QUATERNARY MICROMAMMALS FROM GORHAM'S CAVE, GIBRALTAR, AND THEIR PALAEOENVIRONMENTAL SIGNIFICANCE.

Joanne H. Cooper / Department of Geology, Royal Holloway, University of London.

Resumen

Los vertebrados fósiles de Gibraltar han atraído el interés de los estudiosos desde al menos el siglo XVIII. Estudios pasados han identificados restos de grandes herbívoros como buey, caballo, cerdo, rinoceronte, ciervo y -muy común- cabra montesa, así como carnívoros como el lobo, oso, hiena, gato silvestre, lince, leopardo y posiblemente león. Sin embargo se le ha prestado poca atención a los microvertebrados, aquellos con peso adulto de menos de 5 kg. Estudios preliminares de la fauna de Gorham's Cave, en el lado Este de Gibraltar, usando datos de los trabajos de campo iniciados en 1994 en asociación con el Gibraltar Museum y Natural History Museum de Londres, han identificado huesos pertenecientes a, al menos, siete micromamíferos: Musaraña Crocidura *sp., Topo* Talpa *sp., ermina o comadreja* Mustela *sp., Lirón careto* Eliomys quercinus, *Ratón de campo* Apodemus *cf.* sylvaticus, *Rata de campo* Microtus breccensis *(posiblemente también* Microtus *sp.) y Conejo* Orytolagus cuniculus *así como restos de peces, ranas, reptiles y aves.*

La identificación de los mamíferos está basada en dientes y mandíbulas. Se recolectaron los huesos de siete niveles en una secuencia de 4 m. de arenas de gris claro a rojas, pardas oscuras y arcillas que son parte de la sucesión en la entrada de la cueva, por encima del nivel P definido por J. Waechter.

Se está trabajando en interpretar esta secuencia en términos de su historia sedimentativa y la palaeoecología vertebrada, para elucidar factores medio ambientales que influenciaran parte de la larga historia de ocupación Neandertal a hombre moderno anatómicamente de esta cueva importante, conservada hasta el momento gracias al acceso militar limitado a este lugar.

Abstract

*The Quaternary fossil vertebrates of Gibraltar, known largely from bone-breccias in caves and fissures of the Rock, have been of interest to scholars since at least the mid 18th century. Successive studies have identified the remains of large herbivores such as ox, horse, pig, rhinoceras, red deer, and (very commonly) ibex, together with carnivores such as wolf, bear, hyaena, wild cat, lynx, leopard and possibly lion. However, little attention has been paid to microvertebrates - those with adult body weight less than 5kg. Preliminary studies of faunas at Gorham's Cave on the east coast of Gibraltar, based on fieldwork initiated in July 1994 in association with the Gibraltar Museum and the Natural History Museum, London, have now identified teeth or bones belonging to at least seven micromammals : White-Toothed Shrew (*Crocidura *sp.), mole (*Talpa *sp.), stoat or weasel (?*Mustela *sp.), Garden Dormouse (*Eliomys quercinus*), Wood / Long-Tailed Field Mouse (*Apodemus *cf.* sylvaticus*), vole(s) (*Microtus breccensis*, possibly also* Microtus *sp.) and rabbit (*Oryctolagus cuniculus*), together with those of fish, frogs, reptiles and birds. Mammal identification is based on teeth and jaws, and made with the kind help of A.P. Currant. Skeletal material was collected from seven horizons within a 4m sequence of pale light grey to dark red brown sands and clays which form part of the succession at the cave entrance, lying above Bed P as defined by J.d'A. Waechter in* Bulletin of the Institute of Archaeology, *no. 4, 1964. Work is in hand to interpret this sequence in terms of sedimentary depositional history, vertebrate palaeoecology, and vertebrate taphonomy to elucidate environmental factors which influence part of the long (Late Pleistocene) history of Neanderthal to anatomically-modern human occupance of this important cave, conserved hitherto by militarily-limited access to the site.*

Introduction

Gibraltar, located at the southern tip of Spain at the western end of the Mediterranean, preserves a rich and varied record of the Quaternary period, aspects of which have attracted interest since at least the mid 18th century (Rose & Hardman, 1994). Quaternary fossil vertebrates have long been known from bone-breccias in caves and fissures of the Rock, and successive studies (*e.g.* Busk, 1877; Waechter, 1964) have identified the remains of large herbivores such as ox, horse, pig, rhinoceros, red deer and (very commonly) ibex, together with carnivores such as wolf, bear, hyaena, wild cat, lynx, leopard and possibly lion.

Gorham's Cave (figure 1) (grid reference 89340008) on the east coast is arguably the most important Quaternary site on the peninsula. It contains a thick sedimentary sequence dated as within the Late Pleistocene (Hoyos *et al.*, 1994; Díaz del Olmo, 1994) whose deposition arguably spanned the last glacial climatic cycle (about 125,000 to 10,000 years before present), from oxygen isotope stage 5. In addition, the site is rich in palaeobiological and archaeological material, associated with evidence of successive occupance by Neanderthal to anatomically-modern humans (J. Cook, in Rose & Rosenbaum, 1991, p.71). It lies within part of the Ministry of Defence estate, and has been effectively conserved by militarily-limited access.

The cave was discovered by Captain A. Gorham in 1907 (Finlayson, 1994), and has been investigated subsequently by a number of workers, notably G.B. Alexander (whose studies were unpublished), F.E. Zeuner (1953) and J. d'A. Waechter (1951, 1964). Aspects of its Quaternary history have been considered recently (notably by Hoyos *et al.*, 1994; Díaz del Olmo, 1994) and the site is being studied currently through a series of investigations directed jointly by Dr. C.B. Stringer (Head of the Human Origins Group, The Natural History Museum, London) and Dr. J.C. Finlayson (Director, The Gibraltar Museum).

