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BONE COLLECTING BY STRIPED HYAENAS, *Hyaena hyaena*, IN ISRAEL

by

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ABSTRACT

Differences in bone collecting behaviour of three species of hyaena and porcupines are discussed. Observations on feeding behaviour of striped hyaenas are described as well as their habit of carrying pieces away particularly if feeding cubs at maternity dens. At one maternity den near Arad the floor of the main cavern was littered with bones which covered an area of 40 m^2. Of this 2,0 m^2 was sampled and found to contain 267 bones and bone fragments from no fewer than 57 individuals, mainly of domestic species such as camel, donkey, caprovines and dogs.

CONTENTS

	Page
INTRODUCTION	99
PROCEDURE	99
RESULTS	100
DISCUSSION	101
CONCLUSION	103
ACKNOWLEDGEMENTS	103
REFERENCES	103

INTRODUCTION

Whether or not hyaenas accumulate bones at den sites has long been a subject of dispute. Some of the confusion has undoubtedly arisen from differences in behaviour between the three species of hyaena and from differences in behaviour of the same species in different geographic regions. Thus, Hughes (1954a, b) and Dart (1957) concluded that hyaenas are not important accumulators of bones, rather feeding where they find their food. On the other hand, Sutcliffe (1970) describes bone accumulations in East Africa which he ascribes to *Crocuta*, and Kruuk (1972) alleges that *Crocuta* does not expressly carry food back to the den to feed its young although they frequently carry objects back to their dens to chew. More recently Bearder (1977) reported bone remains in six *Crocuta* dens in the eastern Transvaal and thereby demonstrated the definite involvement of this species in accumulating bone fragments.

Recent studies (Skinner 1975, Mills and Mills 1977, Mills 1978, Owens and Owens 1978) have shown that brown hyaenas, *Hyaena brunnea*, carry food items away from the site of discovery either to cache them or more frequently to feed their young in maternity dens. Preliminary studies of striped hyaenas, *Hyaena hyaena*, in East Africa (Kruuk 1976) have indicated that they are similar in this regard. The present paper describes bone accumulations at a cave in Israel which have been attributed to *Hyaena hyaena*, and some observations on the feeding behaviour of this species.

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PROCEDURE

During studies on *Hyaena hyaena* in Israel in December 1977 and January 1978, the opportunity arose to visit at least three maternity dens and four other lairs of this species. The dens were all situated in the Judean and Negev deserts.

The most significant maternity den was discovered in 1974 by a Bedouin goat herd. It was sited some 3,5 km south-west of Arad about 200 m above the valley floor and some 100 m from the top of the plateau. There are at least two entrances. The first is through a round hole nearly half a metre in diameter which opens out after some ten metres into a large, totally dark cavern about 100 m^2 and over 1,5 m from floor to ceiling at its highest point. Leading off this cavern are five short passages into small caverns and at least one long passage to another large cavern some 20 m away on a higher level. Another exit from this second cavern seemed to be used primarily as a latrine.

The Arad maternity den was occupied by a mother and cubs at the time of this investigation, and the main cavern was reserved as an eating place. Hundreds of bone fragments, including

skulls, covered the floor of this cavern over an area of 40 m^2. Because we were reluctant to disturb this extraordinary deposit we sampled two 1 m^2 areas (A and B) 10 m apart, and the bones were taken to the Hebrew University for identification.

We also made nightly observations on the feeding behaviour of *Hyaena hyaena* using mounted and hand-held floodlights to which the hyaenas were habituated and floodlights at feeding sites established by the Nature Reserves Authority at En Gedi and Sde Boqer. Five dead donkeys were placed one at a time at one of these feeding sites. There was competition with other carnivores at both sites. At En Gedi at least four individual hyaenas were identified plus a pack of six wolves *Canis lupus*, and about 20 foxes *Vulpes vulpes*. At Sde Boqer the site was visited by at least three individual adut and three subadult hyaenas plus three wolves, about six foxes, a caracal, *Felis caracal*, and at least 20 griffon vultures.

RESULTS

Striped hyaenas feed one at a time except the subadult siblings which may feed together. A donkey carcass is opened at the anus and the flesh on the buttocks devoured. The ribs are "scissored" using the carnassial shear. After two nights of eating the first donkey was completely dismembered, devoured or carried away. All that was left was the earless head, the masseter muscle on the one side and a few neck vertebrae and the pelvic girdle stripped of flesh, the latter being the only remaining skeletal part after three nights. Although no exact measurements were made, it was estimated that adult hyaenas would consume 7–10 kg of soft flesh at a "meal", and subadults, which were only about 5,0 kg lighter, each consumed about 5,0 kg.

