THE CONTRIBUTION OF NAMIB DESERT HOTTENTOTS TO AN UNDERSTANDING OF AUSTRALOPITHECINE BONE ACCUMULATIONS

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(With 4 figures and 5 tables)

INTRODUCTION

It is appropriate that a collection of papers published in honour of Dr. V. FitzSimons should include one with a bearing on the South African fossil ape-men or australopithecines. During Dr. FitzSimons' directorship of the Transvaal Museum, between 1947 and 1966, spectacular discoveries of fossil ape-man remains were made in the Transvaal — discoveries which put the Transvaal Museum in the forefront of anthropological research. The success of this palaeontological programme was due, in no small measure, to the enthusiastic support which it received from Dr. FitzSimons. In this respect, physical anthropology owes him a considerable debt.

It is natural that most of the earlier work on the australopithecines should have been concerned with detailed anatomical description. Likewise, studies on the associated fauna were essentially taxonomic. By contrast the first analysis of a complete bone accumulation associated with fossil ape-men was published by Professor R. A. Dart ten years ago (Dart, 1957 a and b). His sample consisted of over 7,000 fossil bones found with *Australopithecus* at Makapansgat Limeworks and, in his study, Dart estimated the minimum numbers of different animals involved, as well as giving an analysis of the skeletal parts by which they were represented. The investigation brought to light some interesting and unexpected facts, to be discussed later in this paper.

Similar studies are now being made by the present writer on the bone accumulations from the other australopithecine caves of Sterkfontein, Swartkrans and Kromdraai. However, interpretations of this kind are much hampered by a lack of background information. The objectives are to reconstruct past events in the history of the fossils, to decide what animals were responsible for collecting the bones and to make deductions about the way of life of the early hominids.

The reconstruction of events from the remote past is always an indirect process. It is no longer possible to make direct observations on the feeding behaviour of the primitive people and carnivorous animals involved. Our conclusions as to what was done to such bones are based entirely on characteristics of the surviving relics — the fossils preserved in the cave breccias.

In such circumstances it is enormously helpful when contemporary situations can be found in which comparable events are taking place. Studies for instance on the feeding behaviour and food remains of various carnivores are proving invaluable in the reconstruction of events which took place a million years ago. Current research on the living bushmen of the Kalahari is bound to make possible more accurate evaluation of archaeological data.

A contemporary situation, which is proving of great value in the interpretation of fossils, exists in South West Africa. It is to be found in the Hottentot villages along the Kuiseb River, where food remains of these primitive people and their dogs are capable of explaining some of the problematic aspects of the bone accumulations associated with the South African fossil ape-men.

THE FOSSIL PROBLEM

The identification of animal species, based usually on anatomical features of their skulls, is a well-established procedure. However the study of complete bone accumulations, and the drawing of conclusions from them, is one which has received very little attention. When Dart (1957) made his study of the Makapansgat bone collection, no comparable analysis of a bone accumulation had been made elsewhere in Africa. There was virtually no information in the literature with which his results could be compared.

The Makapansgat study revealed some interesting and unexpected facts. The 7159 bone fragments analysed were found to represent parts of at least 433 animals; 293 of these were antelope, while the rest included a wide variety of animals among which were 45 baboons, 20 pigs, 17 hyaenas, 7 porcupines, and 5 ape-men or australopithecines. Dart concluded that the bones had been collected originally by the ape-men who had used them both as food and as tools.

It was found that 91.7% of all the bone fragments came from antelope, the 283 individual animals being made up as follows: 39 large (like roan or kudu), 126 medium (like wildebeest), 100 small (like gazelle) and 28 very small (like duiker). From the point of view of the overall bone accumulation, the antelope are by far the most important group and, in the present discussion, are the only animals which need concern us.

An analysis of the parts of the antelope skeletons found at Makapansgat revealed some unexpected facts. Parts of the skulls were, for instance, exceptionally common, making up 34.5% of all recognisable fragments. Vertebrae on the other hand were unaccountably rare, a total of only 163 (or 1.4% of what there should have been) being found. Among these scarce vertebrae, the first two neck ones (atlas and axis) were abnormally abundant, while tail vertebrae were not represented at all.

Similar remarkable disproportions were found in the limb bones, parts of the fore-limbs being much more abundant than those of the hind-limbs. Turning to individual bones in the legs, Dart found that some ends of such bones were more common than others. In the humerus, 336 distal ends were found but only 33 proximal ones, a ratio of 10:1. Similarly in the tibia, the ratio of distal : proximal ends was 119:64.

What do these disproportions mean? In an attempt to explain them, Dart suggested that the ape-men brought back only certain parts of the prey animals to the cave. They concentrated particularly on bones which made good tools: mandibles for saws and scrapers, distal humeri for clubs. Parts missing from the fossil collections were either not brought back at all or, as in the case of tails, were used for special purposes outside the cave. These served as "whips or signals in hunting".

