

The Mammalian Fauna from Redcliff Cave, Zimbabwe

Author(s): Kathryn Cruz-Uribe

Source: *The South African Archaeological Bulletin*, Vol. 38, No. 137 (Jun., 1983), pp. 7-16

Published by: South African Archaeological Society

Stable URL: <https://www.jstor.org/stable/3888210>

Accessed: 27-01-2019 18:44 UTC

## REFERENCES

Linked references are available on JSTOR for this article:

[https://www.jstor.org/stable/3888210?seq=1&cid=pdf-reference#references\\_tab\\_contents](https://www.jstor.org/stable/3888210?seq=1&cid=pdf-reference#references_tab_contents)

You may need to log in to JSTOR to access the linked references.

---

JSTOR is a not-for-profit service that helps scholars, researchers, and students discover, use, and build upon a wide range of content in a trusted digital archive. We use information technology and tools to increase productivity and facilitate new forms of scholarship. For more information about JSTOR, please contact [support@jstor.org](mailto:support@jstor.org).

Your use of the JSTOR archive indicates your acceptance of the Terms & Conditions of Use, available at <https://about.jstor.org/terms>



JSTOR

*South African Archaeological Society* is collaborating with JSTOR to digitize, preserve and extend access to *The South African Archaeological Bulletin*

# THE MAMMALIAN FAUNA FROM REDCLIFF CAVE, ZIMBABWE

KATHRYN CRUZ-URIBE

Department of Anthropology, University of Chicago  
Chicago 60637

## ABSTRACT

A large sample of animal bones from later Pleistocene deposits at Redcliff Cave (Zimbabwe) is analyzed in terms of three successive culture-stratigraphic units: Earlier Bambata, Later Bambata, and Tshangula. Stone Age people accumulated most of the Bambata bones, and a portion of the Tshangula ones, while hyaenas contributed the rest. Species frequency fluctuations throughout the long sequence probably reflect broad environmental change in the region. The Earlier Bambata and Tshangula periods appear to have been cool/wet, while the intervening Later Bambata period was comparatively warm/dry.

The Redcliff inhabitants exploited a wide variety of ungulates. Age profiles of the most common species indicate that Bambata people hunted alcelaphine antelopes by driving them into some kind of trap or surround where individuals of various ages were caught in proportion to their live abundance. Zebra, on the other hand, were probably hunted individually, resulting in the capture of relatively few prime-age adults. Definitive statements about Tshangula hunting practices cannot be made due to small sample sizes and the fact that some bones were not accumulated by people.

## The Site

Zimbabwe has a rich Stone Age record, but until recently most research focused on stone artefacts. Relatively little has been done on associated animal remains, largely because many key sites yielded little or no bone. Redcliff Cave is a striking exception. The large sample of bones from this site offers a nearly unique opportunity to examine Late Pleistocene man-animal interactions in Zimbabwe.

Redcliff (19°01'S; 29°46'E) is located in the Zimbabwe Midlands, about halfway between Harare and Bulawayo (Fig. 1).

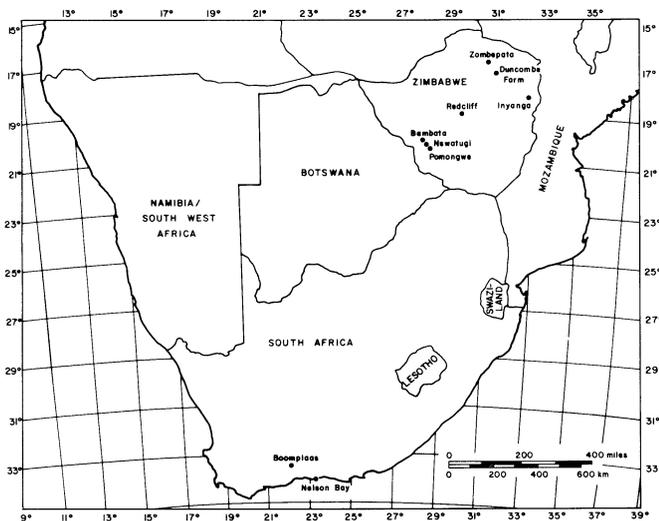


Fig. 1. Map of southern Africa showing approximate locations of sites mentioned in the text.

Brain and Cooke excavated the site between 1964 and 1966 (Brain & Cooke 1967), and Cooke (1978) later described the artefacts. Brain (1967, 1969) discussed the formation of the cave, its geological setting and the sediment profile.

Brain believed the cave floor originally sloped gently back from the entrance, and then dropped off sharply, forming a hollow more than 20 m deep and 8-9 m across. The hollow was filled by detritus introduced from the front of the cave. Since the detritus accumulated on a talus slope, the layers within it were steeply in-

clined. The base of the deposit was archaeologically sterile, but the top 10 m was rich in artefacts and bones.