Usually after consuming as much soft flesh as they wanted, a carcass would be slowly dismembered as each hyaena tore off limbs or large pieces and carried them away. It took an adult hyaena 30 minutes of intense effort to tear off a hind leg from an adult donkey. Three individual hyaenas between them removed both hind limbs and tore out the stomach of the third donkey and carried them away. The head and forequarters were all that remained after one night, and the following day the vultures devoured the remaining soft flesh and left only the head for the hyaenas.

A characteristic of all the dens visited was that one area was used exclusively for feeding. It was here that the bones had accumulated, and these consisted mostly of cranial and mandibular pieces, metacarpals, hoof and horn sheaths and bone flakes from domestic ungulates. At no den was there a very large accumulation of bone fragments; this mostly ranged from 20–30 bone fragments per den.

The hyaenas occupying the den at Arad had recently brought in a domestic goat, *Capra hircus*. The rest of the sample (tables 1 and 2) contained 267 bones and bone fragments that represented at least 57 individuals, mainly camel (38 %), donkey (25 %), caprovines (18 %) and dogs (16 %). Although not weighed and measured, a large proportion of the bone-fragments appeared to be over 50 g. There was no evidence of porcupine gnawing on a large sample of randomly selected bones.

TABLE 1

Bones collected from the Arad cave from 2,0 m^2 of a 40 m^2 area covered by bones. The areas sampled, A and B, were of equal size, and the earth beneath was sampled to a depth of 20 cm, but no identifiable bones or rodent bones were found in this.

AREA A

SPECIES	*LISTING BY ANATOMICAL PARTS*	
Camel:	*Left side*	*Right side*
Skull 1 and 1 maxilla (palate + both dental arcades)		
Mandible	4	6
Scapula	3	—
Humerus proximal	—	—
Humerus shaft	—	—
Humerus distal	—	4
Humerus complete	—	2
Radius proximal	3	2
Radius shaft	2	3
Radius distal	2(1 = u*)	2 (1 = u)
Radius complete	1	1
Metacarpus proximal	3	1
Metacarpus shaft	3	1
Metacarpus distal	1	1
Metacarpus complete	1	1
Acetabulum	—	2
Femur proximal	—	—
Femur shaft	3	—
Femur distal	3(f)	1(u)
Femur complete	—	—
Tibia proximal	—	—
Tibia shaft	—	1
Tibia distal	—	4 (1=u)
Tibia complete	—	1
Metatarsus proximal	5	2
Metatarsus shaft	5	2
Metatarsus distal	4	1
Metatarsus complete	4	1
Calcaneum	—	1 (f)
Astragalus	—	1
Phalanx 1	—	—
Phalanx 2	—	—
Phalanx 3	—	—
Shafts of camel size	8	
	1 axis + 2 cervical vertebrae	
Bos:		
Mandible	1	—
Humerus distal	1	—
Donkey:		
Skull 1		
Maxilla 1 complete palate with both maxillary arcades (6 max. teeth + 4 mand. teeth)		
Mandible	—	3
Radius complete	—	1
Femur distal	1	4
Femur shaft	—	4
Femur proximal	—	2 (1=horse?)
Tibia distal	2	6 (2=horse?) (1=u)
Tibia complete	2	2
Tibia shaft	2	6
Metacarpus complete	1	1
Metatarsus complete	—	1 = horse
Phalanx 3	2	

*Epiphysis:
u = unfused
f = fused

Goat/ibex/sheep:

Horns 16 (1 only with core inside) + 2 cores without horn			
Complete palate with both arcades 2			
Single max. arcades	3		3
Mandible (+ post. parts)	9		5
Acetabulum	3		—
Humerus	—		1
Astragalus	1		1
Metatarsus shaft		1	
Metatarsus complete (goat) 1			
Ibex ♂ skull		1 (with maxilla)	
Gazelle ♂ skull		1 (without maxilla)	

Dog:

Skull 1			
Mandible	2		4
Maxilla/palate — complete	2		—
Scapula	2		—
Humerus distal	1		1
Humerus proximal		1	
Humerus shaft	1	1	1
Radius complete			1
Pelvis complete	1		1 (=1 pelvis girdle)
7 vertebrae			

Hystrix:

1 palate with both maxillae

Pig:

Teeth — few			
Radius proximal	1		—

Man:

mandible	1		1 (1 complete lower jaw)

AREA B Camel:

Mandible	2		5 (+ 1 palate with both dental arcades)
Scapula	3		2
Humerus proximal	—		—
Humerus shaft	—		—
Humerus distal	—		1
Humerus complete	1		—
Radius proximal	—		2
Radius shaft	—		2
Radius distal	—		—
Radius complete	—		—
Metacarpus proximal	—		1
Metacarpus shaft	—		3
Metacarpus distal	—		—
Metacarpus complete	—		2
Acetabulum	2		4
Femur proximal	—		—
Femur shaft	—		—
Femur distal	—		—
Femur complete	—		1
Tibia proximal	1(u)		—
Tibia shaft	—		2
Tibia distal	—		2
Tibia complete	—		—
Metatarsus proximal	3		8
Metatarsus shaft	4		7
Metatarsus distal	1		1
Metatarsus complete	1		1
Calcaneum	—		2 (u) + 1R(f)
Astragalus	1		1
Phalanx 1		2	
Phalanx 2		—	
Phalanx 3			
Shafts of camel size		14	
Cervical vertebrae		1	