When dealing with fossils, such speculations must inevitably remain speculations; there is no way of substantiating them. However, observations on contemporary situations can be illuminating. The food remains of Hottentots described in this paper suggest that the disproportions found by Dart at Makapansgat do not, in fact, require any special explanation. They follow a pattern which is to be anticipated when whole skeletons are subjected to destructive treatment.

THE KUISEB RIVER HOTTENTOTS AND THEIR FOOD REMAINS

Stretching across the Namib Plain from the escarpment in the east to Walvis Bay in the west is the Kuiseb River, dry throughout the year, except after sporadic rain. Scattered along its banks over a distance of about 100 miles are eight Hottentot villages, each consisting of a small group of beehive-shaped huts built from the bark of Acacia trees which grow in the river bed. These villages house a Topnaar Hottentot population of about 130, whose way of life, pedigree and blood-groups have been studied in some detail (Jenkins and Brain, 1967).

The Namib Plain, where it is traversed by the Kuiseb River, is extremely inhospitable. To the south is an immense area of high dunes while northwards featureless gravel plains extend for many miles. The result is that the human population is closely tied to the river-bed itself, from which water is obtained in shallow wells. The economy of the Hottentots is built around their goat herds and these, in turn, are dependent on the Kuiseb River for survival. They subsist very largely on the dry seed-pods of *Acacia albida* and villages are spaced in a linear fashion along the river, at intervals determined by the number of goats kept at each. In 1966 there was a total of aproximately 1750 goats in the Kuiseb villages. These provide the Hottentots with milk, meat and skins.

The aridity of the environment results in a general absence of vegetation around the villages. Occupational relics, such as bones, are easily seen and it was appreciated in 1966 that an analytical study of these bones could be of great interest from the point of view of fossil interpretation (Brain 1967 a). Although they have accumulated in natural circumstances, the situation is remarkably simple and controlled: perhaps 95% of all bones to be found round the villages came from goats, these being the only mammals normally used for meat. The bones are simply broken for extraction of marrow and are then discarded, no bone tool-use being practised. Once discarded, the bones are further gnawed by dogs, after which the remnants are left to bleach on the gravelly desert surface. Apart from Pied Crows, other scavengers are not involved.

Finally, the great merit of the Kuiseb River situation lies in the fact that the accumulation is constantly being added to and that the process can be observed directly. There can be no doubt as to what influences the bones have been subjected to; problematical aspects can be verified on the spot.

PROCESSES INVOLVED IN BUILDING UP THE BONE ACCUMULATION

Fairly detailed information on Hottentot butchering technique and eating habits is now available both from direct observation and from questioning of local people. An apparently typical goat-processing procedure will be described; these observations where made in the Zoutrivier village in February 1966. The goat was led to a particular tree where slaughtering is normally carried out. Several Hottentots held the goat down on its side while another cut its throat with a pocket-knife. The blood was caught in an enamel basin and fed to two waiting dogs who lapped it avidly. Once dead, the goat was suspended by its hind feet from an overhanging branch and the skin removed complete, being split along the mid-ventral line. along the insides of the limbs and round the neck just behind the horns. It was salted and pegged out in the shade. The abdominal cavity was opened next and the viscera removed; the stomach was slit open, its contents emptied out and its lining washed. This, together with the liver and kidneys, was said to be a delicacy. The intestine, once the contens had been squeezed out, was kept for the making of sausage. Other abdominal organs were fed to the dogs.

Turning again to the carcase, the front legs were removed complete with the scapulae; hind limbs were taken off with the innominate bones attached, by cutting through both the pubic symphysis and the sacro-iliac joints. The feet were severed from the legs at their metapodial/phalangeal joints; these were taken by the children who cooked them themselves over a fire.

Ribs on one side of the carcase were separated at their vertebral articulations. Finally the head was removed, a knife being used to sever the axis from the third cervical vertebra. The atlas and axis vertebrae remained attached to the occiput.

All meat is normally cooked before it is eaten, either by boiling in large metal pots or by direct roasting over the fire. The head was dealt with in a characteristic manner: the horns were broken off at their bases by a sharp blow from an axe and were discarded. The complete head was then boiled for several hours in a pot standing over the fire. All edible meat was picked from it and eaten, after which the brain-case was smashed in the occipital region with a hammer-stone for removal of the brain. The skull and mandibles were then passed on to the dogs.

As the eating progressed, all marrow-containing bones were broken. They were held on a rock anvil and hammered with another stone. Neither the anvil nor hammer-stone is an artefact in the usual sense of the word — they are simply suitable pieces of rock which happen to be at hand. The Hottentot habitually eat in a squatting attitude on the ground. Typical utensils are small pocket-knives, rock anvils and hammer-stones.

