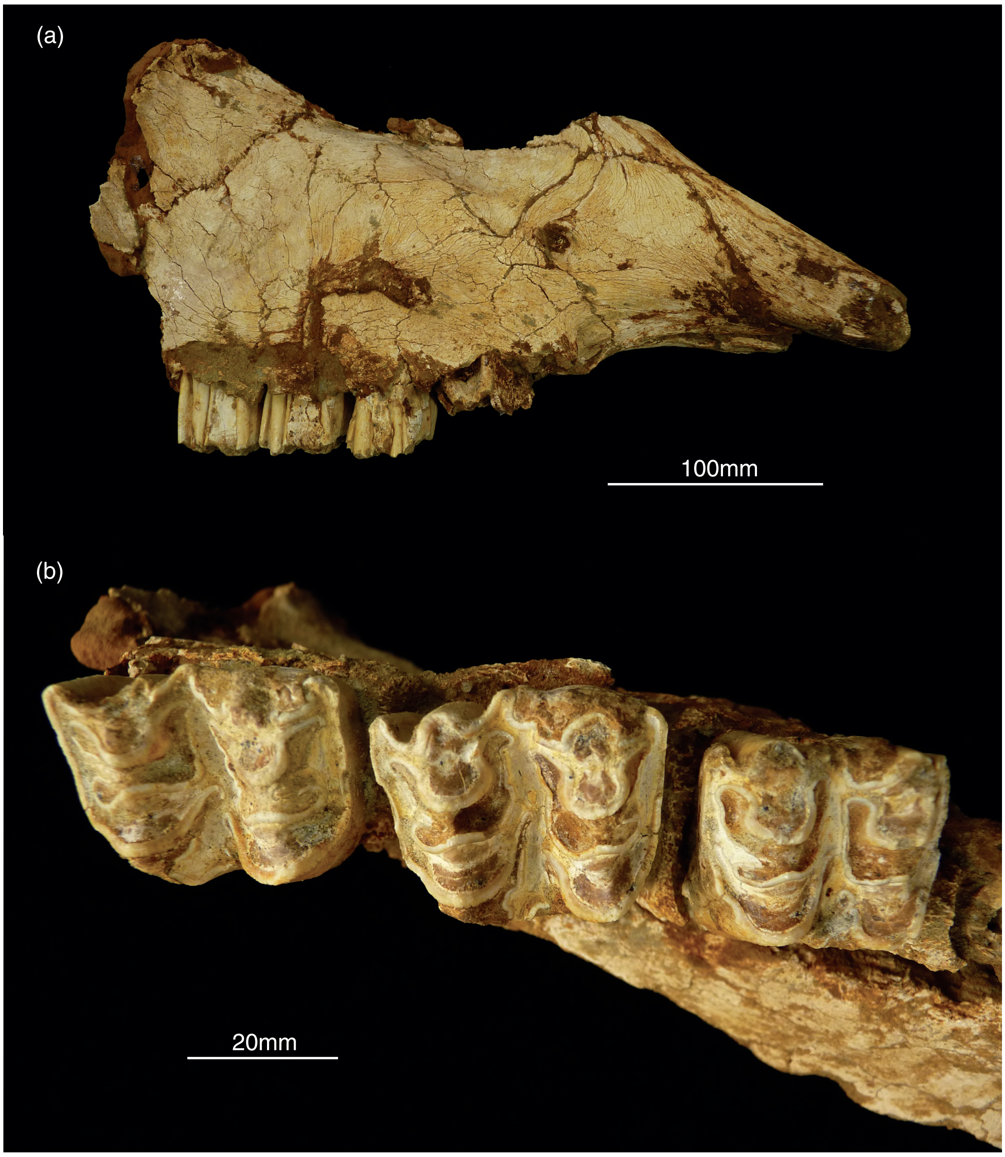


Figure 9.18 *Bos primigenius* maxilla (Δ.43298, context 40025): (a) lateral view, (b) occlusal view of M^{1-3}

MAMMALIAN EVIDENCE FOR THE AGE OF THE SOUTHFLEET ROAD INTERGLACIAL SEDIMENTS

A chart showing the occurrence of mammalian species at Southfleet Road is given in Table 9.14 and Figure 9.19. In sum, the mammalian fauna is entirely consistent with an interglacial phase providing regional deciduous woodland as well as locally open vegetation. The fauna includes a number of extant species found today in the European temperate zone. The same species (or their close relatives) are also important elements in interglacial faunas throughout NW Europe. Although several of these taxa are also known from interstadial contexts (for example straight-tusked elephant, aurochs), the Southfleet Road assemblage includes thermophilic species, such as rabbit and Merck's rhinoceros that are known only from interglacial contexts in Britain.

There appears to be no significant, abrupt break, but rather a succession of subtle changes in the composition of the faunal through the sequence, reflecting changes in the local vegetation and proximity to water bodies. Importantly, there is no evidence from the vertebrate fauna suggesting a substantial hiatus between the basal fluvial sediments (Phases 3-5) and the overlying fine-grained sequence of Phase 6, reinforcing similar indications from the lithological and ostracod records (Chapters 4 and 11 respectively). Both faunal groups suggest interglacial conditions, although the basal fluvial sediments have also yielded ground squirrel, a rodent more typical of cold stage faunas in Britain (Stuart 1982). Another small mammal that is more commonly found in cold stage faunas is the northern vole. This vole is found together with ground squirrel in Phase 5, but it is also present in Phase 6b, where it is associated with a fully interglacial woodland molluscan fauna. The presence of ground squirrel and northern vole in an otherwise interglacial context at Southfleet Road may suggest continuity with the preceding cold stage and survival in suitable microhabitats of dry grassland favoured by ground squirrels and marshland habitats favouring northern vole. The presence of a fully interglacial ostracod fauna in underlying deposits attributed to Phases 3 and 4 appears to rule out any possibility that this small mammal assemblage is associated with cold conditions in Phase 5.

