Cetaceans From a Possible Striped Hyaena Den Site in Qatar

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A small bone assemblage from Qatar is described. The bones were found in a small cave eroded out of marine sediments and the most likely accumulator of the bones was striped hyaena, *Hyaena hyaena*. Four species of large mammal are represented in the assemblage, striped hyaena, camel, gazelle and the finless porpoise. In addition there were some rodent and bird bones, the origin of which was uncertain. There were 68 identifiable large mammal bones in total, 2 skulls, 6 mandibles, 11 isolated teeth and 23 postcranial elements, together with 26 ear ossicles of the finless porpoise. In addition, 10 indeterminate large mammal bones were collected. The assemblage was identified as a striped hyaena accumulation firstly by the presence of a skull and mandible of this species in the assemblage, and secondly by the nature of the damage and modifications of the bones. The striped hyaena is probably now extinct in Qatar, and one of the bones was dated radiometrically to 580 ± 200 years. This bone showed characteristic signs of desiccation, and it is similar in preservation to the rest of the assemblage. The numbers and sizes of chewing marks are similar to those seen in spotted hyaena assemblages, and particularly when the maximum sizes of marks is taken into account they are distinct from canid chewing marks. The most striking feature of the assemblage is the abundance of finless porpoise skull bones representing at least 13 individuals, and this is taken to indicate that the hyaena was hunting or scavenging along the coast of the Arabian Gulf about 4 km from the den site.

Keywords: BONE ASSEMBLAGE, BONE BREAKAGE, PORPOISE PREDATION, SCAVENGING, PUNCTURE MARKS

Introduction

Hyaena bone assemblages are known from a number of sites across Africa and into the Middle East. Hyaenas were assumed to be bone accumulators in the 19th century (e.g. Buckland, 1824), based on good but anecdotal evidence of “dragging them [carcasses] to their den and accumulating … the bones of all kinds of...
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animals”. Comparisons at that time were made with captive hyaenas in zoos, and these were used to interpret past bone assemblages, particularly in caves. For example, Buckland excavated a cave in Kirkdale in Yorkshire that contained the remains of over 300 spotted hyaenas with the bones of their inferred prey species (Buckland, 1824). Similarly, Balch (1914) accepted without question that hyaenas were the accumulators of the bones in Hyaena Den at Wookey Hole, based in this case on the fact that hyaena bones were the most abundant animal remains at the site. In the second half of the 20th century, more detailed comparisons with present day hyaena assemblages were made, both their feeding habits (Kruuk, 1972) and the characteristics of their bone assemblages. For the most part, these are accumulations of the spotted hyaena, and bone accumulations from striped hyaenas are less well known, although they can be more substantial.

Numerous studies have been undertaken to identify the characteristics of hyaena assemblages (Hughes, 1954, 1958; Sutcliffe, 1970; Maguire et al., 1980; Hill, 1989; Kerbis Peterhans, 1990; Pokines & Kerbis Peterhans, 2007 for the spotted hyaena; Skinner, 1980; Horowitz & Smith, 1988; Kerbis-Peterhans & Horowitz, 1992, Leakey et al., 1999 for the striped hyaena). Types of bone damage recognized include splintering of long bones by adult hyaenas, gnawing of shafts and ends of bones by juveniles, scooping out of cancellous bone, and damage by partial digestion. Detailed descriptions of hyaena bone breakage (Maguire et al., 1980; Ghaleb, 1984) have led to systematic analyses of breakage that are now used as standard for bone breakage (Villa & Mahieu, 1991).

The bone accumulator

The striped hyaena is one of four extant species of Hyaenidae: the spotted hyaena (Crocuta crocuta), brown hyaena (Hyaena brunnea), striped hyaena (Hyaena hyaena), and the aardwolf (Proteles cristatus). The only species present in Qatar is the striped hyaena, and the only other large carnivore which could have accumulated the bones at Jebel Nakhsh is the Arabian wolf Canis lupus (Harrison, 1981). Jackals are common in the area (Canis aureus), but they are smaller and do not accumulate large bones. The outsides of their dens have large accumulations of scats, which are smaller than hyaena scats, and few bones. On the evidence of a single hyaena scat and skeletal remains of striped hyaena in the Jebel Nakhsh den site, it is suggested that the most likely accumulator of the bone assemblage at the site was striped hyaena.