Once discarded by the Hottentots, the goat bones were gnawed sporadically for many days by the dogs, all of which were jackal-like in size (for a photograph of one of these dogs, see Brain 1967 a). In 1966 it was found that a total of 40 dogs were kept at the eight Kuiseb River villages. Jackals themselves are now extremly rare in this part of the desert and do not seriously enter into the picture.

Pied Crows are fairly common along the Kuiseb River and, when they can, will certainly carry off scraps of meat, sometimes with bones adhering to them. On one occasion in 1966, a crow was seen flying from the Zoutrivier village with most of a goat's tail in its bill.

When, lying in fully exposed positions on the gravel surface bone fragments become bleached and degreased within three months. Exposure to the sun results in weathering of the bone surface and a soft, chalky superficial layer develops. Gnawing of the bones by gerbils of the genus *Desmodillus* (whose burrows are often concentrated around old goat kraals) is not uncommon. Where bones lie on sand which is constantly disturbed by the feet of animals, a remarkable polish may develop on their surfaces (see Brain 1967 b).

The feeding behaviour of Kuiseb River Hottentots is a mixture of long-standing tradition and European influence. The anvils and hammer-stones are perhaps atypical of Stone Age counterparts in that they are not specifically fashioned for their purpose. Folding pocket-knives, enamel basins and iron cooking-pots appear to be standard equipment in all the villages. The use of bones as tools was not practised by any of the Hottentots living in the villages at the time of the study.

It seemed advisable to be able to seperate the damage done to goat bones by Hottentots themselves from that caused by their dogs. A goat was consequently bought from one of the inhabitants of the Zoutrivier village and was then given back to the people of the community. Over two days they consumed, in their traditional manner, all that was edible of the goat and returned the bones without allowing their dogs access to them. The goat was a young male, estimated to be one year old, in which the second molar teeth were about to erupt. The following is a summary of the observed damage to the skeleton:

Skull:	the 7-inch horns were broken off at their bases to allow cooking of the head; the occiput was smashed to allow removal of the brain; snout and palate were broken off as a unit; mandible undamaged.
Vertebrae:	the head was removed by chopping through the axis; the atlas and part of the axis remained attached to the occiput. Very little damage was done to the other cervicals. Thoracic vertebrae suffered fairly extensive damage to their dorsal spines and transverse processes.
	Lumbars: slight damage to transverse processes.
	Sacrum: undamaged.
	Caudal: only the first survived, all the rest had been chewed and eaten.
Ribs:	slight damage to their distal ends only.
Scapula:	undamaged.
Pelvis:	chopped through pubic symphysis and across actabula. No other damage.
Humerus:	both shafts were broken transversely through their middles for extraction of marrow. One proximal end was completely chewed away, one left complete; both distal ends were undamaged.
Radius and ulna:	both severely shattered by stone impact.
Femur:	heads and trochanters removed and proximal shaft ends chewed; both shafts were broken through the middle; both distal epiphyses removed and distal shaft ends chewed.
Tibia:	both shafts were broken through middle. Some damage to each end.
Metapodials:	all four proximal ends complete; all distal epiphyses removed and distal shaft ends chewed back severely.
Carpal and tarsal bones:	undamaged.
Phalanges:	undamaged.

Apart from the results of stone impact, it was surprising to find that the Hottentots are capable of inflicting quite considerable damage to bones with their teeth. Fifteen tail vertebrae were chewed and swallowed, while limb bones, such as femora and metapodials suffered severely at their ends. It is doubtful if the condition of Hottentot teeth would be as good as that of hunter-gatherer peoples. The staple Hottentot diet, apart from occasional meat, is mealie-meal porridge which very likely results in accellerated dental decay. It is to be expected that Stone Age people would have done even greater damage to bones with their teeth than is the case with Kuiseb River Hottentots.

THE COMPOSITION OF THE BONE ACCUMULATION

During 1966 and 1967 a collection of 2373 goat bone fragments was made in the Hottentot villages along the Kuiseb River. This collection has been described elsewhere (Brain 1967 a) and is made up of parts shown in Table I.

The minimum number of individual goats which contributed to the sample is, when estimated on horns, 190. Since the bone accumulation was originally described, it has been found that the figure of 190 is deceptively high. The reason for this is as follows: in the extreme aridity of the Kuiseb River environment, horn is almost indestructible and lasts for many years after the last trace of bone has disappeared. Part of the original sample came from two deserted village sites which had not been occupied for over ten years. These yielded horns to the almost complete exclusion of other skeletal parts.