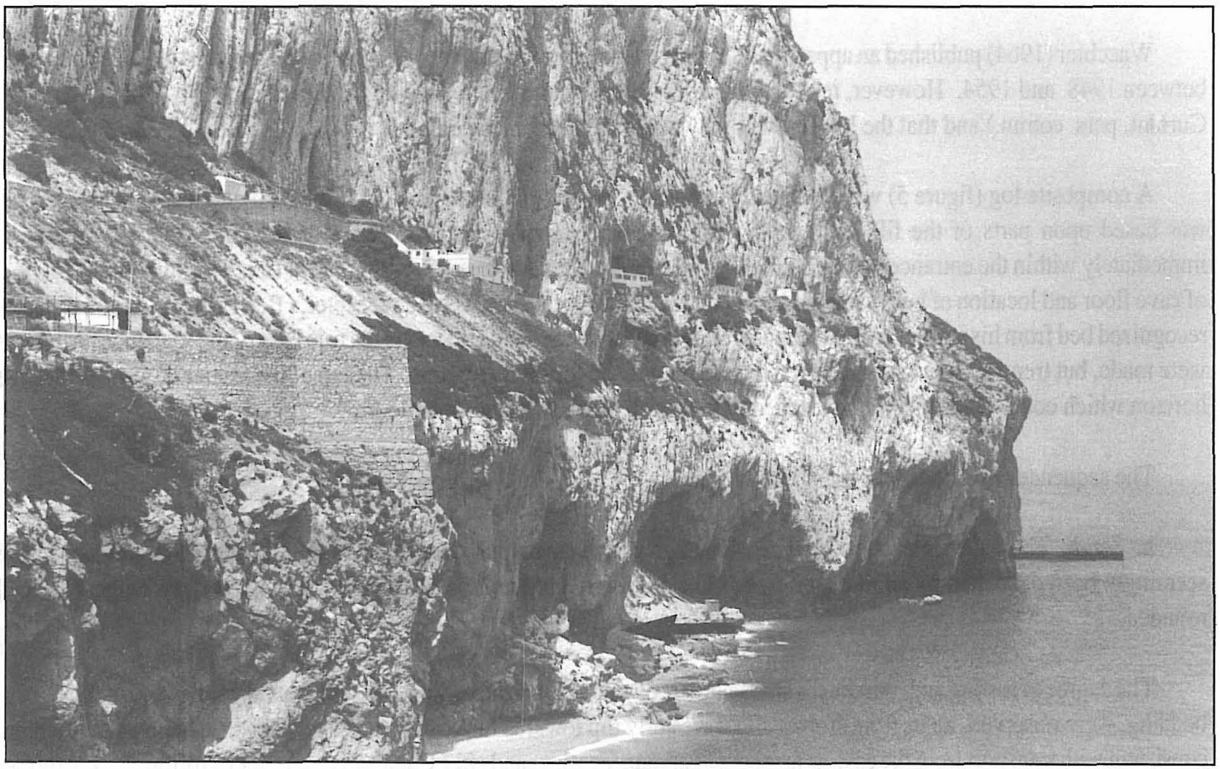

Fig. 1. View nortn along the east coast of Gibraltar. Gorhm's Cave is arrowed.

Early investigations were focused on the abundant archaeological remains, which include lithics, charcoal, hearths, butchered bones and other debris. More recent studies have concentrated on details of the sedimentary record, which includes raised beaches at the cave entrance as well as a thick and complex sequence of cave fill. These latter sediments include those derived from outside the cave as well as those originating from within it, and therefore reflect both external and internal palaeoenvironments.

The fossil material from this sequence includes terrestrial and marine molluscs, charcoal, coprolites and bones. The diversity of the bone assemblage is remarkable as it includes not only mammals, but also the remains of birds, reptiles, amphibians and even fish - groups generally rare as fossils, especially in terrestrial Quaternary environments. It is only the large mammal fauna that has been considered in significant detail (Zeuner & Sutcliffe, in Waechter, 1964). This is a preliminary report in which small mammals are considered from both ecological and taphonomic viewpoints, the first such investigation on Gibraltar. Birds form the basis of a continuing study.

Stratigraphy

Gorham's and its adjacent caves are considered to represent part of a phreatic cave system in the Gibraltar Limestone, exposed by coastal erosion and cliff collapse (Cook, in Rose & Rosenbaum, 1991, p.71). The cave is aligned approximately NNE - SSW, close to the trend of major fault and joint patterns in the rock. Enlargement of the entrance is almost certainly due to marine erosion.

Waechter (1964) published an apparently definitive account of the cave's stratigraphic sequence, based on excavations between 1948 and 1954. However, re-examination indicates that he omitted the highest levels from his description (A.P. Currant, pers. comm.) and that the lower levels may also have been misrecorded.

A composite log (figure 5) was therefore constructed for part of the sequence near the cave entrance (figure 2). This was based upon parts of the fill left standing from previous excavations as stacks, situated laterally north and south immediately within the entrance, and as central sections further into the cave. (See figure 3 for cave profile, figure 4 for plan of cave floor and location of beds sampled.) The logged sequence takes as its base Waechter's Bed P, the lowest confidently recognized bed from his stratigraphic scheme. Below this it was impossible to locate the true base of the sequence. Attempts were made, but trenches had low stability and were abandoned for safety reasons. The top of the sequence was taken at the horizon which could conveniently be reached in the North Stack from the cave floor.

The sequence comprises four main lithologies:

a. *Sands.* These dominate the sequence. Although varying in colour, they are of a similar nature throughout and have seemingly been deposited by similar processes. The grains are predominantly of quartz, of uniform size range, and well rounded.

The degree of sorting and rounding is characteristic of wind-blown deposition. No sedimentary structures, such as cross-bedding, were observed, apart from from a slight westerly dip towards the rear of the cave. This is a depositional feature consistent with transport from the east, as in other Quaternary aeolian sands (the Catalan Sands) which crop out 1.5 km further along the coast to the north (Rose & Hardman, 1994). However, it is also possible that this direction of dip is merely a slope into the rear of the cave from a cone of deposits developed at the cave entrance - a common feature of cave sequences. Whatever the cause, this landward slope may have had a significant role in the cave environment, sheltering the interior from conditions outside.

b. *Speleothem.* Speleothems, together with cave earths and breccias, form the set of deposits related to the internal processes of the cave. Speleothems are particularly well developed in the North Stack, showing distinct floors with stalagmites at two levels above the sampled sequence.

These speleothems appear to have largely developed as a diagenetic feature, formed by the percolation of carbonate-rich water through the accumulated sands, causing their cementation. It is not yet clear how far the sequence reflects diagenetic rather than depositional events. In the North Stack, for example, the alternation of cemented and unconsolidated horizons within part of the sequence (most pronounced in the horizon here designated the Red Bone Beds) may represent a section through the side of a stalagmitic formation. If the North Stack represents merely a concentrated column of speleothem development, its stratigraphy may be highly localized. Similar cases of false stratigraphy may well occur throughout the sequence.

c. *Cave earths.* These are the second most abundant type of cave deposit. Typically fine-grained and strongly red/brown in colour, they may include external materials, but also develop by the *in situ* breakdown of internal components (Lowe &

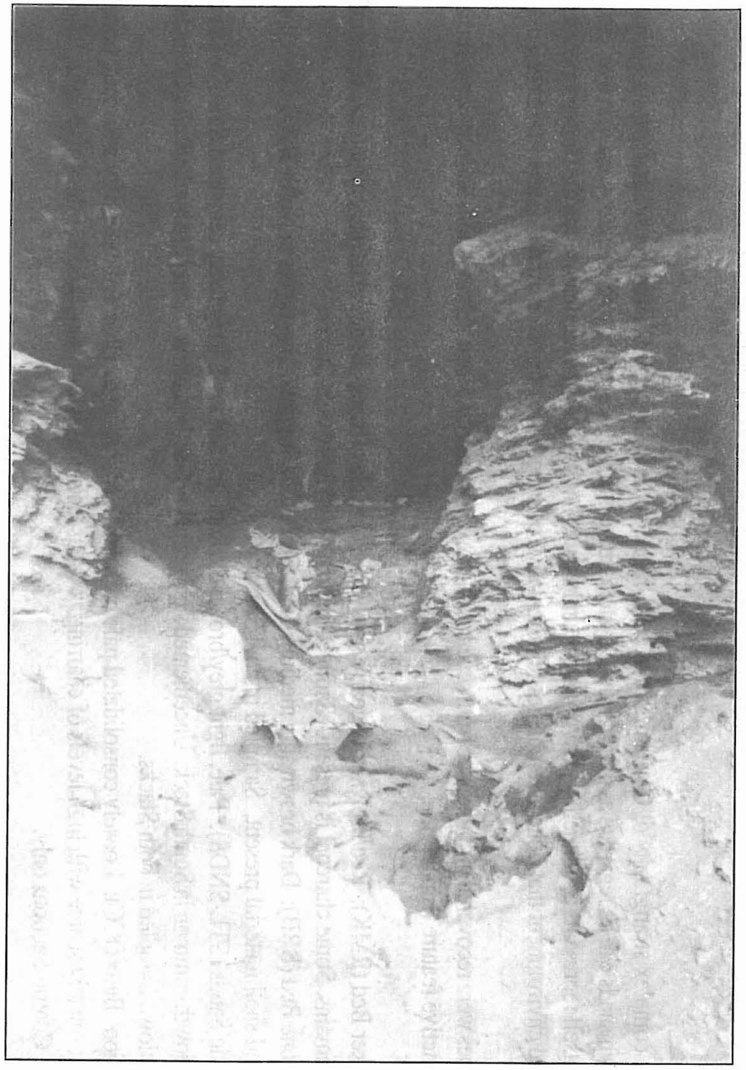

Fig. 2. Gorham's Cave, viewed from entrance.