Striped hyaenas have been reported as solitary foragers (Kruuk, 1976), but they have also been seen foraging in pairs (MacDonald, 1978). They are classic opportunists, feeding on insects, birds, and small mammals (Kruuk, 1976; Mills, 1977), human waste and digging up human bodies (Prater, 1946; Kruuk, 1976), livestock (Leakey et al., 1999), and they also eat considerable vegetation (Kruuk, 1976). The striped hyaena is strictly nocturnal and secretive, and as a result it is not as well known as the spotted hyaena. Perhaps also as a result of its secretive habit, it has the largest geographic range of any of the extant hyaena species and can be found from the Bay of Bengal through the Middle East into the northern half of Africa, and it is still extant in parts of the Arabian peninsula (Figure 1).
Qatar topography, geomorphology and the Jebel Nakhsh cave sites

The north-south projection of the State of Qatar into the Arabian Gulf is the result of Tertiary uplift of the Qatar anticline. Despite this feature, the topography of most of the northern two-thirds of Qatar is a low plain rarely more than 40 meters above sea level. It is made up of hard Eocene limestones with some aeolian sands. Until recently, there were numerous freshwater wells in this region and some cave collapse structures had exposed freshwater pools with blind cave shrimps that indicate an extensive phreatic system (Whybrow: personal observation and collection, 1982). In the southern third, by contrast, there are fewer water wells, the topography undulates and is interspersed with isolated butte-like hills (jebels) consisting of cyclic deposits of mainly marine Miocene sediments in the Jebel Nakhsh and Al Kharrarah areas. The jebels, some of which attain heights of nearly 100 meters above present sea level, consist of hard limestones and evaporites, and soft clays. On their flanks, where the soft clays have been eroded by infrequent rains and deflation, the overlying limestones sometimes become unstable and collapse to form a jumble of blocks that provide a habitat for some desert mammals. In other places, the soft clays have been actively excavated by canids to make burrows.

Figure 1. Distribution of the striped hyaena in Arabia (from IUCN report, 1998).
To the south of these Miocene exposures lie extensive salt flats (around the border of Qatar with the Kingdom of Saudi Arabia) that are at, or below, sea level. An isolated jebel surrounded by salt flats, Qarn Abu Wayil lies about 2 km south of the southern extremity of Jebel Nakhsh. In 1933, H. St. J. Philby whilst collecting Miocene invertebrates from this hill commented (1933: 46-47) that the salt flats were once an arm of the sea and that Qatar was “...once an island as Bahrain is today...”. This was certainly so at the time of the Flandrian transgression, about 6,000 BP, when Arabian Gulf sea levels were 1-2 meters higher than at present. Since that time gradual progradation of the Qatar and Saudi Arabian coastlines have rejoined Qatar with the Arabian peninsula.

Another survey of the Miocene deposits was undertaken in the 1983-84 field season that included Jebel Nakhsh and the Al Karrarah region of southern Qatar (Figures 2 & 3). During a search for the 1979 burrow, a large bone bearing cave site (Jebel Nakhsh South) was found about 5 km from the southern part of Jebel Nakhsh. This was also located on the eastern flank of the jebel and about 4 km from the coast of the Gulf of Salwah.

The den is a narrow rift in Miocene marine deposits, eroded out of a clay horizon and topped by collapsed blocks of hard white limestone that form the roof of the cave. It was not possible to follow the full extent of the cave, which is very narrow, but it was possible to ascertain that it had

**Material and methods**

*The Jebel Nakhsh cave sites*

The site at Jebel Nakhsh (pronounced Nash) was discovered in the 1983-84 field season at Al Kharrarah, southern Qatar (Figure 2) led by Peter Whybrow (Whybrow & Hill, 1999). The Jebel is a narrow ridge running northwest to southeast for about 33 km, parallel to the western coast of Qatar adjacent to the Gulf of Salwah. Its highest point of 95 m is at its southernmost part. A possible den was found on the eastern flank of the jebel (Jebel Nakhsh North), about 15 km south of the most northernmost part. The entrance is in soft Miocene clays, about 70 cm wide and 40 cm high. One striped hyaena mandible was found about one metre into the burrow, as well as one hyaena scat, identified as such by its size. No other bones were found at this stage.