The average rainfall on the Kuiseb study area is less than 1 inch per year. In more normal climatic areas, with rainfalls of over 10 inches per annum, horn disappears rapidly, exposing the bony core which is composed of easily destructive spongy bone. It is now obvious that, while the goat bone sample is being considered as an entity in itself, horns may reasonably be included; nevertheless, if it is to be used for comparison with bone accumulations from other areas, the incidence of horns will appear deceptively high.

The purpose of the present communication is to compare the goat bone sample with a fossil accumulation from Makapansgat. There is evidence that although the Makapansgat climate was drier than it is today (Brain 1958), it certainly did not approach the aridity of the Namib Plain. For purposes of discussion therefore, horns will be omitted from the bone accumulations under review.

Following horns, the most numerous single skeletal parts present are mandibles. It was found that the 188 fragments could be divided into 53 left-

TABLE I:

	Skeletal part		Totals
Skull	Horns and cores	385	
	Cranial fragments	70	
	Maxillary fragments	57	512
Mandible	Complete half mandibles	38	
	Mandibular fragments	150	188
Loose teeth		15	15
Vertebrae	1st cervical (atlas)	12	
	2nd cervical (axis)	14	
	Other cervical	12	
	Thoracic	21	
	Lumbar	31	
	Sacral	1	
	Caudal	0	
	Fragments	24	115
Ribs		174	174
Scapula	Head portion	28	
	Other fragments	31	59
Pelvis	Acetabular portion	34	
	Other fragments	21	55
Humerus	Proximal ends	0	
	Distal ends	82	
	Shaft fragments	114	196
Radius+ulna	Complete bones	3	
	Proximal ends	62	
	Distal ends	19	
	Shaft fragments	123	207
Femur	Proximal ends	18	
	Distal ends	9	
	Shaft fragments	88	115
Tibia	Proximal ends	13	
	Distal ends	72	
	Shaft fragments	152	237
Metacarpal	Complete bones	8	
	Proximal ends	24	
	Distal ends	15	
	Shaft fragments	53	100
Metatarsal	Complete bones	9	
	Proximal ends	30	
	Distal ends	11	
	Shaft pieces	51	101
Astragulus	Complete	16	16
Calcaneum	Complete	14	14
Phalanges	Complete	21	21
Bone flakes		248	248
			2373

mandibles and 64 right half ones. These indicate a minimum of 64 individual goats which have contributed to the sample. Following ageing criteria quoted by Cornmall (1956) for sheep, the age structure of the sample has been worked out from the mandibles. The ageing criteria used are as follows:

1st molar unerupted:	under 6 months.
1st molar in use; 2nd unerupted:	6—12 months.
2nd molar in use; 3rd unerupted:	12—20 months.
3rd molar in use:	over 20 months.

On this basis, indicated ages for the left and right mandibles are given in Table II.

TABLE II:

Age class	Number of goats	
	Left side	Right side
Under 6 months	1	0
6—12 months	17	23
12—20 months	7	6
over 20 months	28	35
Totals	53	64

The age-groups are plotted graphically in Figure 1. It is clear that goats are slaughtered predominantly either when young, less than one year of age, or when fully adult at two or more years old. Such indications are confirmed by verbal statements of the Hottentots. As a generalisation one may say that almost half the goats represented in the bone sample are immature animals.

The combined feeding action of Hottentots and dogs on the bones has resulted in the disappearance of some parts of the skeletons and survival of others. It has also resulted in some very characteristic damage to certain parts. Such damage will now be considered briefly:

Skull: the brain-case has been broken open by stone impact to allow removal of the brain. In most cases the occiput or floor of the skull has been broken out resulting in the production of a receptacle-like fragment (figured in Brain 1967 a, Plate III). At Makapansgat, Dart (1957 b) has suggested that bowl-like skull fragments have been used as receptacles. Among the goat bones, their presence and form is clearly coincidental. In most cases the palates have been detached from the brain-cases complete; mandibles are