Two lines of evidence help to constrain the age of the sediments containing the Clactonian artefacts, namely: (a) their geomorphological position in relation to other mammal-bearing fluvial sequences in the lower Ebbsfleet Valley (Wenban-Smith *et al.* forthcoming); and (b) mammalian biostratigraphy. In terms of altitude, the Southfleet Road fluvial sediments (occurring at *c* 20-25m OD) are higher (and therefore older) than the fluvial sequences (occurring at *c* 8-12m OD) in the vicinity of the famous 'Bakers Hole' site. These lower-level deposits have yielded interglacial faunas with horse and mammoth, which have been correlated with the penultimate (MIS 7) interglacial.

Species of particular biostratigraphic interest include the rhinos *Stephanorhimus hemitoechus* and *S. kirchbergensis* and the aurochs (Table 9.14, Fig. 9.19). These ungulates are often common in late Middle Pleistocene temperate faunas, but unknown in Britain before the Anglian stage. Although aurochs is a persistent element in British post-Anglian faunas, Hoxnian aurochs are distinguished by their exceptional size combined with bulky horncores of a distinctive shape (Gee 1991). The morphology of the aurochs horncore from Southfleet Road is of the same distinctive form as Clacton and Swanscombe and provides strong evidence that the site dates to the Hoxnian stage. The detailed morphology and size of the red deer and fallow deer is also of biostratigraphical interest. Lister (1993) has highlighted the relatively small size of red deer at Clacton and Swanscombe (spanning Basal Gravel to Upper Middle Gravel); in comparison the animals from Hoxne are much larger bodied. He further noted (ibid.) that the Hoxne red deer combined relatively large body size with small dental size. In terms of skeletal and dental size the Southfleet red deer match those from Swanscombe and Clacton. Similarly, fallow deer from Swanscombe and Clacton are distinctive, being typified by unusual antler form, relatively large size and features of the premolar dentition that define the late Middle Pleistocene subspecies *Dama dama clactoniana* (Lister 1981; 1986). The stratigraphical range of *D. d. clactoniana* is poorly known and the taxonomic status of the fallow deer from Hoxne as well as those from the succeeding (MIS 9) interglacial is currently uncertain. Although antlers have yet to be found from these sites, the fallow deer from Grays and Hoxne are similarly large-bodied and, on the basis of size alone, indistinguishable from *D. d. clactoniana*. Another feature potentially linking these populations is the high frequency of metaconid fusion in the third lower premolar found in samples from Clacton/Swanscombe and Grays. The foregoing discussion illustrates that the fallow deer and red deer from Southfleet Road are entirely consistent with a Hoxnian age. However, in the absence of well-preserved fallow deer antlers from Southfleet Road and Grays, it is not currently possible to discriminate between MIS 11 and MIS 9 using evidence from the cervids in isolation. Stronger evidence for an upper age limit is provided by the presence of pine vole *Microtus* (*Terricola*) cf. *subterraneus*. This vole is unknown in Britain from the Holocene and has not been found in any Late Pleistocene fauna; during the later Middle Pleistocene it is known only from sites correlated with MIS 11 such as Hitchin, Beeches Pit, Barnham, Hoxne and Swanscombe. The absence of pine voles in post-MIS 11 faunas in Britain is unlikely to be due to insufficient sampling, as the British small mammal fauna is now rather well known, with rich samples from successive warm and cold stages spanning this time period.

The significance of other biostratigraphic 'indicator species' (*sensu* Schreve 2001a, b) is less clear. This group includes the mole *Talpa minor* and rabbit, which Schreve (2001a) has included in her list of taxa that define the 'Swanscombe Mammal Assemblage Zone'. In Britain, both taxa are unknown from deposits younger than the 'Upper Sequence' at Hoxne (Fig. 9.19; Table 9.15). However, these are rare taxa that are of dubious biostratigraphical significance because their absence could represent sampling bias due to small sample size. Virtually nothing is known of the fossil species of mole present in Britain between the Hoxnian and the Holocene. Similarly, the fossil record of lagomorphs is extremely poor for this time period (Mayhew 1975).

The problem of range extension is highlighted by the unexpected presence at Southfleet Road of the large and distinctive shrew *Sorex* (*Drepanosorex*) sp. This shrew has long-been regarded as a pre-Anglian 'indicator species' (Bishop 1982; Parfitt 1999; Schreve 2001a). It is a common element in many European Early and early Middle Pleistocene faunas, and in Britain it is well-represented in the early Middle Pleistocene at West Runton, Westbury and Boxgrove (Maul and Parfitt 2010). The identification of *Sorex* (*Drepanosorex*) sp. at Southfleet Road is based on a mandibular ramus from the tufaceous channel-fill; although broken, this specimen is identical in preservation to other small mammal bones from the same context, ruling out reworking from earlier deposits. In terms of morphology, the Southfleet Road mandible is indistinguishable from mandibles in the type series of *Sorex* (*Drepanosorex*) *savini* from West Runton. Given the weight of evidence suggesting a post-Anglian age for the Southfleet Road sequence, the most parsimonious explanation for the presence of *Sorex* (*Drepanosorex*) sp. at Southfleet Road is that its stratigraphical range extended beyond the Anglian. Additional evidence for a range extension of *Sorex* (*Drepanosorex*) sp. comes from poorly described post-Elsterian (?Holstenian) specimens of *Sorex* (*Drepanosorex*) sp. (sometimes assigned to *Drepanosorex postsavini*) from sites in central Europe (van Kolfschoten, pers. comm.). That such a characteristic species could have been overlooked in post-Anglian/Elsterian context warns against placing too much reliance on species presence or absence in mammalian biostratigraphy (cf. Lister 1992).