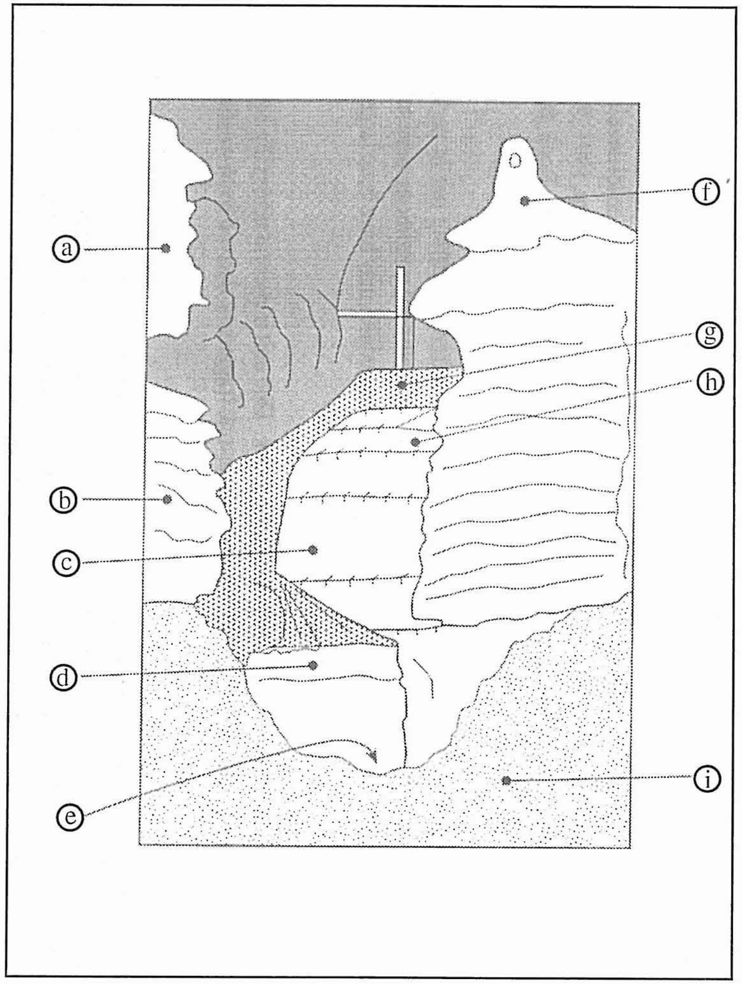

Fig. 3. Diagram of Gorham's Cave, based on **Figure 2**, indicating positions of North and South Stacks and Central Sections: **a.** South Stack 'smeared' on cave wall; **b.** South Stack; **c.** Central Sections; **d.** base of logged sequence (Bed P), **e.** test trench for actual sequence base, **f.** North Stack stalagmite, 1st floor, Red Bone Beds; **g.** main cave floor; **h.** Red Marker Bed, this level; **i.** spoil heaps.

Walker, 1984). In Gorham's, cave earths are represented by horizons here designated the Red Bone Beds and the Red Marker Bed. The Brown Bone Bed may also be a cave earth, but is apparently less developed.

Formation of these oxidised, soil-like horizons indicates pauses in sand deposition. A palaeosol developed in the lower slopes of the Catalan Sands has been considered to represent a similar hiatus (Rose & Rosenbaum, 1991; Rose & Hardman, 1994). Such pauses might be a reflection of changes either in climate or in sea level relative to the Rock, the latter affecting the exposure of the source areas from which the sands were derived.

Clay lenses in several of the cave earths are apparently the result of sediment settling out in puddles gathered in depressions on the landward slope. Such puddles could be almost permanent features if conditions were sufficiently damp. The large size of some of the frog remains recovered suggests that some of the puddles may have been large enough to merit description as ponds.

d. *Cave breccias.* These occur mainly as lenses in the North Stack. One unit is present across the cave in both stacks (see figure 5, at 4.75m). These deposits are composed of angular limestone fragments, derived from weathering of the cave roof and walls.

No breccias are forming in Gibraltar at present, so they are considered to represent climatic conditions significantly different to those of today. Generally, colder conditions with higher levels of frost shattering are inferred for such deposits (Lowe & Walker, 1984). The Gorham's breccias appear to have developed alongside cave earths and may be the result of seasonally affected deposition, forming during winters only. The most extensive breccia horizon might be related to the height of the last glaciation, at approximately 26,000 - 15,000 years before present. However, this has yet to be confirmed by dating.

The complex stratigraphy of Gorham's cave is the result of the interaction of two depositional settings. Firstly, the windblown sands can be regarded as part of a dune system, related to the external environment beyond the cave. Secondly, the cave itself represents a sedimentary environment, and as such has imposed its own features on the stratigraphy. It is from this mixed environment that bone assemblages representative of a sequence of micromammal faunas have been extracted.

Bones were recovered in abundance from seven beds, to which names and their abbreviations were assigned on the basis of a distinctive feature (figure 5):-

Red Marker Bed (RMK): Red/brown silty coarse sand with some clay lenses. Bones extremely abundant, also molluscan remains. Some charcoal is present. Sampled in both North and South Stacks.

Brown Bone Bed (BBB): Dark brown silty medium sand. Some thin, irregular clay layers in North Stack. Abundant bone and shell material present. Sampled in both Stacks.

Stalagmitic Sands (STL-SNDS): Pale, light grey/brown medium-grained sand, irregularly cemented.Spicular calcite growth common in South Stack. Uncemented sand occurs in friable pockets. Bones are markedly less abundant than below. Sampled in both Stacks.

'Occupation' Bed (OCC): Loosely consolidated pale buff/brown coarse sand. Charcoal extremely abundant; bones reasonably scarce with high levels of charring. Molluscan remains are abundant and lithics also occur. Sampled in Central Sections only.

Red Bone Beds 1 - 3 (RBB 1 - 3): Dark red/brown medium-grained clay-rich sand. Bones present in great abundance; charcoal, molluscs and lithics also occur. These beds (of which Red Bone Bed - 1 is the uppermost bed), although sampled and considered individually, actually appear to represent a thick, single unit, divided by speleothem layers which give rise to a false stratigraphy.

Microvertebrate Fauna

Approximately seven litres of sediment were removed from each of the seven horizons described above, sieved on site using a 500 µm mesh sieve, and the residue transported to the U.K. for sorting by hand to recover the bone material from the remaining sedimentary matrix. Individual teeth and mandibles (*cf.* figures 6, 7) were identified in the Department of Palaeontology of the Natural History Museum, London, with much kind assistance from Mr. A.P. Currant. Specimens, currently subject to further study at the Natural History Museum, will ultimately be returned to the Gibraltar Museum for retention.