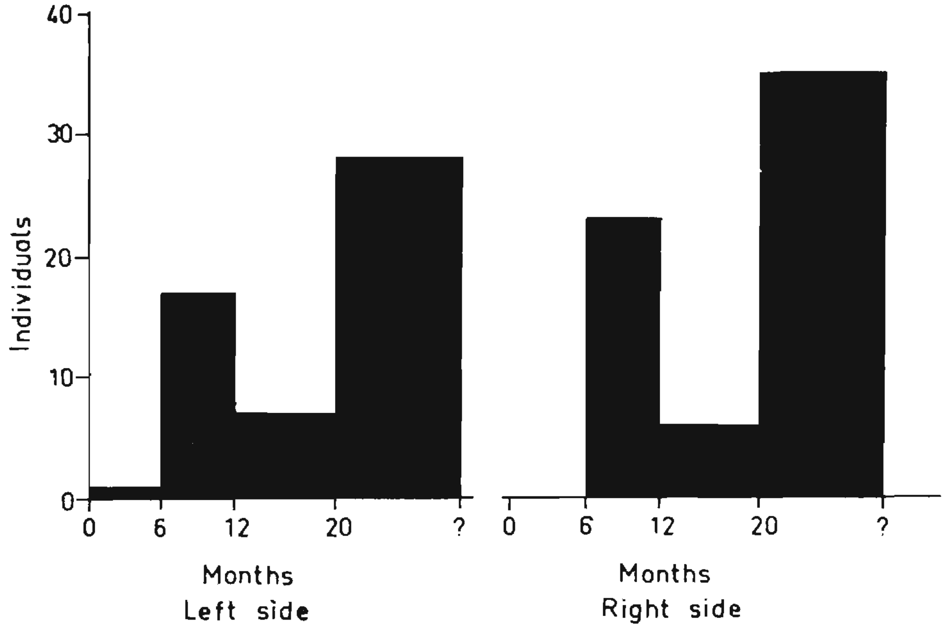

Figure 1: Histogram showing the numbers of individual goats in each age class as estimated by tooth-eruption in left and right half-mandibles.

generally little damaged except round their angles and lower margins.

Vertebrae: these show damage particularly on their spines and processes.

Ribs: these have generally been chewed at both ends.

Scapulae: extensive damage has normally been done to the flat blades.

Pelves: these have characteristically been gnawed down to little more than acetabular portions.

Damage to limb bones is reflected best by the presence or absence in the sample of their ends (to be discussed shortly). Shafts have typically been broken through by hammer-stone impact and spiral fractures are common (see Brain 1967 a, Plate III). Such fractures are a feature noted by Dart at Makapansgat.

Carpal, tarsal and phalangeal bones, when they occur, are typically undamaged.

SURVIVAL AND DISAPPEARANCE OF SKELETAL PARTS

The survival of parts of the goat skeletons in the sample under review is clearly based on the durability of such parts. Certain elements in the skeletons disappear when subject to the combined chewing of Hottentots and their dogs, others do not. The percentage survival of different parts is therefore a measure of their resistance to this kind of destruction.

Working on a minimum number of 64 individual goats it is possible to calculate the original number of each skeletal part which must have existed and from this one may estimate the percentage survival of the part in the sample.

In the case of ribs for instance, 26 of which are found in a single goat skeleton, the original number contributed by 64 goats must have been 1664. Only 170 have been found, indicating a 10.2% survival.

Table III shows different parts of the goat skeleton arranged in descending order of survival. These results are plotted graphically in Figure 4 (a). It will be seen that the parts most resistant to destruction are mandibles and distal ends of humeri. These are the most numerous. Proximal ends of humeri and caudal vertebrae have proved so vulnerable as to have disappeared entirely.

THE PREDICTABLE PATTERN OF SURVIVAL IN LIMB-BONES

It is clear that those parts of the goat skeletons which survive best are the unchewable ones. Nevertheless in the case of limb-bones, percentage survival can be related in quantitative terms to particular qualities. In the case of the humerus for instance, survival of the proximal end is nil, while that of the distal end amounts to 64.0%. As has previously been discussed (Brain 1967 a), survival of part of a long-bone can be related to the times at which each

TABLE III:

Part	Number found	Original number	% Survival
Half mandibles	117	128	91.4
Humerus, distal	82	128	64.0
Tibia, distal	72	128	56.3
Radius & Ulna, proximal	65	128	50.8
Metatarsal, proximal	39	128	30.4
Scapula	35	128	27.4
Pelvis, half	34	128	26.6
Metacarpal, proximal	32	128	25.0
Axis	14	64	21.9
Atlas	12	64	18.8
Metacarpal, distal	23	128	18.0
Radius & Ulna, distal	22	128	17.2
Metatarsal, distal	20	128	15.6
Femur, proximal	18	128	14.1
Astragalus	16	128	12.5
Calcaneus	14	128	10.9
Ribs	170	1664	10.2
Tibia, proximal	13	128	10.1
Lumbar vertebrae	31	384	8.1
Femur, distal	9	128	7.0
Cervical 3—7 vertebrae	12	320	3.8
Phalanges	21	768	2.7
Thoracic vertebrae	21	832	2.5
Sacrum	1	64	1.6
Caudal Vertebrae	0	1224	0
Humerus, proximal	0	128	0

epiphysis fuses to the shaft. In the case of the goat, the distal epiphysis fuses when the animal is four months old; fusion of the proximal end is not complete until 17 months. This means that when a year-old goat is eaten, the distal end of the humerus will be fully ossified and unchewable, while the proximal end remains cartilagenous.