A Late Pleistocene age for the entire Redcliff deposit is suggested by the artefacts and radiocarbon dates and supported by the essentially modern character of the fauna (see below). The profile is divided into two parts by a rockfall, with Bambata (=Stillbay) horizons below and Tshangula (=Magosian) above. Bambata assemblages are known from many sites in Zimbabwe, and it is clear that they belong to the Middle Stone Age (MSA) as this is traditionally defined in southern Africa. Like other MSA assemblages, the Bambata ones at Redcliff all lie beyond 30-40 000 B.P., the conventional limit of radiocarbon dating (Brain 1969; Vogel 1970; Cooke 1971; Sheppard & Swart 1971).

Tshangula industries are more difficult to place in the traditional cultural stratigraphy. This is because the name 'Tshangula' has been applied to a number of different industries, some of which are older than 40 000 B.P. and have MSA affinities, while others are younger than 20 000 B.P. and contain elements usually regarded as Later Stone Age (LSA) (Walker 1980; Volman 1981, in press). The Redcliff Tshangula may have affinities to the 'older' Tshangula group (Volman, in press). Cooke emphasized the continuity between the Redcliff Bambata and Tshangula, and in fact did not recognize a distinct Tshangula 'industry', but only a Tshangula phase of the basically MSA Bambata industry. Cooke's assessment is supported by the absence of bone artefacts and other LSA elements in the Redcliff Tshangula deposits. However, it remains possible that the Tshangula at Redcliff is an early LSA variant, as suggested by a radiocarbon determination of 25 650 ± 1800 B.P. (I-3726).

The Redcliff profile can be analyzed in terms of three successively younger culture-stratigraphic units: Earlier Bambata, Later Bambata and Tshangula. The distinction between the Tshangula (above) and Bambata (below) is based on artefacts (following Brain 1969). The break between the two Bambata phases is based on an abrupt increase in bone at the top of the 'Earlier' Bambata, following a series of spits in which bone was relatively sparse. A multivariate (principle components) analysis of the faunal contents of successive spits supports the tripartite subdivision of the Redcliff deposit.

## Identification and Counting of the Bones

The present report is based on an initial sorting of the fauna by Klein (1978b) and on my own more detailed analysis of the super-abundant ungulate teeth. The Redcliff bones are highly fragmented and even the teeth occur mainly as isolated specimens, rarely situated in mandibles or maxillae (Table 1). This complicates iden-

Table 1. The total number of teeth and the number of teeth still in either mandibular or maxillary bone of the common ungulate species at Redcliff.

Species	Total	
	Number of Teeth	Number of Teeth in Mandibles or Maxillae
Blesbok/bontebok	381	9 (2,3%)
Tsessebe/hartebeest	612	4 (0,6%)
Mountain reedbeek	145	4 (2,7%)
Common springbok	69	5 (6,8%)
Impala	106	4 (3,6%)
Roan/sable antelope	79	0 (0,0%)
Zebra	632	5 (0,8%)
Giant Cape horse	68	3 (4,2%)
Warthog	121	1 (0,8%)

tification, especially since the fauna may contain several pairs or groups of closely related species whose isolated teeth are difficult or impossible to separate. These groups include: (1) roan and sa-

ble antelope; (2) medium size alcelaphines - Lichtenstein's hartebeest, tsessebe, Cape hartebeest, and black wildebeest; and (3) southern and mountain reedbucks. In order to check the possibility of species mixture among morphologically indistinguishable teeth, the basal breadth of each tooth was measured (Fig. 3). It was assumed that species mixture in any dental sample would be reflected by a high coefficient of variation (CV) (Simpson *et al.* 1960).

Table 2 shows that for the hippotragines and reduncines, CV is

Table 2. Sample size (N), mean ( $\bar{x}$ ), standard deviation (s) and coefficient of variation ( $CV=100s/\bar{x}$ ) for measurements of basal breadth on Redcliff bovid mandibular third molars. In each case, the high CV suggests that more than one species is probably present.

Group	N	$\bar{x}$ (mm)	s	CV	Probable species present
Hippotragines	12	13,8	1,85	13,66	roan and sable antelope
Reduncines	14	8,3	2,51	30,23	mountain reedruck, southern reedruck
Medium Alcelaphines	23	10,8	0,80	7,87	tsessebe, Lichtenstein's hartebeest, Cape hartebeest <i>Alcelaphus caama</i> , black wildebeest ( <i>Connochaetes gnou</i> )

greater than 10, a figure that definitely suggests samples that comprise more than one species. Unfortunately, only in the case of the reedruck sample do the crown breadth measurements form two distinct clusters, providing a basis for sorting the teeth into discrete categories (species). Although the alcelaphine CV is less than 10, it is still high, and again it is likely that more than one species is present. The lower value of the CV simply reflects the fact that the species present are more similar in size than the reedruck or the roan and sable antelope.

The skeletal element frequencies for the various taxa identified at Redcliff are presented in Tables 3-12. Counts for the post-cranial bones are from Klein's earlier analysis. For the mandible and maxilla, the number comprises the number of intact teeth plus an estimate of the number of whole teeth represented by fragments (fractions). For other skeletal elements the numbers are simply the numbers of fragments assigned to each body part.