Table 9.14 The Southfleet Road Middle Pleistocene mammal fauna. Group A includes occurrences in the basal fluvial sediments (Phase 5) and those from Group B are found in the overlying fine-grained sediments and tufa-filled channel (Phase 6b). # Taxa first appear in the British sequence in Hoxnian; † extinct taxa; * taxa are known only in the British Pleistocene interglacials and are missing from cold stage assemblages (excluding interstadials)

Group	*A*	*B*	
Phase	*5*	*6*	*6b*
MAMMALIA			
Lipotyphla			
Sorex minutus, pygmy shrew	+		+
Sorex sp. 1, shrew (smaller than *S. araneus*)	+	+	+
Sorex (*Drepanosorex*) sp., shrew (large) †			+
Neomys sp., water shrew	+	+	+
Soricidae gen. et sp. indet., shrew		+	+
Talpa minor, mole †		+	+
Chiroptera			
Myotis daubentonii, Daubenton's bat *			+
Primates			
Macaca sylvanus, Barbary macaque			+
Homo sp., hominin (C = Clactonian)	C	C	C
Lagomorpha			
Oryctolagus cuniculus, rabbit *	+	+	+
Rodentia			
Sciurus sp., squirrel *			+
Spermophilus sp., ground squirrel	+		
Clethrionomys glareolus, bank vole	+	+	+
Castor fiber, beaver		+	
Arvicola cantianus, water vole †	+	+	+
Microtus (*Terricola*) cf. *subterraneus*, common pine vole	+		+
Microtus agrestis, field vole			+
Microtus agrestis / *M. arvalis*, field or common vole	+	+	+
Microtus oeconomus, northern vole	+		+
Microtus sp., vole	+	+	+
Apodemus maastrichtiensis, mouse †			+
Apodemus sylvaticus, wood mouse	+	+	+
Apodemus sp., mouse	+	+	+
Carnivora			
Mustela cf. *putorius*, polecat			+
Mustela sp., mustelid			+
Panthera leo, lion	+		
Proboscidae			
Palaeoloxodon antiquus, straight-tusked elephant †	+	+	+
Elephantidae gen. et sp. indet., indeterminate elephant		+	
Perissodactyla			
Stephanorhinus hemitoechus, narrow-nosed rhinoceros # †		+	cf
Stephanorhinus kirchbergensis, Merck's rhinoceros* # †		+	
Artiodactyla			
Sus scrofa, wild boar		+	
Dama dama, fallow deer	cf	+	+
Cervus elaphus, red deer	+	+	+
D. dama or *C. elaphus*, fallow or red deer	+	+	+
Capreolus capreolus, roe deer		+	+
Cervidae gen. et sp. indet, indeterminate deer		+	+
Bos primigenius, aurochs # †	+	+	
Bos primigenius or *Bison priscus*, aurochs or bison	+	+	

Climatostratigraphy	'Cromerian Complex'			Anglian	Hoxnian							Ipswichian
Marine Isotope Stage	?	14	13	12	11c	11a	10	9	8	7	6	5
British Interglacial Site	West Runton		Boxgrove		Swanscombe Clacton Barnham Beeches Pit	Hoxne (B2-B1)		Purfleet Grays Thurrock Cudmore Grove		Aveley West Thurrock Selsey		Joint Mitnor Trafalgar Square
Equus sussenbornensis	●											
Equus altidens	●											
Mimomys savini	●											
Macroneomys brachygnathus	●											
Megaloceros savini	●											
Pliomys episcopalis	●		●									
Praemegaloceros dawkinsi	●		●									
Praemegaloceros verticornis	●		●									
Ursus deningeri	●		●									
Sorex (Drepanosorex) sp.	○		○		○							
Talpa minor	○		○		○	○						
Microtus (Terricola) subteranneus	○		○		○	○						
Trogontherium cuvieri	●				●	●						
Macaca sylvanus	○				○	○						
Crocuta crocuta	●		●									
Mammuthus sp.	●							●		●		●
Oryctolagus cuniculus			○		○					●		
Ursus spelaeus					●							
Equus ferus			●		●	●		●		●		
Arvicola sp.			○		○	○		○		○		○
Stephanorhinus kircherbergensis					○			○		○		
Palaeoloxodon antiquus					○			○		○		○
Megaloceros giganteus					●	●		●		●		●
Bos primigenius					○			○		○		○
Stephanorhinus hemitoechus					○			○		○		○
Ursus arctos								●		●		●
Hippopotamus sp.												●

Figure 9.19 Summary of mammalian faunal change during the Middle and Late Pleistocene in Britain, showing the stratigraphic ranges of selected mammal taxa. O = taxon present at Southfleet Road; ● = taxon present at other sites. Many species have longer ranges in continental Europe and their absence from contemporaneous sites in Britain may be due to sampling failure or climatic, environmental and palaeogeographical factors.

Table 9.15 Comparison of Southfleet Road mammal fauna with other MIS 11 sites. With the exception of Clacton, where pollen is well preserved, attribution of the assemblages to the substages of the Hoxnian is based on lithostratigraphical and/or biostratigraphical inferences (Preece *et al.* 2007).