In addition to fusion times, structural considerations are very important. The proximal end of the humerus is wide, thin-walled and filled with spongy bone; the distal end is comparatively narrow and compact. Such qualities may be expressed quantitatively, in terms of Specific Gravity of each end of the bone. Experimental procedure is as follows. The shaft of a dry, defatted humerus is cut through at right angles to its axis, midway along the length of the bone. Each end is weighed individually, the cut ends of the hollow shaft are then filled with plasticine. Any other openings are similarly filled. The volume of each end is then measured by submersion in water and Specific Gravities are calculated. It is found that the proximal end of a goat humerus has a S. G. of approximately 0.6; that of the distal end is about 1.0. There is a clear and

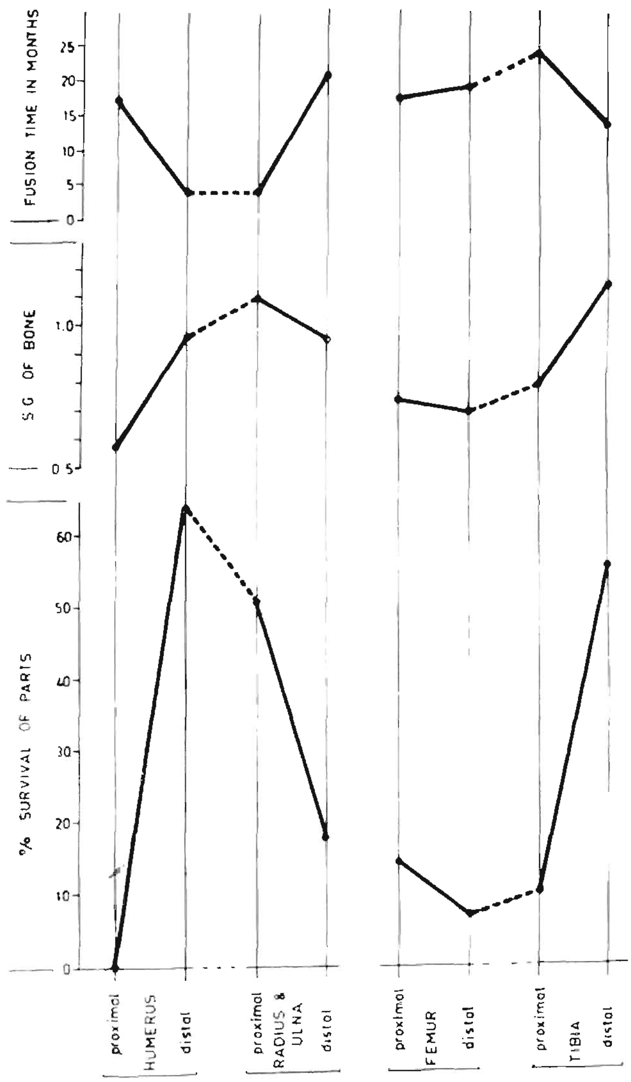

Figure 2: Graphical representation of certain qualities of the proximal and distal ends of goat limb bones. Percentage survival of each part is related to its Specific Gravity and the age at which its epiphysis fuses to the shaft.

direct relationship between Specific Gravity of the end of a long bone and its percentage survival.

Table IV gives figures for percentage survival, Specific Gravity and fusion time (based on Smith 1956) for each end of the goat limb-bones listed. These figures are plotted in Fig. 2. It will be seen that percentage survival is related directly to Specific Gravity of the part concerned, but inversely to the fusion time expressed in months.

The conclusion to be drawn is simply that survival is not haphazard, but is determined by inherent qualities of the parts.

TABLE IV:

Part	% Survival	S.G.	Fusion time (months)
Humerus:			
proximal	0	0.58	17
distal	64.0	0.97	4
Radius & Ulna: proximal	50.8	1.10	4
distal	17.2	0.97	21
Femur:			
proximal	14.1	0.75	18
distal	7.0	0.72	20
Tibia:			25
proximal	10.1	0.82	
distal	56.3	1.17	15

TABLE V:

Part	Number found	Original number	% Survival
Half mandibles	369	586	62.9
Humerus, distal	336	586	57.3
Radius & Ulna, proximal	279	586	47.6
Metacarpal, distal	161	586	27.4
Metacarpal, proximal	129	586	22.0
Scapula	126	586	21.5
Tibia, distal	119	586	20.3
Radius & Ulna, distal	114	586	19.5
Metatarsal, distal	110	586	18.8
Metatarsal, proximal	107	586	18.3
Pelvis, half	107	586	18.3
Calcaneus	75	586	12.8
Tibia, proximal	64	586	10.9
Astragalus	61	586	10.4
Femur, distal	56	586	9.6
Axis	25	293	8.5
Atlas	20	293	6.8
Humerus, proximal	33	586	5.6
Sacrum	16	293	5.5
Femur, proximal	28	586	4.8
Cervical 3—7 vertebrae	47	1465	3.2
Lumbar vertebrae	30	1758	1.7
Phalanges	47	3516	1.3
Ribs	66	7618	0.9
Thoracic vertebrae	24	3809	0.6
Caudal vertebrae	1	4688	0