Table 3. The number of bones per skeletal element by which hedgehog (*Erinaceus frontalis*), hares (Leporidae), springhare (*Pedetes capensis*), and porcupine (*Hystrix africae australis*) have been identified at Redcliff. All excavation units are combined.

	Hare(s)		Springhare	Porcupine
	Hedgehog	small		
Edentulous mandible	1	—	—	—
Complete or fragmentary dentitions	—	21	—	6
Humerus-distal	—	2	—	—
Radius-proximal	—	5	2	—
Metacarpal-proximal	—	2	1	—
Phalanges-first	—	—	—	2
Ilium	—	5	3	—
Ischium	—	3	—	—
Pubis	—	1	—	—
Femur-proximal	—	1	—	—
-distal	—	2	—	—
Tibia-distal	—	1	—	—
Calcaneum	—	5	1	—
Astragalus	—	3	—	—
Metatarsal-distal	—	1	1	—

Table 4. The number of bones per skeletal element by which pangolin (*Manis temmincki*), baboon (*Papio ursinus*), people (*Homo sapiens*), and jackal (*Canis cf. mesomelas*) have been identified at Redcliff. All excavation units are combined.

	Pangolin	Baboon	Homo	Jackal
Maxilla	—	4	5	11
Mandible	—	1	—	5
Indet. maxillary or mandibular dentition	—	22	—	1
Atlas	—	—	1	—
Axis	—	—	—	2
Humerus-distal	—	—	—	1
Radius-proximal	—	—	—	1
Ulna-proximal	—	—	1	—
Metacarpal-proximal	—	—	—	1
Phalanges-first	—	1	—	2
-third	—	—	2	—
Metatarsal-proximal	—	1	—	—
Indet. metapodial	1	—	—	—

Table 5. The number of bones per skeletal element by which silver fox (*Vulpes chama*), hunting dog (*Lycan pictus*), ratel (*Mellivora capensis*), and otter (cf. *Aonyx*) have been identified at Redcliff. All excavation units are combined.

	Silver Fox	Hunting Dog	Ratel	Otter
Maxilla	1	2	—	—
Mandible	3	—	—	—
Indet. maxillary or mandibular dentition	—	2	—	—
Metacarpal	—	—	—	1
Calcaneum	—	—	1	—
Metatarsal	—	—	—	1
Distal Metapodial	—	—	—	2

Table 6. The number of bones per skeletal element by which civet (cf. *Viverra*), white-tailed mongoose (*Ichneumia albicauda*), banded mongoose (*Mungos mungo*) and indeterminate Viverrids (Viverridae gen. et spp. indet.) have been identified at Redcliff. All excavation units are combined.

	Civet	White-tailed	Banded	Indet. Viverrids	
		Mongoose	Mongoose	small	medium
Mandible	3	1	1	1	1
Radius-proximal	—	—	—	2	—
Metacarpal	—	—	—	1	—
Tibia-distal	—	—	—	1	—

Table 7. The number of bones per skeletal element by which spotted hyaena (*Crocuta crocuta*), brown hyaena (*Hyaena brunnea*), indeterminate hyaenids *Hyaenidae* and wildcat (*Felis libyca*) have been identified at Redcliff. All excavation units are combined.

	Hyaenidae			
	Spotted Hyena	Brown Hyena	Indet.	Wildcat
Maxilla	4	1	—	1
Mandible	1	9	—	1
Indet. maxillary or mandibular dentition	3	2	7	—
Radius-proximal	—	—	1	—
Ulna-proximal	—	—	1	—
Phalanges-first	—	—	3	—
-second	—	—	1	1
Femur-distal	—	—	1	—
Metapodial-proximal	—	—	1	—
-distal	—	—	—	2

Table 8. The number of bones per skeletal element by which caracal/serval (*Felis caracal* aut *serval*), lion *Panthera leo*, leopard (*Panthera pardus*), and indeterminate carnivores (Carnivora gen. et spp. indet.) have been identified at Redcliff. All excavation units are combined.

	Carcal/ Serval	Lion	Leopard	Indet. Carnivores	
				Small	Medium
Maxilla	4	3	3	—	—
Mandible	2	5	1	2	3
Indet. maxillary or mandibular dentition	—	2	1	2	—
Lumbar Vertebrae	—	—	—	2	6
Thoracic Vertebrae	—	—	—	—	4
Humerus-proximal	—	—	—	—	1
Radius-proximal	—	—	—	1	2
-distal	—	—	—	—	1
Ulna-proximal	—	—	—	3	2
Carpals	—	—	1	—	—
Metacarpal	—	—	—	—	1
Phalanges-first	—	—	1	3	1
-second	—	—	1	—	1
Femur-proximal	—	—	—	1	—
-distal	—	—	—	—	1
Tibia-proximal	—	—	—	—	1
-distal	—	—	—	2	—
Patella	—	—	—	—	1
Calcaneum	—	—	—	1	1
Astragalus	—	—	—	—	1
Metapodial-proximal	—	—	—	2	4
-distal	—	—	—	2	4

Table 9. The number of bones per skeletal element by which aardvark (*Orycteropus afer*), tree hyrax (*Dendrohyrax arboreus*), rock hyrax (*Procavia capensis*), and elephant (*Loxodonta africana*) have been identified at Redcliff. All excavation units are combined.