Site	***Hoxne***	***South-fleet Rd.***	***Swans-combe***	***Clacton***	***Barn-ham***	***Beeches Pit***	***Ingress Vale***	***Swans-combe***	***Beeches Pit***	***Hoxne***	***Hoxne***
Horizon	*Stratum F*	*5-6*	*LG-LL*			*Lower fauna*		*UMG*	*Upper fauna*	*Stratum C*	*Strata B2-B1*
Pollen substage	*Late Anglian*	*?I-II*	*?I-II*	*II*	*?II*	*II-III*	*III*	*?III-IV*	*?*	*?*	*?*
Stage	*Anglian*	*Hoxnian*	*Hoxnian*	*Hoxnian*	*Hoxnian*	*Hoxnian*	*Hoxnian*	*Hoxnian*	*Hoxnian*	*Hoxnian*	*Hoxnian*
Marine Isotope Stage	*12*	*11c*	*11c*	*11c*	*11c*	*11c*	*11c*	*11c*	*11c*	*11b*	*11a*
Lipotyphla											
Sorex minutus, pygmy shrew	–	+	–	–	+	+	–	–	+	–	–
Sorex sp. 1, shrew (smaller than *S. araneus*)	–	+	–	–	+	+	–	–	+	–	+
Sorex (Drepanosorex) sp., shrew (large)	–	+	–	–	+	–	–	–	–	–	–
Neomys sp., water shrew	–	+	–	–	+	+	–	–	+	–	+
Crocidura sp., white-toothed shrew	–	–	–	–	+	–	–	–	–	–	–
Talpa minor, mole	–	+	+	–	+	+	–	–	+	–	+
Desmana sp., Russian desman	–	–	–	–	+	–	–	–	–	–	+
Chiroptera											
Myotis daubentonii, Daubenton's bat	–	+	–	–	–	–	–	–	–	–	–
Plecotus sp., long-eared bat	–	–	–	–	+	–	–	–	–	–	–
Pipistrellus pipistrellus, common pipistrelle	–	–	–	–	+	–	–	–	–	–	–
Primates											
Macaca sylvanus, Barbary macaque	–	+	+	–	–	–	–	–	–	–	–
Homo sp., hominin (C = Clactonian, A = Acheulian)	–	–	C	C	C/A	A	A	A	A	–	A
Lagomorpha											
Oryctolagus cuniculus, rabbit	–	+	+	–	+	+	–	–	–	–	–
Lepus timidus, mountain hare	–	–	–	–	–	–	–	+	–	–	–
Rodentia											
Sciurus sp., squirrel	–	+	–	–	+	–	–	–	+	–	–
Spermophilus sp., ground squirrel	–	+	–	–	–	–	–	–	–	–	–
Trogontherium cuvieri, beaver-like rodent	–	–	–	+	–	–	+	–	+	–	+
Castor fiber, beaver	–	–	+	+	–	–	–	–	–	–	+
Dicrostonyx sp., collared lemming	–	–	–	–	–	–	–	–	–	+	–
Lemmus lemmus/Myopus schisticolor, Norway/wood lemming	–	–	–	–	–	–	–	+	+	–	+
Clethrionomys glareolus, bank vole	–	+	+	+	+	+	+	–	+	–	+
Arvicola cantianus, water vole	–	+	+	+	+	+	+	–	+	–	+
Microtus (Terricola) cf. *subterraneus*, common pine vole	–	+	+	–	+	+	–	–	+	–	+
Microtus agrestis, field vole	–	+	+	–	+	+	–	cf.	+	–	+
Microtus arvalis, common vole	–	–	cf.	–	+	–	–	–	+	–	cf.
Microtus agrestis/M. arvalis, field or common vole	–	+	+	+	+	+	–	+	+	–	+

Table 9.15 (continued)

Microtus oeconomus, northern vole	–	+	+	–	–	–	–	+	–	–	–
Apodemus maastrichtiensis, mouse	–	+	–	–	+	+	–	–	+	–	–
Apodemus sylvaticus, wood mouse	–	+	+	–	+	+	cf.	–	+	–	+
Eliomys quercinus, garden dormouse	–	–	–	–	–	–	–	–	+	–	–
Cetacea											
Tursiops cf. *truncatus*, bottlenose dolphin	–	–	–	–	–	–	+			–	–
Carnivora											
Canis lupus, wolf	–	–	+	–	–	–	+	+	–	–	sp.
Ursus spelaeus, cave bear	–	–	+	–	–	–	–	–	–	–	
Ursus sp., bear	–	–	–	–	+	–	–	–	+	–	+
Mustela nivalis, weasel	–	–	–	–	–	+	–	–	–	–	–
Mustela cf. *putorius*, polecat	–	+	–	–	+	–	–	–	–	–	–
Mustela sp., mustelid	–	+	–	–	–	–	+	–	–	–	–
Martes martes, pine marten	–	–	+	–	–	–	–	–	–	–	–
Lutra lutra, otter	–	–	–	–	–	–	–	–	–	–	+
Felis sylvestris, wild cat	–	–	+	–	–	–	–	–	–	–	–
cf. *Lynx lynx*, lynx	–	–	–	–	–	–	–	–	–	–	+
Panthera leo, lion	–	+	+	+	+	–	+	+	–	–	+
Proboscidae											
Palaeoloxodon antiquus, straight-tusked elephant	–	+	+	+	+	–	+	+	–	–	–
Perissodactyla											
Equus ferus, horse	–	–	+	+	–	–	+	+	+	–	+
Equus hydruntinus, equid (at Swanscombe, horizon unknown)	–	–	?	–	–	–	–	?	–	–	–
Stephanorhinus kirchbergensis, Merck's rhinoceros	–	+	+	+	–	–	+	+	–	–	–
Stephanorhinus hemitoechus, narrow-nosed rhinoceros	–	+	+	+	–	–	+	–	+	–	–
Stephanorhinus sp., rhinoceros	–	–	+	–	+	–	–	+	–	–	+
Artiodactyla											
Sus scrofa, wild boar	–	+	+	+	+	–	+	–	–	–	
Megaloceros giganteus, giant deer	–	–	+	–	–	–	–	+	–	–	+
Dama dama clactoniana or *D. dama* ssp. indet., fallow deer	–	+	+	+	+	+	+	+	–	–	+
Cervus elaphus, red deer	+	+	+	+	+	+	+	+	+	–	+
Capreolus capreolus, roe deer	–	+	+	–	–	–	–	–	–	–	+
Bos primigenius, aurochs	–	+	+	+	–	–	+	+	+	–	–
Bison priscus, bison	–	–	+	+	–	–	–	–	–	–	+
Bos primigenius or *Bison priscus*, aurochs or bison	–	+	–	–	+	–	–	+	–	–	–