Figure 2. Map of Qatar showing location of Al Kharrarah.
The other end of the cave has another entrance on the north face of a small side gully cutting into the side of the Jebel (seen on the far right of Figure 4) where it is exposed as a long narrow slit sloping down into the gully. Adjacent to this are three jackal dens (Canis aureus), at least one of which is currently occupied, with bones accumulating across the gully, and because of possible confusion with jackal bone accumulations, no bone was collected from this region. This was an unfortunate omission, for it would have been interesting to compare the assemblages.

The bone assemblage

In the 1983 season, the den site at Jebel Nakhsh South was surveyed, along with a number of other sites of potential interest, and plans were drawn for all sites. No excavation was attempted, for the intention was to return and excavate the site at a later stage, but it is now unlikely that we will be able to do this. Hence this will be a preliminary report of this site. Two collections of surface bones were made in December 1983. One came from inside the east entrance chamber of the cave, as far back as it was possible to reach. Bones were found littering the floor of the cave and buried in the disturbed surface debris on the floor (Figure 5). Both were collected, but we were unable to excavate far into the sediments. The other collection was made on the erosion terraces immediately outside the east entrance, and all surface bone was collected over an area of just over 8 m² (6 x 1.4 m). A total of 69 bones were collected for four main taxa, including a skull of the striped hyaena, together with 10 indeterminate fragments which have not been included in the analysis except for the calculation of the weathering profile.
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All bones were identified as far as possible to taxon and skeletal element. Minimum numbers of individuals were calculated based on these criteria and on the added factor of age (Gordon-Maclean, 2000). This was determined where possible from the teeth, but epiphyseal fusion of articular ends of limb bones was also used to distinguish mature from immature individuals. Breakage was analysed according to the method of Villa & Mahieu (1991), distinguishing fracture angles (oblique versus right angled breaks) and fracture form, that is curved, spiral or straight (transverse). Carnivore damage was categorized following Andrews & Fernández-Jalvo (1997) distinguishing four types of tooth mark:

a. pits on surfaces of long bones diaphyses, mandibular bodies and ear ossicles;
b. surface scoring on the same types of bone;
c. deep punctures on articular surfaces that penetrate into the soft articular bone; and
d. punctures or crenulations on the edges of broken surfaces, specifically in this case on spiral breaks.

For recording the distribution of weathering stages, five stages of alteration by desiccation are shown, stage 1 signifying minimal alteration and stage 5 indicating bones that are in the last stages of splintering. These stages parallel Behrensmeyer’s (1978) stages even though the nature of alteration is not exactly the same and the rate of weathering in the mid-latitudes is different from that described by Behrenesmeyer for the tropics (Andrews & Whybrow, 2005).

A C14 date was obtained on one of the camel bones recovered from inside the cave, and this gave an age of 580 ± 200 years (Caroline Grigson, personal communication). The bone came from inside the cave and

Figure 4. Section along the length of the cave at Jebel Nakhsh. The main entrance is to the east (left of figure), and the floor rises nearly 2 m above the entrance along the south side of the cave. The dashed line marked ‘floor of cave’ shows our estimate of the lowest part of the cave floor on the northern side of the cave.
Figure 5. Photograph of the east entrance of the Jebel Nahsh hyena den showing the floor of the den with several bones visible.
showed little evidence of weathering. In all respects it had similar preservation to the rest of the bone assemblage, but the age spread of the assemblage as a whole is not known.

Results

Species representation in the den assemblage

**Hyaena hyaena.** One adult hyaena skull was found inside the cave, JN46 (and the mandible JN2 which came from JN North). They are considerably smaller than *Crocuta crocuta*, and a series of measurements showed that they can be attributed to *H. hyaena*. Seven measurements of the skulls are shown (Table 1) comparing the two species. Two subspecies were formerly recognized in the Middle East: *H. h. syrica* from Israel, Jordan and Lebanon, and *H. h. sultana* from Saudi Arabia, Oman and Yemen (Harrison & Bates, 1990), but current usage does not distinguish them (Wilson & Reeder, 2005). Three individuals are represented at Jebel Nakhsh, for the young adult mandible is distinct from the old adult skull, and a third individual is indicated by the isolated teeth.