Donkey:

Mandible	1		2
Humerus	—		5
Radius complete	1		1
Radius shaft	3		2
Radius proximal	3		2
Femur distal	1		—
Femur shaft	1		—
Tibia distal	2		2
Tibia shaft	2		2
Tibia complete	1		—
Acetabulum	5		3
Metacarpus proximal		3	
Metacarpus distal		3	
Metacarpus shafts		4 (1 = complete)	
Metatarsus proximal	3		3
Metatarsus distal	2		3
Metatarsus shafts	2		3
Metatarsus complete	2		3
Calcaneum	—		2
Astragalus	1		—
Phalanx 1		1	
Phalanx 3		2	
4 max teeth shafts — n/o + 1 rib			

Capra:

Horns 13	2 with cores + 2 horn cores i.e. total of 4 cores		
Maxilla	2		3
Mandible	2		5
Scapula	1		—
Humerus distal	1		— +2 shafts
Tibia	1		— + 1 shaft
Acetabulum	1		—
Radius proximal	1		—

Dog:

Skull complete		1	
Maxilla	8		6
Mandible	5		6
Acetabulum	—		1

Fox:

Maxilla	1		1

Gazelle:

Horn		1	

DISCUSSION

Although predation by spotted hyaenas has been discussed at length during the past fifteen years (Eloff 1964, Kruuk 1972), brown and striped hyaenas are regarded as ineffective hunters that are capable of capturing only the smallest of prey (Mills 1978, Owens and Owens 1978, Kruuk 1976, Skinner and Ilani in press). This difference in hunting ability may be due to the fact that *Crocuta* are much larger than *Hyaena* (Skinner 1976, Skinner and Ilani in press) and to social behaviour because *Crocuta* live, hunt and feed in clans (Kruuk 1972), whereas *Hyaena* forage alone or at most in family groups (Kruuk 1976, Mills 1978, Owens and Owens 1978, MacDonald 1978, Skinner and Ilani in press). This social behaviour may be related to brain capacity (Oboussier 1979), since *Crocuta* has a larger brain and evolved later than *Hyaena* (Oboussier *pers. comm.*). However, there are probably other differences in social behaviour

TABLE 2

A quantitative faunal list of mammalian species present in the Arad cave.*

	Bone counts		Min. No. of individuals		A + B COMBINED			
							Minimum No. of individuals	
	A	B	A	B	Bone counts	%		%
Camel	49	52	6	8	101	38	14	25
Donkey	24	43	6	5	67	25	11	19
Cow	2	0	1	0	2		1	
Caprovines	31	17	9	5	48	18	14	25
Dog	17	27	4	8	44	16	12	21
Fox	0	1	0	1	1		1	
Hystrix	1	0	1	9	1		1	
Gazelle	1	0	1	0	1		1	
Pig	1	0	1	0	1		1	
Man	1	0	1	0	1		1	
							57	or a total of 1 140 individuals over the 40 m^2 area

*Counts not exhaustive but for estimating the minimum numbers of animal species represented and for comparing areas A and B.

which are not yet fully understood; for example, the *Crocuta* female is larger than the male, has a well developed penile clitoris and is dominant (Racey and Skinner 1979), but in *Hyaena* sexual dimorphism favours the male. There are also interesting differences in the behaviour of *Crocuta* clans in different geographic regions such as East Africa (Kruuk 1972), the Kalahari desert (Eloff 1964), and the eastern Transvaal lowveld savanna (Bearder 1977). These seem to be related to the presence and behaviour of lions.

However, *Hyaena* are best known as scavengers that carry food to a cache or to their dens, particularly when they have cubs (Harrison 1968, Kruuk 1972, Mills and Mills 1977, Mills 1978, Owens and Owens 1978). The present study confirms this behaviour. Not only does *Hyaena* feed singly (Ilani 1975, Kruuk 1976, Mills 1978, Skinner and Ilani in press), but, after filling their stomachs, their whole strategy is aimed at dismembering the carcass and carrying away large parts. The amount they appear capable of devouring at one meal (7–10 kg) is half that which *Crocuta* can devour at one time (Bearder 1977).