	Hyraxes			
	Aardvark	Tree	Rock	Elephant
—	Maxilla	4	143	—
Mandible	—	—	74	—
Indet. maxillary or mandibular dentition	—	—	—	21
Scapula	—	—	2	—
Humerus-proximal	—	—	1	—
distal	—	—	9	—
Ulna-proximal	—	—	2	—
-distal	—	—	1	—
Phalanges-first	1	—	—	—
-second	1	—	—	—
-third	2	—	—	—
-lateral third	1	—	—	—
Ilium	—	—	2	—
Ischium	—	—	1	—
Pubis	—	—	1	—
Femur-proximal	—	—	2	—
-distal	—	—	1	—
Tibia-distal	—	—	1	—
Calcaneum	—	—	1	—
Metapodial-proximal	—	—	3	—
-distal	—	—	2	—

Table 10. The number of bones per skeletal element by which zebra (*Equus burchelli*), "giant Cape horse" (*Equus capensis*), white rhinoceros (*Ceratotherium simum*) and indeterminate rhinoceros (Rhinocerotidae gen. et spp. indet.) have been identified at Redcliff. All excavation units are combined.

	Zebra	Giant Cape Horse	White Rhinoceros	Indeterminate Rhinoceros
	Occipital Condyle	2	—	—
Maxilla	321	45	1	—
Mandible	311	23	3	—
Indet. maxillary or mandibular dentition	—	—	4	1
Atlas	4	—	—	—
Axis	1	—	—	—

Cervical Vertebrae 3-7	1	—	—	—
Lumber Vertebrae	1	—	—	—
Caudal Vertebrae	2	—	—	—
Humerus-proximal	—	1	—	—
Radius-proximal	1	—	—	—
Carpals	17	—	—	—
Metacarpal-proximal	3	—	—	—
Phalanges-first	19	3	—	—
-second	10	—	—	—
-third	1	—	—	—
-indet.	1	—	—	—
Femur-distal	2	—	—	—
Astragalus	4	—	—	—
Cuneiform (tarsal)	1	—	—	—
Sesamoid-proximal	19	1	—	—
-distal	5	—	—	—
Metapodial-proximal	4	—	—	—
-distal	6	—	—	—
Lateral Metapodial	2	—	—	—

Table 11. The number of bones per skeletal element by which hippopotamus (*Hippopotamus amphibius*), wart-hog *Phacochoerus aethiopicus*, giant wart-hog (*Metridiochoerus* sp.) and giraffe (*Giraffa camelopardalis*) have been identified at Redcliff. All excavation units are combined

	Hippopotamus	Wart-hog	Giant wart-hog	Giraffe
	Maxilla	—	12	—
Mandible	—	18	—	5
Indet. maxillary or mandibular dentition	—	91	6	1
Carpals	—	2	—	—
Central phalanges-first	—	5	—	1
-second	1	5	—	—
-third	—	4	—	—
Lateral phalanges-first	—	2	—	—
-second	—	2	—	—
-third	—	2	—	—
Central metapodial	—	—	—	—
-distal	—	2	—	—
Lateral metapodial	—	—	—	—
-proximal	—	2	—	—
-distal	—	4	—	—

Table 12. The number of bones per skeletal element by which various bovids have been identified at Redcliff; all excavation units combined. In the context of the table, small bovids include grey duiker (*Sylvicapra grimmia*), oribi (*Ourebia ourebi*), klipspringer (*Oreotragus oreotragus*) and steenbok/grysbok (*Raphicerus* spp.). Small-medium bovids include mountain reedbuck (*Redunca fulvorufula*), common springbok (*Antidorcas marsupialis*), and Bond's springbok (*Antidorcas bondi*). Large-medium bovids include kudu (*Tragelaphus strepsiceros*), nyala (*Tragelaphus angasi*), roan/sable antelope (*Hippotragus* spp.), waterbuck (*Kobus ellipsiprymnus*), lechwe (*Kobus lechwe*), southern reedbuck (*Redunca arundinum*), blesbok/bontebok (*Damaliscus dorcas*), tsessebe/hartebeest (*Damaliscus lunatus/Alcelaphus lichtensteini*) blue wildebeest (*Connochaetes taurinus*), and impala (*Aepyceros melampus*). Large bovids include eland (*Taurotragus oryx*), giant hartebeest (*Megalotragus priscus*), Cape buffalo (*Syncerus caffer*), and giant buffalo (*Pelorovis antiquus*).