**Neophocaena phocaenoides.** The finless porpoise is the most common animal represented in the cave. It has an eastern distribution today, in the China Sea and the Indian Ocean, and although it is still seen in the Arabian Gulf, its presence there has been drastically reduced in recent years. It is known to hunt in shallow waters, and Arabian fishermen claim it enters water less than 1m deep at night to give birth. One adult skull (JN9) was found with the raised bony bosses in front of the nares that are characteristic of the Phocoenidae, and the convex shape of the maxilla and the small nares are similar to that of *N. phocaenoides*. The most abundant elements in the deposits are the porpoise ear ossicles, which were found throughout the deposits but which are not themselves diagnostic to species. It is assumed that they can be attributed to the same species as the skull, and they represent 13 individuals. The disproportionate number of ear ossicles is probably because they consist of extremely dense bone, and whereas the thinner bones of the skull could be broken up and eaten by the hyaenas, the compact bone of the ear ossicles would resist breakage. They are also in the part of the skull with little nutrient value.

**Gazella gazella.** The Arabian gazelle is the next most common species at the Jebel Nakhsh den site. Two mandibles and numerous postcrania were represented for this species (Table 2). The four humerus fragments (Table 2) represent four individuals, for there are three adult left humeri and one juvenile right humerus. Together with the scapula and radius, the forelimb elements make up the greater part of the gazelle sample, with only three hind limb elements. The two femora are from an adult and a juvenile, and similarly mandible JN14 is from an adult, but JN14b is juvenile.

**Camelus dromedarius.** The Arabian camel is represented by three mandibles, one without teeth and difficult to age, a mandibular symphysis, and the third, JN30, is complete. It is from a young adult with the third molar just coming into wear. It is probable that two individuals are represented.
Table 1. Measurements of *Hyaena hyaena* skulls.

<table>
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<tr>
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<th>Jebel Nakhsh</th>
<th><em>Hyaena h. syriaca</em></th>
<th><em>Hyaena h. sultana</em></th>
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<tr>
<td></td>
<td>JN46</td>
<td>JN2</td>
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<td>240.0</td>
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<td>157.0</td>
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<td>150.5</td>
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Table 2. Skeletal elements represented at the Jebel Nakhsh den site.

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<th><em>Neophocaena phocaenoides</em></th>
<th><em>Camelus dromadarius</em></th>
<th><em>Gazella gazella</em></th>
<th><em>Hyaena hyaena</em></th>
<th>Horse</th>
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<td>18</td>
<td>7</td>
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</table>
Striped hyaena den from Qatar

Equidae. There were a number of horse teeth that were too incomplete to identify. In addition there was a small assemblage of small mammals and birds (table 2), and as they were not badly broken and showed no signs of digestion they were probably incidentals not related to the hyaena accumulation.

Preservation of the bones

All the bones showed signs of weathering, even the ones inside the cave. Some of the bones found on the surface outside the cave have advanced stages of weathering (Behrensmeyer, 1978), but it is not clear how long they may have been exposed on the surface. Heavy rains occur in this region at least once every five to seven years, and examination of the sediments reveals that both sediment and bones are currently being washed out of the cave. Most of the bones now outside the cave show advanced stages of weathering, as they were exposed to the full force of the weather. They were mostly at stages 4 or 5 following Behrensmeyer’s categories of weathering, but those partly buried have differential weathering on the exposed and buried sides (Figure 6B). The differential weathering indicates that the bones have been static for a considerable period of time. The only long term study of weathering rates in Arabia only spanned 15 years, and

Figure 6. A, Extreme splitting of a diaphysis fragment from inside the cave; B, chewed end of limb bone showing deep perforation and deformation of the broken end; C, conical perforation close to epiphysis of limb bone. Both the latter two specimens were in place in the floor of the cave.
Andrews

while these showed the same progression of weathering described by Behrensmeyer (1978), they differed in the rate of weathering, being much slower in the sub-tropical environment of Abu Dhabi than in the tropical environment of Kenya. After 15 years, most bones were only at stage 2 weathering, but some were still at stage 1 and some at stage 3 (Andrews & Whybrow, 2005). It is likely, therefore, that the bones were exposed to weathering for considerably longer, although clearly not for several hundred years. The dated camel bone came from inside the cave and was thus protected from weathering.

The nature of the weathering of bones still inside the cave is not the same as that described by Behrensmeyer (1978) for surface bone in tropical regions. Nor is it the same as bones from nearby desert environment at Jebel Barakah, Abu Dhabi (Andrews & Whybrow, 2005). The most notable feature of the bones from inside the hyaena den at Jebel Nakhsh is that they are extremely desiccated, with loss of collagen so that they are friable and easily broken, but they do not always show evidence of this other than through cracking of the bone surfaces. There is little evidence of flaking and splitting of surface bone that occurs in bone exposed on the surface, as defined by Behrensmeyer (1978). Instead the bone cracks open and splits into elongated splinters, presumably due to loss of collagen as the bones dry out in the intense heat of the Arabian desert climate. The pattern of modification is shown in figure 6A.