Remains of at least seven species of micromammals (defined as those with adult body weight of less than 5kg) were identified, with stratigraphic distribution as summarized in Table 1. Common names and details of distribution and habitat can be assessed from Corbet & Harris (1991) and Macdonald & Barrett (1993):

a. *Apodemus* cf. *sylvaticus*. Wood (alternatively Long-Tailed Field) Mouse. Teeth and jaws of this species make up most of the identified material. At present, its distribtion is widespread throughout Europe, extending into southern Scandinavia and northern Africa. Its Late Pleistocene range is known to extend to Gibraltar (Kurten, 1968). An adaptable species, it inhabits a range of habitats, including woodland, bramble and bracken scrub and sand dunes. It is also tolerant of damper conditions. From its local abundance and known habitat preferences, it seems likely that this species actually inhabited the cave during the sampled time range.

b. *Oryctolagus cuniculus*. Rabbit. This well-known species dominated the fauna recorded by Waechter (1964) from Gorham's Cave. Present day range is widespread in western Europe. It favours open habitats such as grassland, heathland and meadows, and is a common inhabitant of vegetated dunes. The presence of neonatal teeth in the Stalagmitic Sands suggests that rabbits might have been living and breeding within the cave, although no signs of burrows were observed. It is equally plausible that the teeth came from the remains of a heavily pregnant animal brought in as prey.

c. *Eliomys quercinus*. Garden (alternatively Oak) Dormouse. This species at present ranges through western Europe, excluding the U.K. Its habits are less arboreal than other dormouse species, and it is frequently found inhabiting scrub environments. Its presence in the Gorham's assemblages suggests a local scrub/shrub flora.

d. *Microtus breccensis*. Vole. This is an extinct Pleistocene vole species, typical of the Mediterranean region (A.P.Currant, pers. comm.). A specimen of this species was positively identified, but it is possible that other specimens may represent different species, so are left in open nomenclature here as *Microtus* sp. Overall, there is a low vole presence in the assemblages, which is suggestive of damp conditions (A.P.Currant, pers.comm), but is also of taphonomic significance.

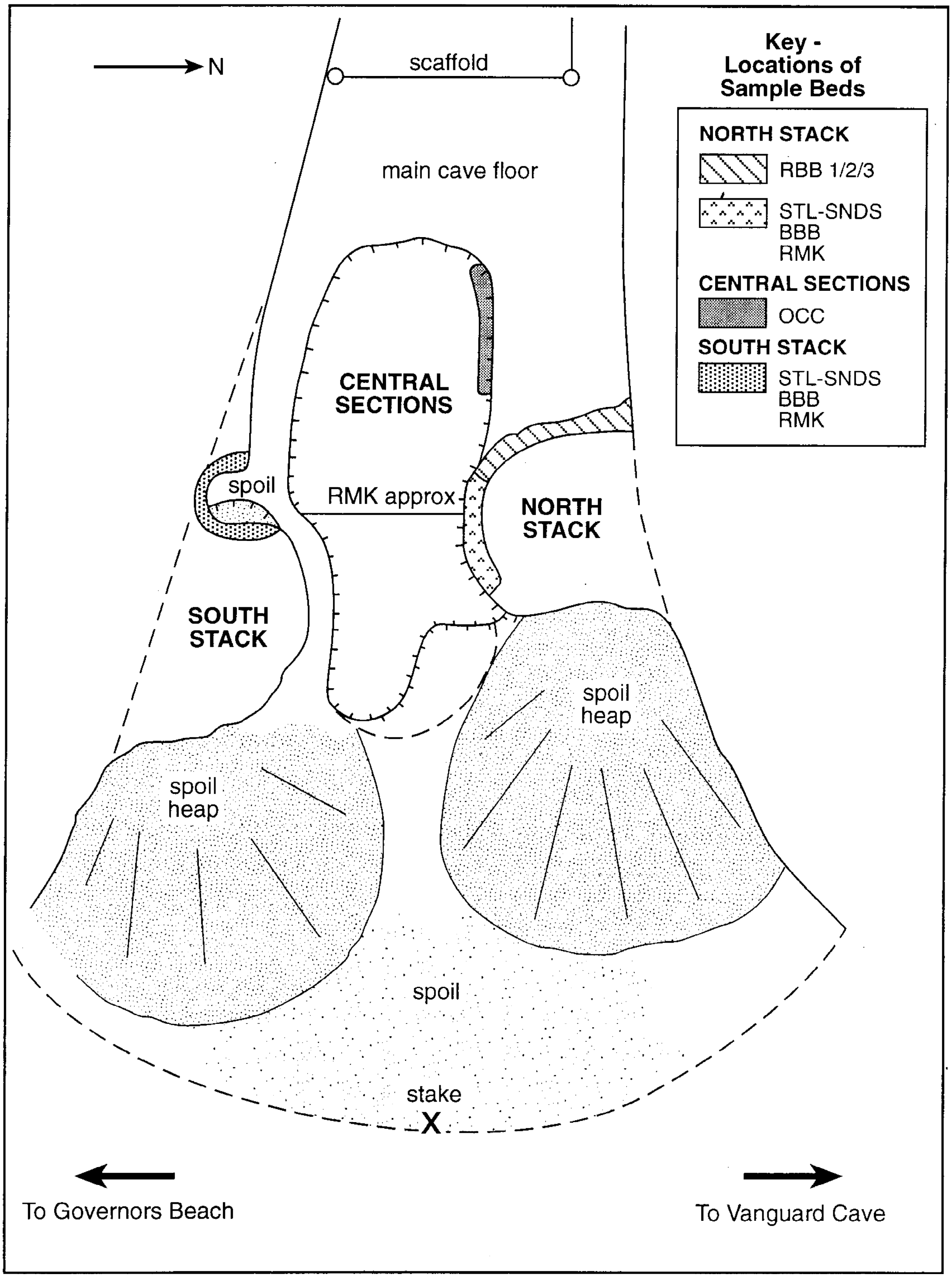

Fig. 4. Sketch plan of Gorham's Cave, with locations of sampled beds. Not to scales.