	Small- Small Bovid	Medium- Medium Bovid	Large- Medium Bovid	Large Bovid
	Occipital Condyle	—	2	2
Maxilla	15	88	581	19
Mandibular Condyle	—	5	4	—
Mandible	33	173	716	32

Axis	—	1	4	—
Cervical Vertebrae 3-7	—	3	3	—
Thoracic Vertebrae	1	1	10	—
Lumbar Vertebrae	1	1	5	—
Sacral Vertebrae	—	1	—	—
Caudal Vertebrae	—	—	1	—
Ribs	1	—	—	—
Scapula (glenoid fossa)	3	2	5	1
Humerus-proximal	—	—	2	—
-distal	2	3	22	1
Radius-proximal	2	4	18	2
-distal	—	1	6	1
Ulna-proximal	—	7	12	2
Carpals	4	11	61	4
Metacarpal-proximal	2	7	25	1
-distal	1	1	7	1
Phalanges-first	18	43	172	12
-second	8	12	72	4
-third	8	12	32	—
Ilium	—	2	2	—
Ischium	1	6	6	—
Pubis	2	—	6	—
Femur-proximal	1	3	10	—
-distal	3	3	5	1
Tibia-proximal	—	—	5	—
-distal	2	9	21	4
Patella	1	2	3	—
Calcaneum	3	9	25	4
Astragalus	8	15	49	9
Naviculo-cuboid	3	1	11	1
Lateral Malleolus	—	—	17	—
Cuneiform (tarsal)	—	8	47	2
Metatarsal-proximal	9	10	35	1
Sesamoid-proximal	—	2	96	3
-distal	—	—	15	—
Indeterminate distal	12	19	112	2
Metapodial	—	—	—	—

their richness and long vertical extent. Column VII may be extended upwards yet further by the addition of Column III. Minimum number estimates (MNI's) were not calculated except where necessary for comparison with other sites. This is because MNI's calculated on a spit-by-spit basis are too small to be informative,

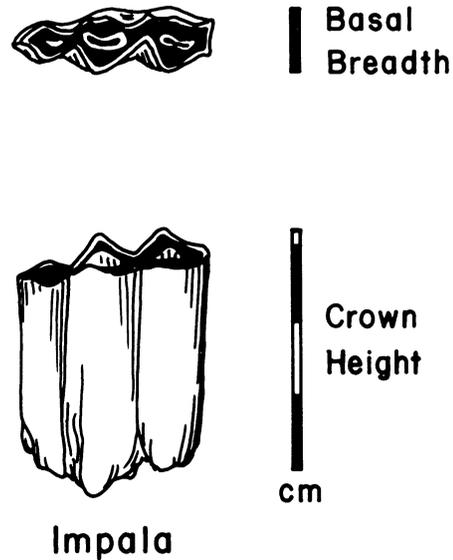


Fig. 3. Lower third molar of an impala, showing measurements of crown height and basal breadth made on all Redcliff ungulate teeth.

while the inadvisability of lumping horizontally adjacent units rules out the possibility of combining columns to build up larger numbers.

**The Nature of the Bone Assemblage and the Agent of Accumulation**

Most of the fragmentation of the Redcliff bones is probably a result of post-depositional processes (i.e. trampling, profile compaction, leaching), which have obscured or obliterated any pre-depositional effects (e.g. butchering). Tables 3-12 support this argument, for it is clear that the best-represented bones are those which are the hardest and most resistant to post-depositional destruction, such as teeth and smaller, more durable postcranial

Table 13. The number of bovid humeri, radii, femora and tibiae fragments from Redcliff. Proximal radii and femora are more common than their distal ends and distal humeri and tibiae are more common than their proximal ends. This reflects the fact that parts of bones which are dense and fuse early will tend to survive better than those that are less dense and fuse later (Brain 1981). Significance was calculated using the binomial distribution.

	Number of bone fragments
Humerus proximal	2
distal	28
	p=0.00
Radius proximal	26
distal	8
	p=0.00
Femur proximal	14
distal	11
	p=0.13
Tibia proximal	5
distal	36
	p=0.00

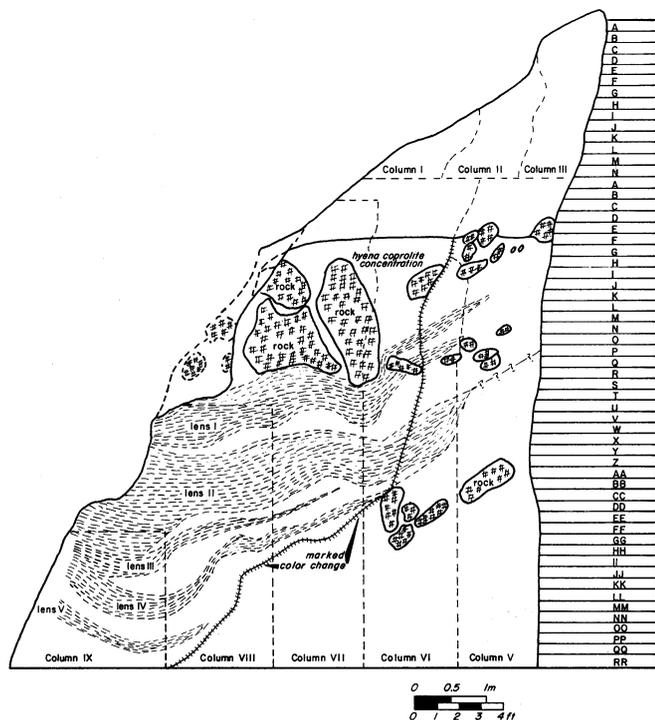


Fig. 2. Redcliff Cave: schematic section of west wall of excavation (after Brain & Cooke 1967: fig. 5).