SURVIVAL OF PARTS IN THE MAKAPANSGAT BONE SAMPLE

Dart's (1957) analysis was based on remains from 293 antelope. His estimation of minimum numbers of individual animals of different sizes was as follows:

Large antelope, based on 74 radial fragments: 39 individuals
Medium antelope, based on 238 humeral fragments: 126 individuals
Small antelope, based on 191 mandible fragments: 100 individuals
Very small antelope, based on 53 mandible fragments: 28 individuals

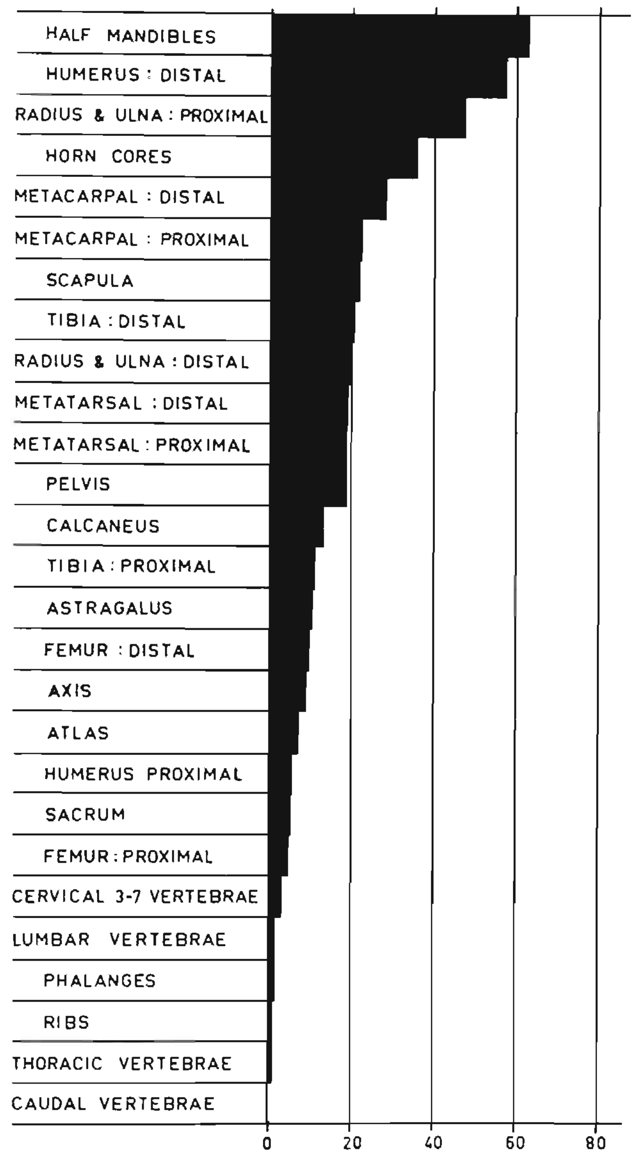

Figure 3: Histogram showing the percentage survival of parts of bovid skeletons from Makapansgat. The sample consists of bones from a minimum number of 293 individuals.