Where the genus is certain, but not the species, the genus is followed by 'sp'; the term 'cf' is used to indicate that the specimen resembles the named species or genus very closely, but is too incomplete to show all diagnostic features. (LG = Lower Gravel; LL = Lower Loam; UMG = Upper Middle Gravel), Barnham Beeches Pit (Lower fauna = beds 3-5; Upper fauna = beds 6-7) and Ingress Vale (Dierden's Pit).

In summary, there is a striking resemblance between the Southfleet Road assemblage and those from Clacton and Swanscombe (Basal Gravel-Lower Loam), as well as other more-or-less contemporary interglacial mammalian faunas from Beeches Pit and Barnham, which have been assigned to the first post-Anglian interglacial (Hoxnian, MIS 11). Although the faunal similarities would appear to imply that the deposits are of the same age, recent work on the Hoxne sequence has shown that the main faunal horizon was deposited during a second (post-Hoxnian) temperate episode. These deposits are separated from the Hoxnian lake sediments by a significant phase of climatic deterioration as represented by the 'Arctic Bed'. The second interglacial stage appears to fall within the latter part of MIS 11, based on the close similarity in its mammalian fauna to that from Swanscombe (Ashton *et al.* 2008). Work is still ongoing to establish whether there are any features of the mammalian fauna which allow differentiation of the two temperate episodes. One important difference between these two faunal groups is in the size of the red deer (Lister 1993). Those from Swanscombe and Clacton are significantly smaller than the red deer from Hoxne, which combine larger body-size with relatively small dental size. The correlation of Southfleet Road with the first post-Anglian interglacial is supported by the red deer, which show a close affinity to the samples from Swanscombe and Clacton.

MAMMALIAN FAUNAS AND A REVISED BIOSTRATIGRAPHICAL SCHEME FOR MIS 11 IN BRITAIN

by Simon A Parfitt and Antony J. Sutcliffe[1]

The emerging picture of climatic complexity within MIS 11 observed in ice and deep-sea records provide the template for this stage (Tzedakis *et al.* 2001; EPICA Community Members 2004). In terms of duration, the ice and deep-sea records show that MIS 11 spans about 65 000 years (425-360 ka). Climatically, the first half of MIS 11 includes a particularly warm interglacial of long-duration, which is terminated by a pronounced and rapid cooling at about 390 000 ka. The latter part of MIS 11 consists of probably several stadials and 'interstadials', one of which may represent the second warm interval observed in the Hoxne sequence.

Anglian Glacial Stage (MIS 12)

The British Anglian ice sheet was the most extensive glaciation of the Pleistocene and at its maximum extent it covered most of the British Isles, with the ice sheet extending as far south as north London and the River Severn. The glaciated areas were subject to considerable erosion, and as a consequence fossiliferous deposits of Anglian age are extremely rare in Britain. There are few records of mammalian remains that may be of Anglian age. The Mundesley (Norfolk) ground squirrel (identified as *Spermophilus undulatus* by Mayhew 1975) is usually assigned to the beginning of this time period. Similarly, the occurrence of remains of the ground squirrel and arctic lemming (*Dicrostonyx* sp.) together with other boreal/arctic biota has been recorded in the 'Arctic Fresh-water Bed' (Parfitt *et al.* 2010b) beneath glacial deposits (Happsiburgh Till) at Ostend (Norfolk). At Boxgrove (West Sussex), cold stage mammals (including grey-sided vole *Clethrionomys rufocanus* and Norway lemming *Lemmus lemmus*) assigned to the early part of the Anglian cold stage occur in chalky slope deposits and 'brickearth' immediately above the interglacial palaeosol horizon. The cavern-infill deposits at Westbury-sub-Mendip (Somerset) also include beds with cold stage mammal faunas (Stringer *et al.* 1996), but this sequence is no longer thought to be equivalent in age to Boxgrove and probably dates to earlier stages within the 'Cromerian Complex' (Preece and Parfitt 2000; Breda *et al.* 2010; Lister *et al.* 2010). At Hoxne, three red deer foot bones found resting on Anglian till represent the only known instance of mammals from the Anglian late-glacial stage (Stuart *et al.* 1993).

Hoxnian Interglacial Stage (MIS 11c)

Conditions immediately following the retreat of the ice sheet are recorded in late Anglian lacustrine sediments that formed on the newly deglaciated landscape in East Anglia. Of the localities with deposits attributed to the Hoxnian stage only a few have yielded any abundance of mammalian remains, the most important being Swanscombe, Kent, Clacton, Essex, Beeches Pit and Barnham East Farm, both in Suffolk (Tables 9.15 and 9.16). At Hoxne, Norfolk (stratotype of the Hoxnian), the mammalian remains are mainly confined to deposits overlying the Hoxnian lacustrine sediments and separated from them by a major cold stage. All of these localities are also important archaeological sites. Unfortunately, at none of these sites (even at the Hoxnian type locality) is there a complete pollen record, although a full sequence, ranging from Anglian till, through pollen zones I-IV and into the beginning of the following cold episode is known from Marks Tey, Essex (Turner 1970). The sequence of faunal changes during this period has therefore been reconstructed from geological sequences that are correlated primarily on the basis of biostratigraphy.