Before excavation the surface of the site was overlain by a grid of squares 1,2 m (4 feet) on a side. The column below each square was excavated in arbitrary, horizontal 150 mm (6 inch) spits (Fig. 2). Because the deposits were so steeply inclined, it cannot be assumed that bones from the same spit in adjacent columns come from the same culture-stratigraphic unit. Therefore, the search for patterning proceeded on a spit-by-spit basis within each column. Columns VI and VII are the most informative because of

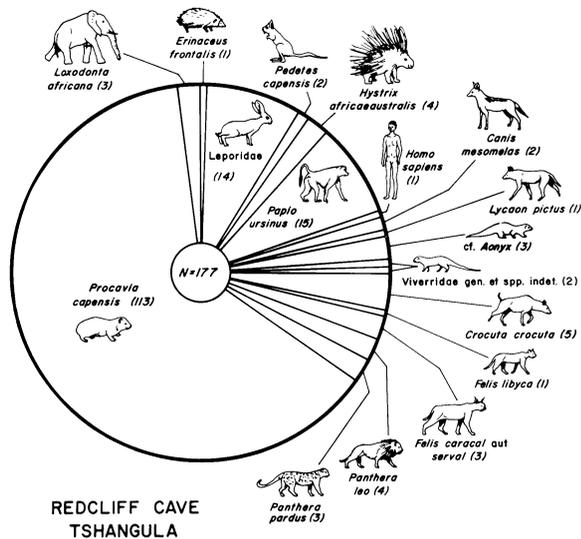


Fig. 4. Species frequencies from Columns III/VI and VII at Redcliff, expressed in terms of the tripartite division of the profile. All species recorded in these columns (except bovids, equids, and suids) are included in this figure. Frequency estimates (in parentheses) are based on the number of teeth.

bones (carpals, tarsals, sesamoids and phalanges). In addition, for each longbone the denser epiphysis is more common than the softer one (Table 13).

Approximately 10 000 artefacts were recovered from Redcliff (Cooke 1978), and there is no doubt that people accumulated most of the bones, at least during Bambata times. The Tshangula situation, however, is more complicated. While the Bambata artefacts occur in concentrated lenses, there is no apparent stratigraphy or visible concentration of artefacts in the Tshangula levels, suggesting less intense human occupation. In addition, both micro-mammal bone and coprolites increase substantially in the Tshangula levels. The micro-mammals were probably brought to the site by owls (Brain 1967, 1981), while the coprolites are from hyaenas.

The spotted hyaena is represented in the Tshangula levels, while both spotted and brown hyaenas occur in the Bambata levels (Fig. 4). Both species accumulate bones in lairs (Mills & Mills 1977) and either could be responsible for the coprolites and part of the bone accumulation. The abundance of carnivore bones in the Tshangula deposits (Table 14) strongly suggests that hyaenas contributed significantly to the assemblage. Carnivores are similarly common in other fossil hyaena lairs in southern Africa, but much rarer in definite archaeological assemblages (Klein 1980b).

The Tshangula levels are also relatively rich in ground game (mostly rock hyraxes) and baboons (Table 15). Since both hyraxes and baboons are favoured leopard prey (Brain 1981), it is possible that leopards also inhabited the cave. Alternatively, the ground game may have been introduced by people or a large raptor.

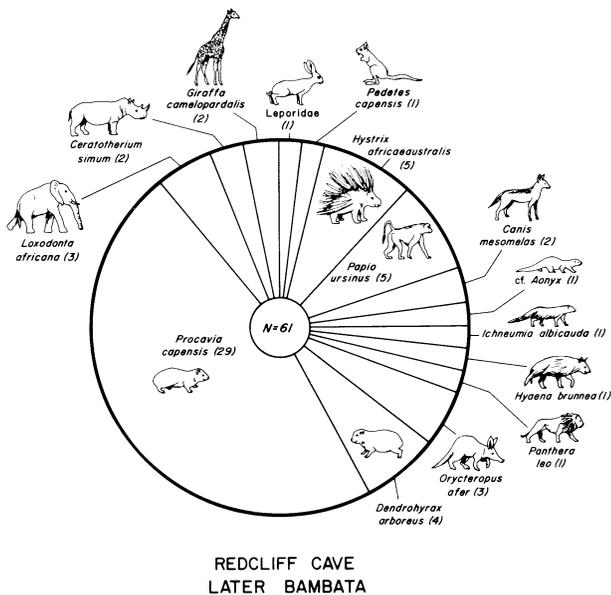


Table 14. Minimum numbers of fissioned carnivores and ungulates in the Tshangula and Bambata parts of the Redcliff profile. Carnivores include jackal, hunting dog, brown hyaena, spotted hyaena, wildcat, caracal/serval, lion, leopard, otter, indeterminate viverrids (small and medium) and white-tailed mongoose. The Tshangula levels have a significantly higher percentage of carnivores than the Bambata levels, indicating that hyaenas may have collected some of the Tshangula bones.