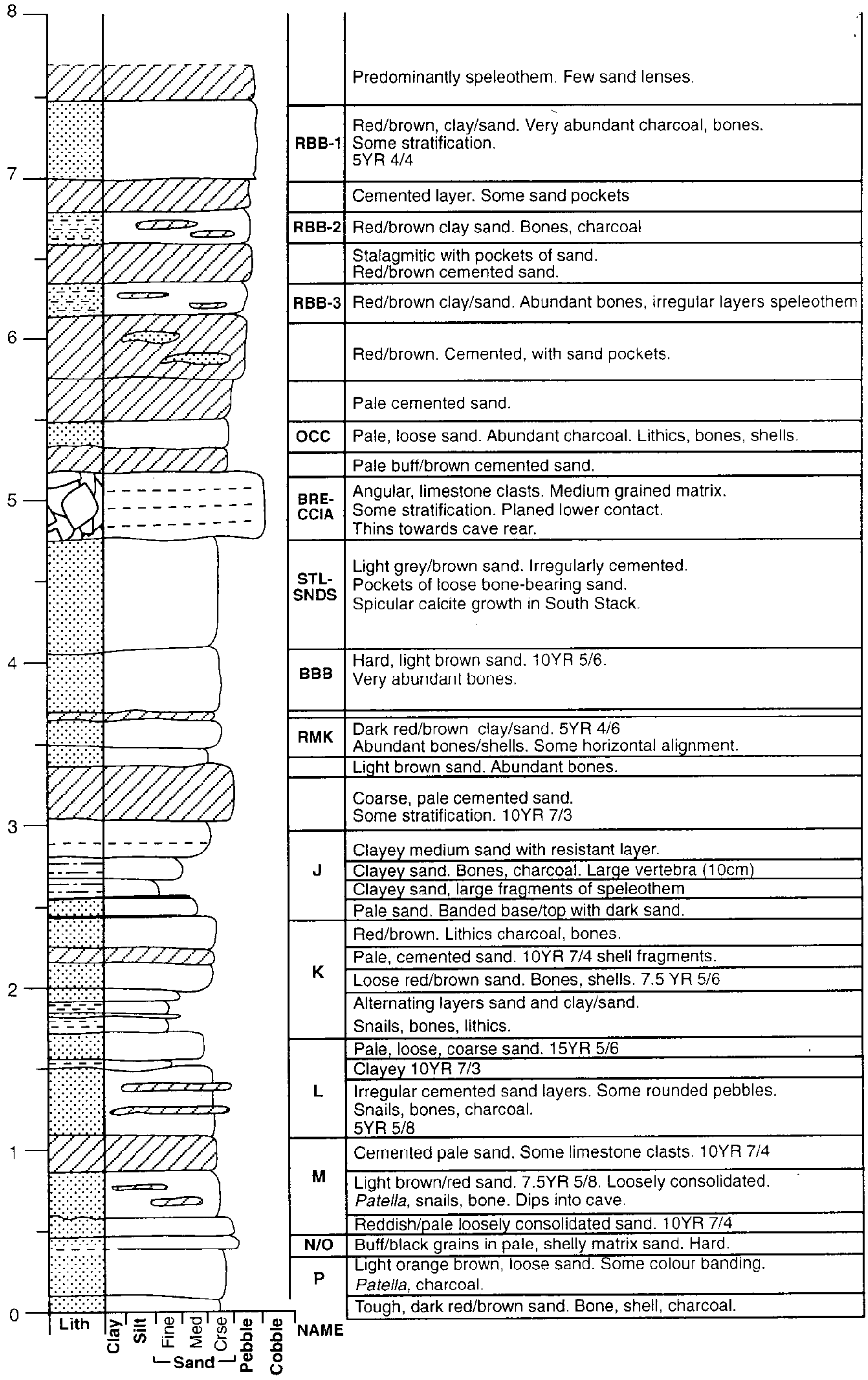

Fig. 5. Graphic sedimentary log of part of Gorham's Cave sequence. Base is Bed P as indicated in **Figure 3**. Abbreviations: RMK - Red Marker Bed; BBB - Brown Bone Bed; STL-SNDS - Stalagmitic Sands; OCC - 'Ocupation' Bed; RBB - 1/2/3 - Red Bone Beds.

e. *Talpa* sp. Mole. The present range of this genus extends over most of Europe. It is not yet known precisely which species is represented. A specialized burrower, its presence in the Red Marker Bed reinforces the evidence for soil development. However, it also occurs in the Stalagmitic Sands, which were not recognized as a potential palaeosol. Its scarcity in the assemblages means that until a more extensive study is made on the stratigraphic distribution of both moles and palaeosols in the cave, the reasons for its presence, as inabitant or prey, remain uncertain.

f. *Crocidura* sp. White-toothed Shrew. At present, members of this genus occur in southern and central Europe. They generally inhabit shrubby habitats, favouring those with undergrowth. Also, they prefer dry conditions. The presence of this genus in the Gorham's assemblages suggests local shrub floras. It seems likely that shrews were inhabiting sand dunes adjacent to the cave, and may have been introduced within it by predators.

g. ?*Mustela* sp. Stoat or Weasel. Both stoat and weasel are known from the Pleistocene of the Mediterranean region (Kurten, 1968). At present, both species range widely in Europe, although the stoat is absent from the Mediterranean countries. A wide variety of habitats is exploited by these species, including grassland, woodland, mountains, shorelines, and sand-dunes - as long as cover and prey are available. Both stoat and weasel take a wide range of prey, including rodents, insectivores, rabbits, and birds and their eggs. Most of the micromammals recorded at Gorham's Cave would have been a potential food source.

Taphonomy

Skeletal elements were sorted into the categories defined by Andrews (1990) for taphonomic assessment. It was originally intended to examine breakage patterns of the bones statistically, but the samples proved numerically too small for this. Categories are summarized in Table 2 and a representative count to show element proportions (from the Red Marker Bed) is given in Table 3. Count totals of bones from the various beds are: RMK - 567; BBB - 320; STL-SNDS - 197; OCC - 162; RBB-3 - 228; RBB-2 - 140; RBB-1 - 263. (Cooper, 1995, unpublished). Levels of charring and charcoal were recorded on a five-point scale, from 1 (occasional) to 5 (abundant).

Overall, the bone assemblages proved to be very similar at each horizon. A high degree of fragmentation is seen throughout, and the proportions of skeletal elements are generally consistent. The same taxa occur at most horizons. Variation does occur in the relative abundance of bone material and the amount of associated charcoal and charring, but overall there appear to be no significant changes in the conditions of accumulation.

Small mammal bone accumulations are largely attributed to predator activity, either avian or mammal. Both are potential factors affecting the bone assemblages at Gorham's, additional to normal inhabitation.

a. *Bird predation.*

Birds, in particular owls and other birds of prey, are known to concentrate bones in their pellets (Andrews, 1990). Such concetrations often show a distinct bias in favour of a preferred prey species, for example a high abundance of vole remains is typical of raptor assemblages (Andrews, 1990; Yalden & Morris, 1990). Another feature of pellet assemblages is the relative abundance of mandibles (Andrews, 1990).

At Gorham's, however, although one species, *Apodemus* cf. *sylvaticus*, does have a high occurrence, the samples show a wide range of species, with a notably low occurrence of voles. This low vole abundance would be an unusual feature in an owl pellet accumulation. In addition, the high counts of isolated teeth appear to indicate preferential destruction of mandibles, which is another indication that this is not a typical pellet assemblage.

Yet birds were almost certainly inhabiting the cave: a large fragment of eggshell found in the Stalagmitic Sands is unlikely to have been transported far from its source. Several species nest at present in Gorham's and the adjacent caves. The remains of raptors have been found in abundance in some of the cave's beds, for example Red Kites (Milvus milvus) from Waechter's level K (Eastham, 1967). Bird bones were recovered during this study and may include the remains of various birds of prey. It is probable that birds of prey did contribute to the bone accumulations, but the extent of this contribution, and the identity of the species concerned is as yet unknown. The high levels of bone fragmentation might be suggestive of diurnal raptors rather than owls, as these tend to tear up prey, whereas owls swallow prey whole, resulting in more complete bones in pellets (Andrews, 1990).

Identification of predator species on the basis of characteristic features of the bone assemblages of their prey, as described by Andrews (1990), is made difficult by the apparent extent of post-depositional modification; the relatively unstudied state of present-day diurnal raptor pellet accumulations; and the possiblity that extinct species were involved. Identification of the associated fossil bird remains is in progress, and should prove revealing, indicating species potentially responsible for accumulating small mammals as prey.