The site with the longest sequence of deposits is Barnfield Pit, Swanscombe, part of the Boyn Hill/Orsett Heath Terrace of the River Thames. This section has been discussed in detail by Conway *et al.* (1996) who group the deposits into three phases. Mammals are common at Swanscombe in all deposits up to and including the Upper Middle Gravels (Phase II), source of the famous human

[1] This section represents an updated version of an unpublished collaborative review paper with the late Antony Sutcliffe (1927-2004).

skull remains (Stringer and Hublin 1999). Two noteworthy features suggest a break in deposition at the base of the Middle Gravels: an abrupt typological change in the flint artefacts from Clactonian in the Lower Gravel and Lower Loams (Phase I) to Acheulian in the Middle Gravel (Phase II), and a horizon covered with animal footprints on the weathered surface of the Lower Loam. A striking feature of the Swanscombe sequence is the change in the character of the freshwater fauna that occurs between the Lower Loam and Middle Gravels. Assemblages from the upper part of the aggradation record an influx of so-called 'Rhenish' molluscan species, which Kennard (1942) suggested indicated a link between the Thames and Rhine. A similar molluscan fauna occurs at Clacton and Tillingham, where it is associated with brackish conditions indicating high sea level. A further important mammal locality in the Swanscombe terrace complex is Dierden's Pit, Ingress Vale, situated less than half a kilometre from Barnfield Pit. Most of the mammal remains probably derive from a shell bed, which has yielded the same 'Rhenish Suite' of molluscs found in the Lower Middle Gravel at Barnfield Pit. Kerney (1971) placed the shell bed above the Lower Loam of Barnfield Pit but slightly earlier than the main body of the Middle Gravel, implying that the hiatus in the Barnfield Pit is a local phenomenon resulting from a shift in the position of the river.

Clacton is situated on the coast far out in the estuary of the Thames where it grades into the North Sea. The site stratigraphy, described by Warren (1923), was elaborated by Pike and Godwin (1953), Warren (1955), Kerney (1971), Turner and Kerney (1971) and more recently by Bridgland *et al.* (1999). A lower series of freshwater deposits with abundant mammalian remains and Clactonian artefacts, assigned to pollen zones IIb-IIIa, is overlain by estuarine clays and silts of IIIb age with an eroded surface at about 10m OD overlain by hillwash and soil. The Clactonian deposits were the focus of major archaeological excavations by Mary Leakey and John Wymer (Singer *et al.* 1973).

The second group of sites with mammalian remains is located in the Breckland region of East Anglia and includes Barnham, Beeches Pit and Elveden. The glacial deposits (including the chalky Lowestoft Till) in this region provide a useful lithostratigraphic marker that extends to the Thames catchment (as at Hornchurch where fluvial deposits of the first post-diversion terrace directly overly till). The interglacial faunas from the Breckland sites are found in lacustrine and fluvial deposits that directly overly the glacial deposits.

Table 9.16 Stratigraphic subdivision of the early part of the late Middle Pleistocene. The climatic stages in the deep-sea record are numbered back from the Holocene (Marine Isotope Stage (MIS) 1) such that odd-numbered marine isotope stages represent warm intervals and even-numbered stages represent cold episodes. Substages of MIS 11 follow Tzedakis *et al.* 2001

MIS	*Pollen substage*	*Climatostratigraphy and suggested correlation with British sites*	
11a		Un-named temperate stage	Hoxne (Strata B2-B1)
11b		Un-named cold stage	Hoxne (Stratum C)
	Ho IV	Hoxnian Interglacial Stage	Swanscombe (UMG)
11c	Ho III		Dierden's Pit (Ingress vale)
	Ho II		Clacton Barnham Swanscombe (LG, LL) Southfleet Road
	Ho I		
12		Anglian Glacial Stage	Hoxne (Stratum F) Ostend ('Arctic Fresh-water Bed')

At Barnham, sedimentation commenced during the closing stages of the Anglian Glacial Stage with the deposition of glaciofluvial sand and gravel and Lowestoft till in a steep-sided channel incised into the Chalk bedrock (Ashton *et al.* 1998; Preece and Penkman 2005). Rich assemblage of small vertebrates, rare large mammal remains and an associated molluscan assemblage occurs in the upper fluvio-lacustrine part of the channel fill. The principal fossiliferous deposits date to the early temperate stage of the interglacial and have yielded southern thermophiles (European pond terrapin *Emys orbicularis* and Aesculapian snake *Zamenis longissimus*) indicating that summers were warmer than the present day.

The interglacial deposits at Beeches Pit rest directly upon glacial deposits (outwash gravels and till, referable to the Anglian Lowestoft Formation), with no apparent break in the sequence (Preece *et al.* 2007). The interglacial sediments consist of limnic, tufaceous and colluvial silts containing rich vertebrate, molluscan (including tufa with a highly distinctive '*Lyrodiscus* fauna') and ostracod faunas. Faunal evidence from the upper levels provides clear indications for climatic deterioration. Both the molluscan and vertebrate faunas suggest correlation with the Hoxnian and the faunal changes seen at Beeches Pit have clear parallels with the succession at Swanscombe (Preece *et al.* 2007). A correlation with MIS 11 is further supported by uranium series dates from the tufa (*c* 455 ka BP), thermoluminescence dates from burnt flints (414 ± 30 ka BP) and amino acid racemization data from *Bithynia* opercula (Penkman *et al.* 2011).