Chi-square value = 6.09; p = 0.02-0.01.

	Tshangula	Bambata
Carnivores	10 (23%)	7 (9%)
Ungulates	34	84

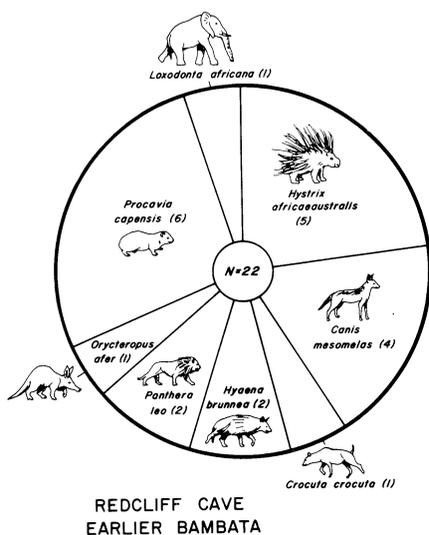


Table 15. The frequency of ground game (rock hyrax, hares, springhare, hedgehog) and of baboons at Redcliff. Frequency estimates are based on the number of teeth. Comparison is made between the Tshangula and Earlier Bambata levels because these were most similar environmentally. Chi-square value = 108.88; p < 0.0001.

	Tshangula	Bambata
Ground game and baboons	145 (34%)	6 (2%)
All other species	288	298

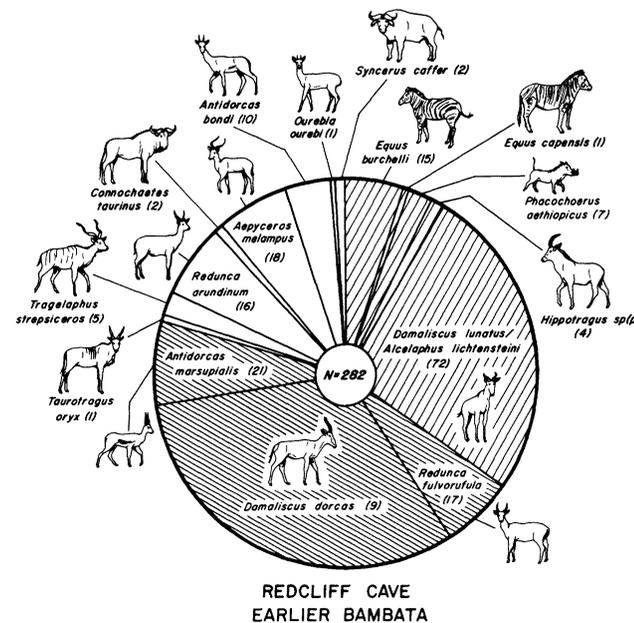
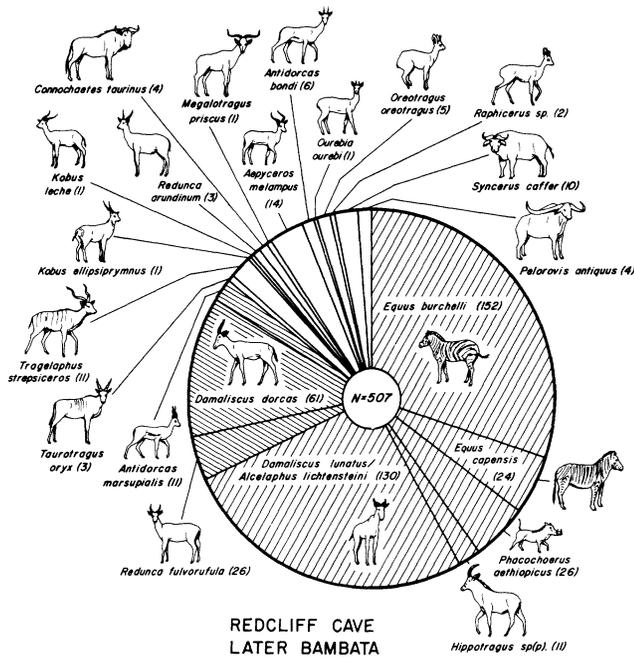
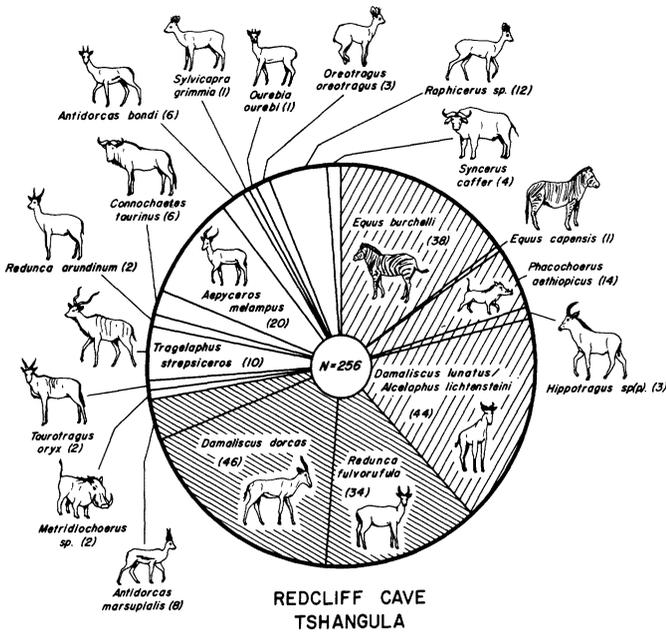