The distribution of weathering stages is shown here in Figure 7. The stages follow Behrensmeyer’s (1978) weathering stages, and although the nature of the alteration is different, as described above, each of the stages represented here is equivalent to those described by Behrensmeyer. There is marked difference between bones from inside and outside the den: outside, nearly all the bones are at extreme weathering stages, but inside the equivalent stages gradually increase from little or no weathering to moderately extreme (Figure 7).

The high degree of weathering/desiccation made it difficult to determine the nature of bone breakage. There are seven humeri, two distal humeri of camel, three distal and one proximal humerus of gazelle and one indeterminate distal humerus. The distal humerus thus makes up 86% of the humerus sample. The only other skeletal element approaching the humerus in abundance is the mandible, with six specimens (Table 2), and these are all portions of mandibular body lacking the ascending ramus. It is interesting, but probably not significant given the small sample size, that gazelles are mainly represented by forelimb elements and camels by hind limb elements.

All bones were broken, with 22 diaphysis or long bone fragments: 55% have less than half the shaft circumference preserved, 15% have more than half the shaft circumference, and 30% have whole shafts preserved. Most of the breaks had oblique or partially oblique fracture angles (92%). Less than 10% had right-angled breaks, and where present it was evident from the different preservations of the broken surfaces that these breaks were more recent than the oblique ones. It appears from this that recent breakage has been minimal, a result consistent with the differential weathering on single bones since both show lack of disturbance of the bones. A high percentage (82%) of the oblique breaks were curved or spiral in form and took place while the bones were fresh, producing green-bone fractures.
It is evident that a considerable quantity of porpoise remains was carried to the cave (table 2). The 26 ear ossicles conservatively belong to a minimum of 13 individuals, and adding the one partially intact porpoise skull to this gives an MNI of 14 for this species. Other than the one skull, there was no trace of the remains of thin-walled skull fragments in the cave, and it is to be presumed that they were totally destroyed by the hyaenas, leaving the compact and extremely hard ossicles uneaten. There is no sign that the ossicles were ingested, although since the compact bone has a polished appearance when fresh it is difficult to be sure on this. Several of the ossicles were broken, and eight of them had tooth marks (31%), evidence of hyaena...
Table 3. Carnivore damage on the Jebel Nakhsh bone assemblage. The classification of carnivore chewing marks is based on Andrews & Fernández-Jalvo (1997).

<table>
<thead>
<tr>
<th>Skeletal element</th>
<th>No. of elements</th>
<th>No. with marks</th>
<th>No. of surface pits category a</th>
<th>Mean size mm</th>
<th>No. of scores category b</th>
<th>Mean diameter mm</th>
<th>Punctures on articular surface category c</th>
<th>Mean diameter mm</th>
<th>Punctures spiral breaks category d</th>
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<td>5.2</td>
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<tr>
<td>femur</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>1.8</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>2.9</td>
<td>5</td>
<td>5.2</td>
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damage. They have no nutritional value, however, and it is probable that the breakage was incidental to the breaking up of the rest of the skulls. Absence of porpoise postcrania is interesting, and it may be attributed to the distance from the sea, where they could be scavenged, or to their total destruction by the hyaenas.

The total count of bones with carnivore damage is 22 bones out of a possible sample of 53 (excluding the 11 isolated teeth), or 41% (Table 3). If all elements are included in the count, including those for which there is no evidence of carnivore damage, the percentage drops to 32%. The presence of pit marks on the hyaena skull and mandible suggests cannibalism, as has been widely documented in striped hyaenas (Kerbis-Peterhans & Horowitz, 1992). Carnivore damage has been scored following Andrews & Fernández-Jalvo (1997), differentiating between pits on the surfaces of bones (a), scores also on the bone surfaces (b), punctures penetrating into articular surfaces (c), and punctures on the edges of spiral breaks (d). The mean size of the first of these categories, surface pits, is 3.5 mm for 65 pits on 17 bones, which is a relatively large pit size. Scoring of the surface by contrast is much less common, and the marks are narrow (Table 3). Punctures penetrating articular surfaces (category c), on the other hand are large, as would be expected given that the underlying bone is weaker and more easily penetrated than diaphyseal bone. The mean puncture diameter is 4.4 mm for 32 punctures on 12 bones (Table 3). When mandibles and scapulae are considered alone, the puncture size is greater, 6.6 mm, for the articular surfaces of these two bones are particularly vulnerable to carnivore chewing (and in fact are rarely preserved in the fossil record). Finally, punctures on edges of broken bone with spiral breaks (category d) have a mean diameter of 3.7 mm for 25 marks on 7 bones, slightly smaller than the marks on articular surfaces (Table 3), but it has to be remembered that the tooth marks exposed on the edges of breaks usually only have part of the diameter preserved since they are seen in profile on the edge rather than in the round on intact surfaces.