The climatic significance of these various faunas has been discussed by a series of writers. Oakley (1952), from information by Bate and Hinton, noted a similarity of the faunas of the Lower Gravel and Middle Gravel of Barnfield Pit. These were indicative of woodlands interspersed by grasslands, although an increase in the relative abundances of horse and bison in the Middle Gravels suggested an increase in the proportion of grassland. He assigned the Upper Middle Gravels with *Lemmus* and an overlying Upper Loam to the closing stages of the 'Great' (Hoxnian) Interglacial. Sutcliffe (1964), who re-examined the collections, also noted a similarity of the mammalian faunas of the Lower Gravel and Middle Gravels, and he independently found support for Oakley's claim for an increase in the abundance of remains of non-sylvan species in the Middle Gravel. He observed a general similarity between the mammalian faunas of Swanscombe and Steinheim an der Murr, Germany, a site commonly referred to the Holsteinian of the chronology of the European continent. Cook *et al.* (1982), from the evidence of the previously unstudied finds from the Lower Loam excavated by Waechter during 1969-72, linked this deposit (in which they observed and abundance of woodland species) with the Lower Gravel. They drew attention to the apparently considerable magnitude of depositional break between the deeply weathered footprint surface to the Lower Loam and the bottom of the Lower Middle Gravel and they interpreted the rodents of the Upper Middle Gravel as indicative of the development of cooler more continental conditions. Stuart (1982) found the mammalian faunas of the Lower Loam and Lower Gravel generally consistent with regional mixed forest, although with some taxa suggestive of, probably local, more open habitats. He drew attention to the occurrence of the pond terrapin (*Emys orbicularis*) at Ingress Vale, showing that at some stage during the Hoxnian the climate was warmer than today (Stuart 1979).

The faunas of all the sites described above have been widely quoted in the literature as being Hoxnian in age (Schreve 2001a), representing various parts of an interglacial cycle. Thus far, on the evidence of the few fossiliferous localities which have been studied, the story

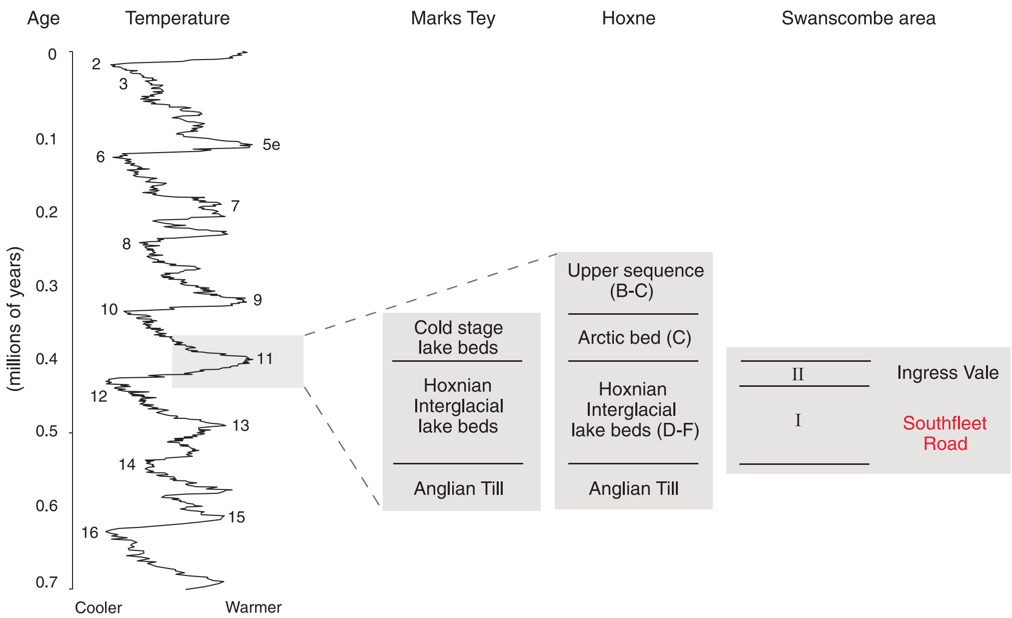


Figure 9.20 Suggested correlation between key Hoxnian sequences and the deep sea oxygen isotope record

of the mammals up to about pollen substages III and IV of the Hoxnian appears to be relatively straightforward. With the palynological evidence at Hoxne, however, truncated after pollen zone IIIa, the further continuation of the sequence has been far from clear. Schreve (2001a, b) has suggested that the main faunal horizons at Hoxne can be correlated with the Swanscombe Upper Middle Gravel. Other authors have suggested a more complex climatostratigraphy involving subdivision into different marine isotope stages (Bowen *et al.*, 1989) or correlation with substages within MIS 11 (Schreve 2001a; b). None of these models is entirely satisfactory. New interpretations of the geological and environmental succession at Hoxne, combined with a reassessment of the biostratigraphical evidence, have helped to clarify this issue. This revision suggests that all of the above mentioned deposits can be accommodated within the first prolonged temperate substage (= Hoxnian Integlacial) equivalent to MIS 11c in the marine record (Table 9.16). The climatic deterioration of the Upper Middle Gravels being unlikely to have occurred earlier than pollen zone IV, more probably representing the early substage of the succeeding cold stage.

Combining these findings in the most simple possible way, the Clacton – Swanscombe (up to the Middle Gravels), Southfleet Road – Beeches Pit (beds 3 to 6) – Barnham sequence is interpreted as a single interglacial episode with woodland fauna, followed by an increase in the amount of grassland and finally the arrival of lemming (*Myopus* or *Lemmus*) at the end of the interglacial or beginning of the following cold stage. On mammalian evidence alone, there is no indication of the major temporal hiatus widely believed to be present between the Lower Loam and Middle Gravels of Swanscombe (Cook *et al.* 1982; Schreve 2001b).