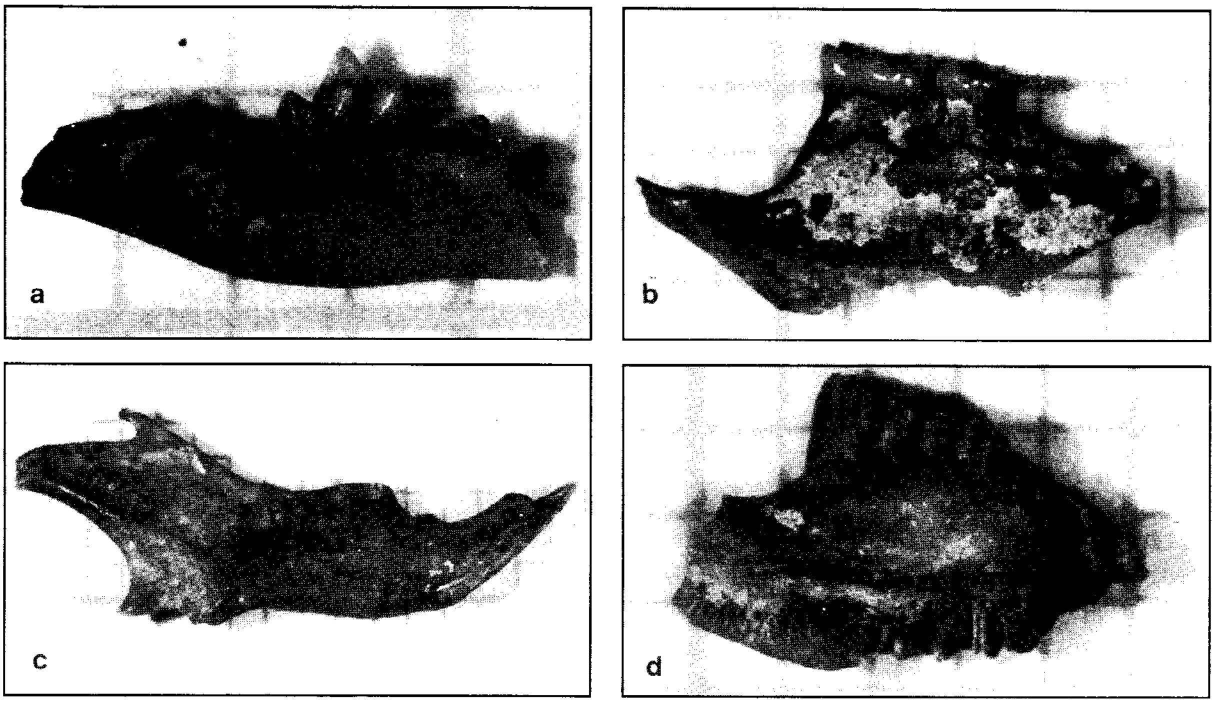

Fig. 6. Micromammal mandibles form Gorham's Cave. Scale in millimeters.
a. *Crocidura* **b**. *Eliomys* **c**. *Apodemus* **d**. *Microtus*

Thus although birds of prey have probably made some contribution to the concentration of micromammal remains, they are neither the only, nor the primary mechanism which may account for the abundance of small mammals within the confines of the cave.

b. *Mammal predation.*

Evidence of mammalian predators is also present. Waechter (1964) lists a number of large predators occurring in the cave, including wolf, bear, lion, hyaena and leopard. Smaller species such as lynx and wild cat also occur (Waechter, 1964), together with the addition here of a mustelid species, probably *Mustela* sp. It is these smaller species that would have had the greatest impact on local micromammal populations, and it seems that the prey remains of small carnivores account for what may be a considerable proportion of the bone accumulation.

Again, high levels of breakage are typical of carnivore generated assemblages, due to the tearing and chewing of carcasses. The eating habits of mammalian predators may also account for the high counts of vertebrae and phalanges as it is the less edible extremities of prey, *i.e.* feet, tails, and also spines that are discarded (A. P. Currant pers. comm.). However, it should be noted that vertebrae and phalanges are the most abundant elements of skeletons and high counts might be expected. Even so, in this case, the counts nevertheless appear to be considerably higher than expected in normal pellet accumulations, again suggesting the involvment of agents other than birds of prey (*cf.* Andrews, 1990).

In addition to the discarded remains of prey, carnivore droppings (scats) would also have been included in the mammalian contribution (Mellett, 1974). These too would show high levels of breakage, and also some traces of digestion. Occasional larger limb bones in some beds showed rounding of the broken ends, a digestive feature typical of mammalian scats (Andrews, 1990).

The wide range of species present is suggestive of opportunistic predators, such as the mustelid, rather than specialists, which would produce a more biased assemblage. This type of predation results in a better sampling of the local community, although the proportions of species may well be altered (Andrews, 1990).

The presence of *Eliomys quercinus*, the Garden Dormouse, is interesting with regard to mammalian predation. It is a species uncommon in pellet assemblages, as it is rarely taken as prey by avian predators. It would, however, be more likely to appear in an assemblage generated by mammalian carnivores.

c. *Cave inhabitation.*

Not all the constituents of the assemblages were necessarily introduced by predators; some animals seemingly died in the cave of their own accord. Good preservation of some particularly fragile specimens indicates lack of transport or post-depositional breakage, suggesting that the animals died in the cave relatively unharmed and were probably buried *in situ*. The best example of this was an entire rodent skull observed in the field.

Animals that died in the cave need not necessarily have inhabited it during normal life, however. Many organisms seek shelter in caves during illness or adverse weather conditions. Whilst in the field, modern examples of simple attritional accumulation were found in the cave: several bird carcasses were present, of different species, including Peregrine Falcon

(*Falco peregrinus*) and Swift (*Apus* sp.). In addition, ill animals, including Herring Gull (*Larus argentatus*) and Rat (*Rattus* sp.) appeared to be seeking refuge in the cave . Excepting the rat and possibly the swift, these species were not living in the cave. Even at present then, a potentially diverse attritional assemblage is accumulating. The fossil faunas identified at Gorham's Cave are therefore at least representative of the environments in the cave's vicinity, if not necessarily precisely the cave itself.

Although there is a high occurence of vertebrae/phalanges which might be an indication of predation, this might alteratively be explained as a post-depositional modification by trampling of bones from animals that had died in the cave. This would also be a possible explanation for the extreme levels of breakage seen.