The different ranges of these four categories is shown in Figure 8. Each category has a different range and pattern of chewing mark sizes: category a ranges from 2.1 to 7.6 mm; category b from 0.5 to 2.1 mm; category c from 2.1 to 9.8; and category d from 2.6 to 12.4.

Only one hyaena scat was found at the site. The age of the site probably accounts for this, for if most of the scats were deposited outside the cave or washed out by flood water during the occasional rains, it is likely that most scats would have been destroyed. The scat was granular in texture and contained no bone. There is no indication, for instance, that the hyaenas had eaten the small mammals present at the site. It is more likely that they represent incidental deaths that just happened to be preserved at the site. Only postcrania were represented and it was not possible to identify them to species.

**Discussion**

It is likely that the striped hyaena is now extinct in Qatar and the United Arab Emirates generally (IUCN report, 1998). One possible sighting in 1984 in the gulf of Oman is given in the IUCN report, and the species is still present in low numbers in Saudi Arabia, close to the Qatari border. It may have been present in Qatar well into
the 20th century, as was much of the wild fauna of the region, for it has been the onset of off-road motoring and hunting that has led to much of the local extinction of larger mammals. It is possible, therefore, that the Jebel Nakhsh den site was occupied until early 20th century, although there is no direct evidence that this was so. The single dated bone from the site indicates that the site was occupied several hundred years ago, but the fact that some of the bones in the assemblage have a low level of weathering suggests that the den was occupied until some tens of years ago. Unfortunately we have no data on the progress of desiccation of bones in caves in the hot desert conditions of Qatar, but data on bones exposed on the surface in this environment (in Abu Dhabi: Andrews & Whybrow, 2005) indicate a weathering profile similar to, but much slower than, that of the tropics (Behrensmeyer, 1978). After 15 years exposure, the camel bones in Abu Dhabi spanned weathering stages 1 to 3, and it might be estimated that it would be at least twice this time interval before any bones reached stage 5.

The bone assemblage from Jebel Nakhsh is too small for any but the most general comparisons with other sites. There is some direct evidence that it was accumulated by striped hyaenas, notably the presence of this species in the assemblage, and the presence and size of chewing marks on many of the bones. Only one scat was found, which supports this identification, but it is surprising there are not more, for typically hundreds of scats may be present in hyaena dens in Israel (Kerbis-Peterhans & Horowitz, 1992). On the other hand, the den at Jebel

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**Size distribution of carnivore marks**

![Graph showing size distribution of carnivore marks](image)

Figure 8. Size ranges of chewing marks on Jebel Nakhsh postcrania, diameters in mm, showing four chewing categories: a, surface pits on limb diaphyses; b, surface scores on limb diaphyses; c, deep perforations on articular surfaces of limb bones; d, deep perforations on spiral breaks on limb bones.
Striped hyaena den from Qatar

Naksh was small compared with the huge cavern in Israel (Kerbis Peterhans, personal communication). In addition, the species assemblage is not one normally associated with hyaenas, with its dominance by porpoises, but it could be argued that if the porpoise remains were not brought to the cave by hyaenas, what else could it be. There is no evidence of human involvement, and the cave site is only a short distance from the sea in the middle of an arid desert with few large terrestrial mammals. An animal assemblage from Kasteelberg B in South Africa is similarly dominated by marine mammals, in this case the Cape fur seal, but in this instance the collecting agency is said to be humans based on the presence of cut marks on many of the bones (Cruz-Uribe & Klein, 1994).