Mid-MIS 11 cold episode (?MIS 11b)

A return to fully arctic conditions is recorded at Hoxne in the lake sediments that unconformably overly the detritus mud of Stratum D (Ho IIIa). The palaeobotanical remains from this horizon were studied by Reid, who identified dwarf birch (*Betula nana*) and three species of dwarf willow (*Salix* spp.). Recent bulk sieving of the 'Arctic Bed' (Stratum C, Ashton *et al.* 2008) has recovered rare teeth of Arctic lemming *Dicrostonyx* sp., together with a beetle fauna indicating severely cold winter temperatures.

Late MIS 11 mammalian faunas from Hoxne (?MIS 11a)

The chronological relationship of the upper layers at Hoxne to the orthodox chronology has been widely discussed. Stuart *et al.* (1993) suggested that the archaeological industries and their associated faunas were of about the same age as the Swanscombe Upper Middle Gravel, possibly within the range of pollen zones IIIb-IV. This interpretation was modified by Schreve (2001a, b), who also correlated Hoxne with the Upper Middle Gravel, illogically assigning them to the same (Hoxnian) interglacial as the lower part of the Swanscombe sequence, but to a later (post-Hoxnian) temperate substage within MIS 11. The uncertainties surrounding the correlation and age of the Hoxne sequence have been clarified to some extent by recent fieldwork (Ashton *et al.* 2008). This has established that the Hoxnian lake muds and the temperate deposits containing the archaeological industries are demonstrably separated in time by a major cold stage as represented by the 'Arctic Bed'. The stratigraphy of Reid (Evans *et al.* 1896), West (1956) and Singer *et al.* (1993) can now be accommodated into a more comprehensive framework (Fig. 9.12; Table 9.16). Although correlation of the Hoxne deposits with the oxygen isotope record must remain a matter of conjecture for the time being, the separation of the Hoxne mammalian faunas from those of the Hoxnian interglacial (such as Swanscombe (phases I and II), Clacton, Barnham) by an intervening cold episode of arctic severity suggests that the mammalian fauna from Strata B2 and B1 at Hoxne belong to the latter part of MIS 11, possibly MIS 11a.

The sequence at Hoxne is contained within a basin in the Anglian till and comprises lacustrine muds overlain by a series of fluviatile and solifluction deposits (West 1956; Gladfelter and Singer 1975; Wymer 1974; 1983). The basal lake deposits (F-D) have been assigned to pollen zones I-IIIa of the Hoxnian, a hiatus in deposition truncating the palynological records of the interglacial sequence, leaving zone IV unproved. Concentrations of mammals and Acheulian artefacts occur at two levels in the succeeding part of the sequence; a lower assemblage in the basal part of Stratum C, and an upper assemblage and industry in bed 5. These archaeological horizons (Strata B2 and B1) have yielded abundant mammalian remains, both large and small; only a few mammalian remains have been found in the interglacial lake muds, so little is known about the mammalian fauna of the Hoxnian *sensu stricto* at the type locality. The vertebrate faunas from Strata B2 and B1 are very similar in composition (Stuart *et al.* 1993. The large-mammal fauna is dominated by herbivores: horse *Equus ferus*, red deer *Cervus elaphus*, fallow deer *Dama dama*), together with occasional remains of macaque *Macacca sylvanus*, bear *Ursus* sp., otter *Lutra lutra*, lion *Panthera leo*, rhinoceros *Stephanorhinus* sp., a small bison *Bison* sp. (Parfitt, unpublished observation) and roe deer *Capreolus capreolus*. The red deer can be distinguished from those at Swanscombe and Clacton by their combination of relatively large body size combined with small dental size (Lister, in Stuart *et al.* 1993). Two species of beaver (European beaver *Castor fiber* and the extinct beaver-like *Trogontherium cuvieri*) were also present. Sieving has recovered a rich small-mammal fauna that includes the mole *Talpa minor*, a soricid *Sorex* sp., pine vole *Microtus* (*Terricola*) cf. *subterraneus* and lemming (identified as *Lemmus lemmus* by Stuart *et al.* 1993). Stuart *et al.* (ibid.) conclude that the vertebrate fauna indicate interglacial conditions that supported forest dominated by deciduous trees.

Conclusion

The discovery of mammalian remains associated with the Clactonian archaeology has important archaeological implications. A detailed environmental and climatic picture can be reconstructed from the vertebrate evidence, which fits best into an interglacial landscape with at least regional deciduous woodland. The mammalian and pollen data suggest that the earliest Clactonian artefacts occur early in the interglacial cycle and extended into the early temperate substage. The upper age limit for this interglacial stage is constrained by the presence of the pine vole *Microtus* (*Terricola*) cf. *subterraneus*, which suggests that the sediments are earlier than those on the north bank of the Thames around Purfleet and Grays Thurrock (Lynch Hill/Corbets Tey Gravel) correlated with MIS 9 (Penkman *et al.* 2011). The presence of other biostratigraphically significant mammals (*Stephanorhimus hemitoechus*, *S. kirchbergensis* and *Bos primigenius*), together with morphometric data, indicate a close correspondence with the mammalian faunas from Swanscombe and Clacton.

The archaeological significance of this correlation is that it establishes a link between the Clactonian archaeology in the tributary valley at Southfleet Road and the main Thames sequence at Barnfield Pit, Swanscombe, where the Clactonian artefacts occur in the lower part (phase I, Lower Gravel and Lower Loam) of the Boyn Hill/Orsett Heath Gravel. In the present state of knowledge, the Clactonian occupation was probably more-or-less contemporaneous at both sites and most likely occurred during the Hoxnian interglacial (MIS 11c).