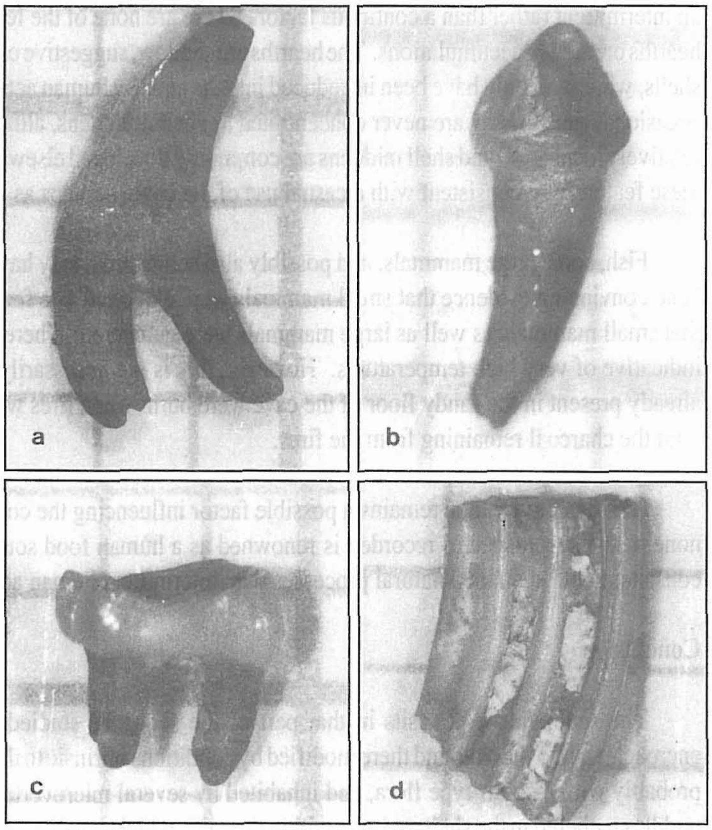

Fig. 7. Micromammal teeth form Gorham's Cave. Scale in millimetres.
a. *Talpa*; canine **b**. ?*Mustela*; premolar **c**. *Eliomys*; molar **d**. *Microtus*. molar.

Andrews (1990) describes experiments on the effects of trampling by large animals, which resulted in bone assemblages in which the smaller bones such as vertebrae, foot bones and ribs survived, but larger elements such as pelvises, scapulae and jaws were severely damaged. The faunal list for Gorham's Cave (Waechter, 1964), includes a number of large animals which could easily have contributed to trampling, for example, hyaenas. Hyaenas are of particular interest as their bones and coprolites are well known from the cave, and it has been suggested that the site was used as a den by these, and also perhaps other carnivores (Waechter, 1964). If so, modification by trampling is highly likely. It is also interesting to note that the most fragmented samples were recovered in the more central locations in the cave, compared with the generally better preserved samples which were from laterally situated sites, in particular the South Stack. This pattern of distribution might be expected if the cave was being used by larger animals, as the central areas would be exposed to greater disturbance than the relatively sheltered lateral beds.

Human Occupation

Additionally, evidence for human presence in the cave is abundant and varied. It includes charcoal, charred bones, lithics, and finds otherwise anomalous in their sedimentary context - such as large shells of the marine limpet *Patella* in non-marine sediments. Layers of charcoal in the «Occupation Bed» are almost certainly hearths.

It thus seems certain that bone accumulation in the cave will have been affected by man, although direct evidence for this (*i.e.* butchering) as yet comes from large rather than small mammals. However, human influence is likely to have been an intermittent rather than a continous factor. There are none of the features typical of long term occupation, such as deep hearths or midden accumulations. The hearths are shallow, suggestive of a single event rather than continued use. The *Patella* shells, which can only have been introduced into the cave by human action rather than that of birds or other animals, are only occasional finds. They are never concentrated as shell midddens, although *Patella* was quite likely an abundant source of relatively local food, and shell middens are commonly developed elsewhere in Europe in favourable circumstances. Overall, these features are consistent with a casual use of the cave, perhaps as an occasional shelter.

Fish, some large mammals, and possibly also some birds, may have been taken into the cave for food. However, there is no convincing evidence that small mammals were exploited as a food resource. There is no indication from their bones that small mammals as well as large mammals were butchered. There is evidence of charring, some to an extreme degree indicative of very high temperatures. However, this is not necessarily a result of cooking. It is quite possible that bones already present in the sandy floor of the cave were burnt when fires were built, and that they were subsequently dispersed with the charcoal remaining from the fires.

Human activity thus remains a possible factor influencing the concentration of small mammal bones in the cave, but none of the seven species recorded is renowned as a human food source, and the patttern of bone accumulation is more consistent with sustained natural processes than intermittent human activity.

Conclusion

The sedimentary deposits in that part of the sequence studied in detail appear to represent a dune environment encroaching into the cave and there modified by conditions intrinsic to the cave itself. The dunes were by inference vegetated, probably with a shrub-type flora, and inhabited by several microvertebrate species. On the landward slope of the dunes, puddles gathered in the sheltered area within the cave, which may have served to attract animals to the site (*cf.* Behrensmeyer, 1991) . Sedimentation rate was not constant, but punctuated by depositional hiatuses, inferred from the development of oxidized cave earths. There were fluctuations in humidity, indicated by periodic development of speleothem. There were also fluctuations in temperature: development of a horizon of cave breccia within the predominantly sand and cave earth sequence is interpreted as evidence of a climate significantly colder or more extreme than otherwise represented.

However, in terms of species distribution the preserved cave fauna of micromammals shows no significant variation with stratigraphic and palaeoenvironmental change. Abundance of the dominant species is essentially constant through the 4 metre interval studied. The mole *Talpa* was recorded only at the base of the sampled sequence, but only on the basis of a few rare skeletal elements. It seems to have been a rare component of the cave fauna, and its absence higher in the section may be an indication of collection failure rather than its absence from the cave as such at these later times. If so, further work using larger samples should detect it. The rare occurrence of *Mustela* only at the top of the measured sequence is probably also a reflection of collection failure. As a predator, it would in any case be expected to occur far less frequently than individuals of its potential prey.

At the present day, the cave is isolated from the rest of the eastern shore of Gibraltar by high cliffs which are nearly vertical to a height of 80 metres or more. It is fronted by a narrow beach, made accessible by a long flight of steps constructed by the military garrison. The cave biota (birds excluded) is therefore effectively cut off from the rest of the Rock. However, this would not have been the case during periods of low sea level during the Quaternary, during glacial stages. Cook (in Rose

& Rosenbaum, 1991, p.71) has inferred that at the time the Gorham's Cave sediments were accumulating, the cave backed an extensive dune-covered sandy plain. This would have provided ready access to land animals from the surrounding areas, an access arguably punctuated by fluctuations in relative sea level caused by glacio-eustacy or local tectonism.

The micromammal bones accumulated in the cave as the result of several normal processes: background attritional assemblages with components from a range of sources representing animals that lived, or at least died, naturally in the cave; also carcasses brought into the cave by predators, possibly both avian and mammalian. Some small animals may have been brought into the cave by humans, but this seems unlikely. The diversity of species present appears to represent a fair cross section of the community that might be expected in such an environment in Late Pleistocene time, and therefore to confirm that samples have not been biased significantly by predators or by human activity.

Gorham's Cave has thus yielded a micromammal fauna consistent with developing interpretations of palaeoenvironmental conditions in the area as it was colonized by anatomically modern hunter-gatherers replacing the earlier Neanderthals, whose presence is attested by artifacts of Mousterian culture lower in the cave - a culture associated with Neanderthal skeletal remains elsewhere on the Rock (Garrod *et al.*, 1928).

Acknowledgements

I thank Dr. J.C. Finlayson (Director, Gibraltar Museum) and Colonel A.J. Reed Screen (Commander Land Forces, Gibraltar) for facilitating fieldwork at Gorham's Cave, and H. Van Gils (Caleta Palace Hotel) for logistical support. Also, I thank Drs. C.B. Stringer and P. Andrews of the Natural History Museum, London for much helpful guidance, and especially Mr. A.P. Currant for his invaluable help in the identification of skeletal remains and useful discussion of ideas. The project was supervised from Royal Holloway by Professor J. Rose and Dr. E.P.F. Rose and field work carried out in association with Miss E.C. Hardman. Diagrams were redrawn for publication by Lynne Blything, and figure 2 was rephotographed by Keith Denyer from a colour print, in the Department of Geology at Royal Holloway. Mr. O. Roucoux kindly printed the photographs for figures 6 and 7, and Dr. E.P.F. Rose provided helpful revision of a draft of the manuscript.