There is evidence of jackal activity in the immediate vicinity of the cave at Jebel Naksh. There are many scat accumulations, and it is possible that some of the bones at the site were accumulated by this small canid. It is unlikely, however, that it brought the larger bones of porpoise and camel to the site, and there is no evidence of jackal occupation of the main site where the hyaena remains were found. A more general point can be made, leaving aside the question of the accumulator of the bone assemblage, and this is that it provides a glimpse of what this part of Arabia was like before it became altered by present human activity.

Camels and gazelles are the commonest large species in the present day Qatari desert, and 400 years ago, when we know that part at least of the Jebel Naksh assemblage was being accumulated, gazelles in particular would have been more common than they are today. It would appear that the hyaenas were taking advantage in an opportunistic way of an even more abundant food source, porpoises along the sea coast, and the question arises as to whether they were predated or scavenged. Either could be possible if the porpoises were resting or even breeding on the shore, and it is possible that the ear ossicles could have come from juvenile individuals. No porpoise postcrania were found, and just the one (adult) skull. It may be surmised that, whether predated or scavenged, parts of the porpoise bodies were carried to the site, including the skull, for clearly the ossicles alone would not have been transported because they have little nutrient value in themselves.

No sheep or goats were found in the bone assemblage. The camel remains must count as domestic stock, but camels in Arabia are often left to wander for considerable distances while foraging, and they lack the protection normally afforded domestic stock. In effect, therefore, the camel activity pattern is more akin to that of wild animals, so that together with gazelles and porpoises, the bones of the Jebel Naksh assemblage are the product of a wild assemblage. This differs, for example, from the striped hyaena assemblage from the Arad den assemblage in Israel, which is largely composed of domestic stock (Kerbis-Peterhans & Horowitz, 1992).

The damage to the bones from the Jebel Naksh site is consistent with evidence from other hyaena dens. Large bone assemblages are commonly found on the surface both inside and outside the dens (Sutcliffe, 1970; Hill, 1989). Maguire et al. (1980) document nine distinct types of surface damage which are characteristic of all three hyaena species. What they call ragged-edged chewing is evident in the Jebel Naksh assemblage (Figure 9). Shallow pitting and perforations are also present at Jebel Naksh, and here they are distinguished according
It is not clear how diagnostic the sizes of tooth marks are on bones. For a start, the sizes vary according to their location, whether on diaphyses or on epiphyses or articular bone (Andrews & Fernández-Jalvo, 1997). For example, the mean pit diameter on diaphysis fragments for the Jebel Nakhsh assemblage is 3.5 mm for 65 pits on 17 bones, and this compares with 3.2-3.5 mm for 75 pits (Table 4) on two spotted hyaena assemblages from Sutcliffe’s Kajiado and Ngorongoro den sites (Sutcliffe, 1970). These compare with the much smaller pit sizes resulting from fox scavenging: mean of 1.25 mm (Andrews & Fernández-Jalvo 1997: N = 99). Similar differences are seen when the sizes of tooth punctures into the soft spongy bone of articular bone. In the scheme of Andrews & Fernández-Jalvo (1997) these marks are designated category c. The average diameter of the punctures for the Jebel Nakhsh assemblage is 4.41 mm for 32

Table 4. Tooth mark sizes for two spotted hyaena assemblages. The number of bones samples are shown on the left, followed by the number of tooth marks (N) and their mean dimensions (in mm) for each of four categories: a, pits on the surfaces of long bone diaphyses; b, linear striations on the surfaces of long bone diaphyses; c, punctures penetrating articular or epiphyseal bone; and d, punctures on the edges of spiral breaks.

<table>
<thead>
<tr>
<th></th>
<th>No. of bones</th>
<th>a</th>
<th>b</th>
<th>c</th>
<th>d</th>
<th>No. bones with no marks</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td>N</td>
<td>mean</td>
<td>N</td>
<td>mean</td>
<td>N</td>
</tr>
<tr>
<td>Kajiado Sokuta den</td>
<td>39</td>
<td>21</td>
<td>3.2</td>
<td>22</td>
<td>1.4</td>
<td>21</td>
</tr>
<tr>
<td>Ngorongoro lake den</td>
<td>79</td>
<td>54</td>
<td>3.5</td>
<td>30</td>
<td>1.4</td>
<td>55</td>
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Andrews