Although Sutcliffe (1970) and Bearder (1977) support the view that *Crocuta* does accumulate bones at den sites, it is probable that the accumulations reported by Sutcliffe also resulted from foraging activities of *Hyaena hyaena,* since he made no attempt to separate the activities of various scavengers. Morever, Brain (1976) has emphasised that any cave which has been open for thousands of years will contain bones brought to it in a variety of different ways. Bearder (1977) examined the bones for evidence of porcupine gnawing but found only two examples in a sample of 409. Brown hyaenas are extremely rare in Bearder's study area and probably made no contribution to the bone accumulations he ascribed to *Crocuta.*

On the other hand evidence has shown that *Hyaena brunnea* usually collects bones at maternity dens (Skinner 1975, Mills and Mills 1977, Mills 1978, Owens and Owens 1978). Bone collections of 20–30 fragments seen at *Hyaena hyaena* dens in the present study were very similar to those described by Mills and Mills (1977) for *Hyaena brunnea.*

However, it frequently happens that vacant dens are used by other species such as aardvarks, warthogs and porcupines. Porcupines have long been known to accumulate bones in quite large quantities in their dens in the Kalahari sandveld (Brain 1976). Indeed, Brain suspects that porcupines carry more bones to African caves than any other species, but he does find this behaviour unusual for a vegetarian rodent. Examining the Nossob porcupine bone collections, Brain (1976) found that the great bulk (70 per cent) of the 1 708 individual specimens weighed between 0–50 g and 77 per cent were between 1–15 cm in length. Furthermore, Brain (1976) suggests that bone collecting by porcupines (*Hystrix africae-australis*) "has to do with the wearing down of the incisor teeth rather than with nutrition". As in other rodents the incisors are open-rooted, grow throughout life and through attrition are kept at usable length. While resting, porcupines select objects and gnaw on them for this purpose. Moreover, Brain (1976) believes collecting behaviour has become compulsive, and they bring back more objects than they require; for example, only 55,2 per cent of the bones from the Nossob collection showed signs of gnawing.

This remarkable behaviour of porcupines is apparently unique amongst other species with similar incisor teeth, even those of similar size and weight such as *Lepus* or *Procavia.* Indeed, the necessary attrition takes place through the wear of upper against lower incisors as well as when gnawing food. Furthermore, the porcupines in Israel, *Hystrix indica,* do not gnaw bones (Mendelssohn *pers. comm.*): In fact Mendelssohn ascribes bone chewing to phosphorus deficiency.

It is well known that the veld in southern Africa is deficient in phosphorus, particularly in the sandy areas of the Kalahari savanna (Du Toit and Bisschop 1929, Du Toit, Malan, Louw, Holzapfel and Roets 1932, 1935a, b, Henrici 1928) and that this results in osteophagia which in turn caused widespread cattle deaths from botulism as early as the eighteenth century in Namaqualand (le Vaillant 1796 cited by Henning 1949). Throughout this region phosphates are given to domestic livestock to compensate for this deficiency. The reason why porcupines do not die of botulism can be ascribed in part to Brain's (1976) observation that no more than 15 bone fragments in the Nossob collection showed appreciable traces of fattiness. In other words porcupines show a preference for weathered bones.

It is therefore not surprising that the bones in the Arad cave accumulation were not gnawed by porcupines. Although porcupine quills and bones were present on the cave floor, these were probably from individuals eaten by *Hyaena*, as *Hyaena* are known to kill porcupines when the opportunity arises (Skinner and Ilani in press). There are possibly three reasons why porcupines have not been a factor in the Arad collection. First, it is not a phosphorus deficient area (Mendelssohn *pers. comm.*), and osteophagia hardly occurs in herbivores in those areas. Secondly, there may be species differences in porcupine behaviour, or compulsive collecting as suggested by Brain (1975) may have evolved in a phosphorus deficient area. Thirdly, the Arad cave is very high and may be inaccessible to porcupines.

The Arad cave has been used by *Hyaena* as a den, perhaps exclusively for maternity purposes, for many years, perhaps for hundreds of years. This does not preclude the possibility that other agents may also have accumulated bones there. Nevertheless, it is a unique deposit because the bone accumulations have largely been protected from weathering as a result of the narrow tunnel openings to the cave. Moreover, it has been protected from incidental scavenging and vultures because of its size and seclusion. Only carnivores seeking such seclusion would find it.

CONCLUSION

We suggest that the Arad collection is largely, perhaps exclusively, that of *Hyaena* and we believe that other agents are unlikely to have been responsible. Primitive man is unlikely to have entered a dark cavern through such a narrow tunnel. "Civilised" man in this region was and still is so suspicious of hyaenas (Harrison 1968) that if he had known of the cave he would probably have avoided it. Leopards have been absent from this area in living memory, and porcupines are not implicated. The collection reflects the present large mammal composition of the surrounding area, and the collection is probably the remains of individuals scavenged by hyaenas and brought to the den to feed cubs.

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