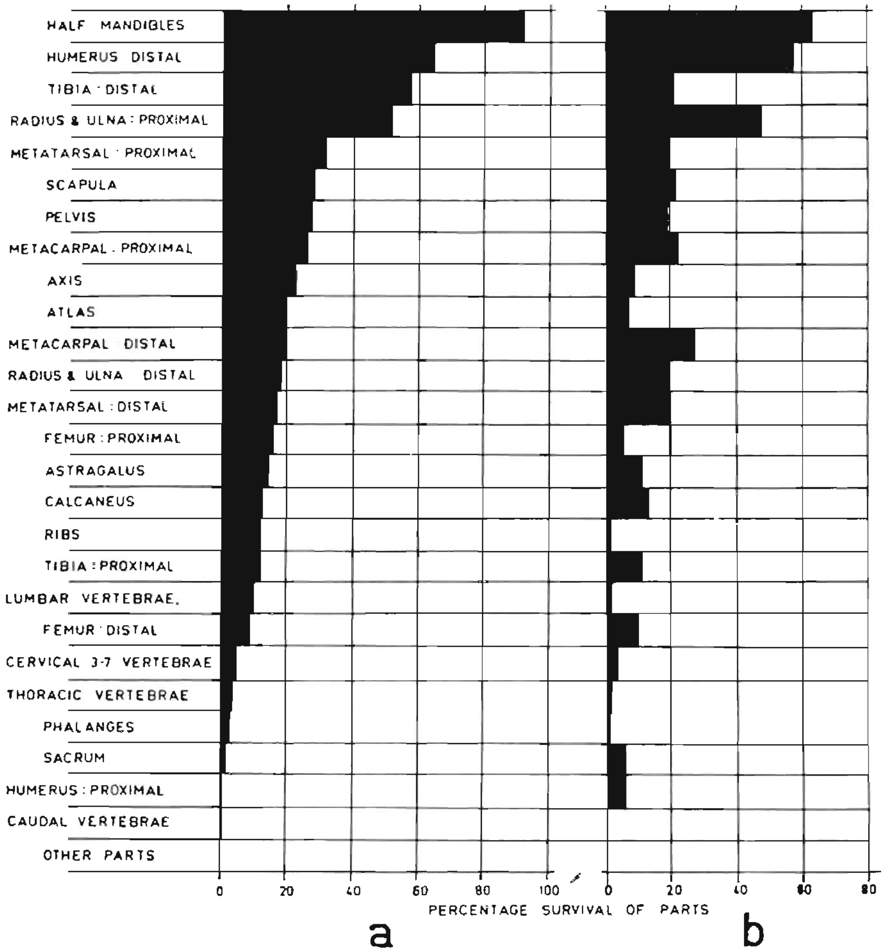

Figure 4: a) Histogram showing percentage survival of parts of goat skeletons from the Kuiseb River. Calculations are based on a minimum of 64 individuals.
b) Percentage survival of parts of bovid skeletons from Makapansgat, arranged in the same order as for (a).

Using the total number of 293 individuals, it has been possible to calculate the percentage survival of different parts of the skeleton, as has been done for the Kuiseb River goat bones. Skeletal parts, listed in descending order of survival are given in Table V and plotted graphically in Figure 3.

THE MAKAPANSGAT/GOAT COMPARSION

The order of survival of different skeletal parts in the goat bone sample is plotted graphically in Figure 4 (a); that of the Makapansgat antelope remains in Figure 3. It will be seen that the form of the two histograms is similar. In both, the parts with the highest percentage survival are mandibles, followed by distal humeri. At the lower end of the survival curve in both collections are such parts as thoracic and caudal vertebrae. In spite of the broad similarity between the form of the two histograms, the detailed order of survival of parts differs in the two cases.

For the purposes of direct comparison, the percentage survival figures for the Makapansgat are replotted in Figure 4 (b) so that they follow the order laid down by the goat bones. It will be seen that although the two histograms are not identical, the trends in survival order are broadly similar.

When comparing these results it should be borne in mind that the Makapansgat sample is made up of bones from animals ranging in size from Eland to Steenbok. They have almost certainly been subjected to destructive treatment of a variety of kinds, including feeding and tool-using activities of australopithecines, as well as scavenging by carnivores. By contrast, the goat-bone sample is made up of bones from one species of small bovid, subject only to feeding activities of men and domestic dogs. In view of this, the overall similarity in composition of the bone collections is remarkable. It is a reflection of the predictable pattern of survival which manifests itself when whole bovid skeletons are subjected to destructive treatment.

CONCLUSIONS

In his pioneering study on the bone accumulation at Makapansgat, Dart found serious disproportions in the parts of skeletons preserved as fossils. Certain parts were common, others were hardly represented at all. In an attempt to explain these disproportions Dart (1957 a and b) postulated that the missing bones were simply not brought back to the cave at all by the resident australopithecines. He writes "the disappearance of tails was probably due to their use as signals and whips in hunting outside the cavern. Caudal and other vertebrae may also have disappeared because of the potential value of their bodies as projectiles and of their processes (when present) as levers and points" (Dart 1957 b page 85). Likewise, "the femora and tibiae would be the heaviest clubs to use outside the cavern; that is probably why these bones are the least common. Humeri are the commonest of the long bones; probably because they would be the most convenient clubs for the woman-folk and children to use at home".

The evidence of the Kuiseb River goat bones strongly suggests that the disproportions which Dart encountered do, in fact, not require any special explanation. Artificial selection of certain skeletal parts need not be postulated. If for instance, antelope were hunted as they came to drink at a waterhole in the entrance of the cave and were then consumed by australopithecines and scavenging carnivores, a considerable bone accumulation could have been built up in the lower parts of the cavern. The bones preserved would have been those best able to survive the destructive treatment to which they had been subjected. The Makapansgat sample, like that from the Kuiseb River, does in fact consist of resistant skeletal elements, whose frequencies follow a predictable pattern.

ACKNOWLEDGEMENTS

I would like to express my appreciation to Professor Dart for many stimulating discussions on the Makapansgat bones. These have served to convince me of the important role which *Australopithecus* played both as a predator and tool-user at the site.

Grateful acknowledgement is also made to the Wenner-Gren Foundation for Anthropological Research in New York and the South African C.S.I.R. for their support of this research.

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