to their position on the bones, whether on the diaphysis, on articular surfaces, or on spiral breaks (designated as a, c or d following Andrews & Fernández-Jalvo, 1997). A fourth category is lunate or crescent-shaped fracture scarring, which has not been seen on the Jebel Nakhsh assemblage, and neither has the irregular chewing marks that appear to result from intensive chewing by juvenile hyaenas. It is possible, however, that the damage to the zygomatic region and sagittal crest of the hyaena skull might fit this category. Striations or gouge marks (designated c in the scheme of Andrews & Fernández-Jalvo, 1997) are present in low numbers on the Jebel Nakhsh bones, and one example of scooping or hollowing out of cancellous bone has been seen. No bone fragments that show clear evidence of digestion have been found, and it is not certain if the ear ossicles of porpoises have been digested or not.
punctures on 12 bones, with values up to 9.5 mm on mandibular condyles and 6-7 mm on limb bone articulations. This is similar to values obtained for the Kajiado and Ngorongoro spotted hyaena den assemblages [average diameters of 5.3 to 6.8 mm (table 4) and maximum values up to 9.6 mm], and it is much higher than values for fox scavenging. Punctures in articular bone average 2.5 mm (N = 114) for fox, with a maximum of 4.5 mm. Similarly for punctures on spiral breaks (category d, Andrews & Fernández-Jalvo, 1997), which average 3.7 mm for 25 punctures on 7 bones in the Jebel Nakhsh assemblage but have maximum values of 8-9 mm. This is compared with average values of 5.4 to 6.1 mm for the Kajiado and Ngorongoro spotted hyaena den assemblages, and an average of 2.7 mm (N = 101) for the fox-scavenged assemblage (Andrews & Armour-Chelu, 1998). Maximum values range up to 12.4 mm for the spotted hyaena assemblages, and while puncture sizes are extremely variable in the fox-scavenged assemblage, they do not exceed 5 mm in diameter.

These average figures may distinguish between carnivores as different in size as hyaenas and foxes, but I would suggest that a more diagnostic feature in tooth mark sizes is the largest size marks left by predators rather than the average. Small pits may be made by all sizes of predator, depending on which teeth they use to make the marks, but large pits would normally only be made by larger predators. The minimum pit sizes in the Jebel Nakhsh assemblage are 2.1, 2.1 and 2.6 mm for categories a, b and d, which is well within the range for fox chewing marks (0.4 to 4.8 mm), but the maximum sizes of chewing marks at Jebel Nakhsh are 7.6, 9.8 and 12.4 mm for categories a, b and d. This is much greater than the maximum sizes of 3.0, 4.6 and 4.8 mm for the same chewing categories for foxes. Another way of approaching this issue would be to take the mean size of the five largest marks; this gives mean values for the Jebel Nakhsh chewing marks of 6.3, 9.4 and 9.8 mm for categories a, b and d. Comparable figures for fox are 2.8, 4.4 and 4.9 mm (Andrews & Armour-Chelu, 1998). Both ranges and largest marks from the Jebel Nakhsh assemblage are similar to values on bones from the spotted hyaena assemblages from Kajiado and Ngorongoro.

It is evident from this discussion that while average sizes of hyaena chewing marks are only slightly greater than the marks left by much smaller canids, the maximum sizes of the marks is much greater in the hyaena assemblages. Spotted and striped hyaena chewing marks are similar in size on average, with maximum sizes being slightly larger in the two samples of spotted hyaena recorded here. The marks left on different parts of the bone, however, have to be analysed separately, for pits on the diaphysis are consistently smaller for both hyaenids and canids than punctures penetrating softer articular bone or those that result in breakage of the bones. When all these factors are taken into account, I believe that this method of analysing chewing marks can usefully contribute to the identification of unknown predators responsible for accumulating bone assemblages.

Conclusions

The Jebel Nakhsh faunal assemblage was probably accumulated by striped hyaenas, which were preying or scavenging along the nearby shore. The most abundant prey species is the finless porpoise, which is represented mainly by ear ossicles, the most
resistant part of the skull. Other species include gazelles and camels and some extremely fragmentary remains of horse. The bones are broken and tooth-marked in ways consistent with other reports of hyaena-ravaged assemblages.

Acknowledgements

Collections were made with the help of Peter Whybrow and Libby Andrews, and parts of the analysis were done by Andrew Gordon-Maclean. Drawings were done by Phil Rye and photographs by Phil Crabbe. To all of these I am most grateful. I also thank Matt Hill and Julian Kerbis Peterhans for most useful and constructive comments on the text.

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