This paper is dedicated to the memory of John Shannon.

References

Andrews, P. 1990. *Owls, Caves and Fossils*. British Museum, Natural History, London. 231pp.

Busk, G. 1877. On the ancient or Quaternary fauna of Gibraltar, as exemplified in the mammalian remains of the ossiferous breccia.*Transactions of the Zoological Society of London*, **10**, 53-156, pls 1-27.

Behrensmeyer, A.K. 1991. Chapter 6. Terrestrial vertebrate accumulations. In: Allison, P.A. & Briggs, D.E.G. (eds) *Taphonomy: Releasing the Data Locked in the Fossil Record*. Plenum Press, New York. 291-330.

Cooper, J.H. 1995. *Aspects of taphonomy and palaeoecology of Gorham's Cave, Gibraltar, based on its microvertebrate fauna*. Unpublished BSc independent project, Royal Holloway, University of London. 56pp.

Corbet, G.B. & Harris, S. (eds) 1991. *The Handbook of British Mammals*. 3rd Edition. Blackwell, Oxford. xiv + 588pp.

Díaz del Olmo, F. 1994. Interferencias sedimentarias y cambios climáticos en Gorham's Cave (Gibraltar). In: Rodríguez Vidal *et al.*, 49-55.

Eastham, A. 1967. The Avifauna of Gorham´s Cave, Gibraltar. *Bulletin of the Institute of Archaeology*, 7, 37-42.

Finlayson, J. C. 1994. History of the Gibraltar excavations. In: Rodríguez Vidal *et al.*, 2 - 5.

Garrod, D.A.E., Buxton, L.H.D., Smith, G. Elliot & Bate, D.M.A. 1928. Excavation of a Mousterian rock-shelter at Devil´s Tower, Gibraltar. *Journal of the Royal Anthropological Institute, London,* 58, 33-133.

Hoyos, M., Lario, J., Goy, J.L., Zazo, C., Dabrio, J.C., Hillaire-Marcel, C., Silva, P., Samoza, L. & Bardaji, T. 1994. Sedimentacion karstica: Procesos morfosedimentarios en la zona del Estrecho de Gibraltar. In: Rodríguez Vidal *et al.*, 36-48.

Kurten, B. 1968. *Pleistocene Mammals of Europe*. Weidenfeld & Nicolson, London. 317pp.

Lowe, J.J. & Walker, M.J.C. 1984. *Reconstructing Quaternary Environments*. Longman Scientific & Technical. 389pp.

Macdonald, D.W. & Barrett, P. 1993. *Mammals of Britain and Europe*. Harper Collins, London. 312pp.

Mellett, J.S. 1974. Scatological origin of microvertebrate fossil accumulations. *Science*, **185**, 349-350.

Rodríguez Vidal, J., Díaz del Olmo, F., Finlayson, C. & Giles Pacheco, F. (eds) 1994. Gibraltar during the Quaternary. AEQUA *Monografías*, Seville, **2**, 1-150.

Rose, E.P.F. & Rosenbaum, M.S. 1991. *A Field Guide to the Geology of Gibraltar*. The Gibraltar Museum, Gibraltar. 192pp.

Rose, E.P.F. & Hardman, E.C. 1994. Quaternary geology of Gibraltar. In: Rodríguez Vidal *et al.*, 21-25.

Waechter, J. d'A. 1951. Excavations at Gorham's Cave, Gibraltar. Proceedings of the *Prehistoric Society*, **17**, 83-93.

Waechter, J. d'A. 1964. The excavation of Gorham's Cave, Gibraltar. *Bulletin of the Institute of Archaeology*, **4**, 189-22.

Yalden, D.W. & Morris, P.A. 1990. *The Analysis of Owl Pellets*. Mammal Society, London. Occasional Publication No. 13. 24pp.

Zeuner, F. E. 1953. The chronology of the Mousterian at Gorham's Cave, Gibraltar. *Proceedings of the Prehistoric Society*, **19**, 180-188.

TABLE 1. Microvertebrate faunal list for part of the succession in Gorham's Cave, Gibraltar. Species listed in taxonomic sequence following Kurten (1968). Abbreviations: RMK - Red Marker Bed; BBB - Brown Bone Bed; STL - SNDS - Stalagmitic Sands; OCC - 'Occupation' Bed; RBB - 1/2/3 - Red Bone Beds 1/2/3. + Denotes presence.

SPECIES	RMK	BBB	STL-SNDS	OCC	RBB-3	RBB-2	RBB-1
Mammals							
White-Toothed Shrew							
Crocidura sp.	+			+			
Mole							
Talpa sp	+		+				
Mustelid (stoat/weasel)							
?*Mustela*							+
Garden Dormouse							
Eliomys quercinus	+	+		+		+	
Wood Mouse							
Apodemus cf. *sylvaticus*	+	+	+	+	+	+	+
Vole							
Microtus sp.	+	+			+		
Microtus breccensis	+						
Rabbit							
Oryctolagus cuniculus	+		+	+	+		+
Other vertebrates							
Fish	+	+	+		+		+
Frog		+		+	+	+	
Reptile	+	+			+	+	+
Bird	+		+		+	+	+

TABLE 2. Categories of skeletal elements used in sorting (after Andrews, 1990)

SKELETAL ELEMENT	DEFINITION
mandible	Lower jaws. Count is of total number of half-mandibles.
maxilla	Total number of upper jaw and other skull fragments.
incisors	Total number of isolated incisors.
molars	Total number of isolated molars.
scapula	Total number of shoulder blades, damaged and entire.
ribs	Total number of entire ribs and fragments.
vertebrae	Total number of vertebrae, all groups (ie includes birds, fish etc), complete and fragmented.
pelvis	Total number of innominates, entire or identifiable fragments.
talus/calcaneus	Combined total of ankle & wrist elements.
phalanges	Combined total of phalanges & metapodials.
femur	Total number of clearly identifiable femurs and proximal ends (femora).
tibia	Total number of clearly identifiable tibias. Often tibio-fibulas.
humerus	Total number of clearly identifiable humeri
radius	Total number of clearly identifiable radii
ulna	Total number of clearly identifiable ulnas.
shafts	Unidentifiable long bones, generally missing one or both ends.
non-mammal teeth/jaws	Total number of mandible/maxilla fragments, mostly teeth bearing, from other groups (reptile & amphibian in particular).

Many categories had 'all group' counting, i.e. elements from non-mammal groups were included in the totals. In particular this applies to: vertebrae; phalanges; all long bone categories, especially shafts.

TABLE 3. Representative count of skeletal proportions, Red Marker Bed (from Cooper, 1995, unpublished)

SKELETAL ELEMENT	No.	%		No.	%
mandible	7	1	phalanges	118	21
maxilla	8	1.5	femur	6	1
incisors	25	4	tibia	7	1
molars	42	7	humerus	2	0.5
scapula	1	0.5	radius	0	0
ribs	27	5	ulna	2	0.5
vertebrae	142	25	shafts	152	27
pelvis	4	1	non-mammal teeth/jaws	12	2
talus/calcaneus	12	2			
			COUNT TOTAL	567	