Fig. 5. Frequencies of bovids, equids and suids from Columns III/IV and VII at Redcliff, expressed in terms of the tripartite division of the profile. Frequency estimates (in parentheses) are based on the number of teeth. 'Exotic' species (narrow hatching) are more common relative to 'historic species' (wide hatching) in the Tshangula and Earlier Bambata levels.

**Environmental Implications of the Redcliff Species Frequencies**

Like most archaeological faunas, the Redcliff assemblage is dominated by ungulates (Figs 4 & 5). Historical and recent records (as summarized in part by Ansell 1971) indicate that the dominant ungulates near Redcliff historically included Burchell's zebra, warthog, tsessebe, sable antelope, blue wildebeest, and impala, all of which are relatively common at Redcliff. However, there are also five species at Redcliff that are now totally extinct, and three which were unknown in the area historically, although they survive elsewhere. The totally extinct species are the 'giant Cape horse', a giant warthog, a giant hartebeest, Bond's springbok and the giant buffalo. None of these species are known from Holocene levels in southern Africa, though all excepting the giant warthog are common in Upper Pleistocene contexts. The presence of the giant warthog in the Redcliff Tshangula levels may be the latest record of this species (Klein 1980a). Unfortunately, all the extinct species are too rare at Redcliff to shed any light on possible causes of extinction.

The three Redcliff species that were absent nearby although surviving elsewhere are the blesbok/bontebok, mountain reedbuck, and common springbok. As a group, these 'exotic' species are much more common in the Tshangula and Earlier Bambata phases than in the intervening Later Bambata phase. This observation is supported by a principle components analysis (Table 16), which isolated two co-varying groups of species. The first group, with loadings of  $\geq 0.79$  on Component 1, includes zebra, 'giant Cape horse', warthog, roan/sable antelope and tsessebe/hartebeest. With the exception of the extinct 'giant Cape horse' this

Table 16. Varimax rotated principle components solution of the frequency variation of the better-represented ungulates in the Redcliff profile. Only components with an eigenvalue of greater than 1 are included. Species with high loadings on one component are probably co-varying in a systematic way. The results support the hypothesis of an inverse relationship between "historic" species (loading highly on Component 1) and "exotic" species (loading highly on Component 2). The analysis was performed on the University of Chicago's Amdahl 470 computer, using the method "PA1" and appropriate options of the subprogram FACTOR from the Statistical Package for the Social Sciences (Nie *et al.* 1975).

	COMPONENT 1	COMPONENT 2
Zebra	0,89	0,13
'Giant Cape horse'	0,86	0,01
Warthog	0,82	0,24
Roan/sable antelope	0,79	0,01
Tsessebe/hartebeest	0,80	0,38
Mountain reedbuck	0,00	0,75
Blesbok/bontebok	0,40	0,65
Common springbok	-0,04	0,83
Impala	0,31	0,50
Eigenvalue	4,22	1,65
Percentage of variance explained	46,9	18,3

group comprises the historically dominant species in the area. It is designated the 'historic' group here. The second group, with loadings of  $\geq 0.65$  on Component 2, comprises the three 'exotic' species which were not present historically. The greater abundance of the 'exotic' group at the top and bottom of the profile is illustrated graphically in Fig. 5 and numerically in Table 17.

Table 17. The frequencies of 'exotic' and 'historic' species in Columns III/VI and VII of the Redcliff profile, expressed in terms of the tripartite division of the sequence. 'Exotic' species are blesbok-bontebok, mountain reedbuck and common springbok. 'Historic' species are zebra, 'giant Cape horse', warthog, roan/sable antelope, and tsessebe/hartebeest. 'Exotic' species are significantly more common relative to 'historics' in the Tshangula and Earlier Bambata periods. Frequency estimates are based on the number of teeth.

	Tshangula	Later Bambata	Earlier Bambata
Exotics	88 (47%)	98 (22%)	128 (56%)
Historics	99	343	99

Chi-square values:

- Tshangula vs. Later Bambata = 38.86;  $p < 0.001$
- Tshangula vs. Earlier Bambata = 3.58;  $> 0.05$
- Earlier Bambata vs. Later Bambata = 78.14;  $< 0.001$

The most reasonable explanation for the fluctuating abundance of the exotic species is that the environment changed during the time span represented by the Redcliff deposit. It is probable that the exotic species were most common near Redcliff during cooler periods of the Pleistocene. This inference comes from the fact that the 'exotic' species are characteristic inhabitants of the South African highveld. They would probably extend their ranges northwards at times when climatic conditions to the north resembled those that prevail today in cooler, more southerly regions.

Changes in certain sediment parameters at Redcliff (established by Brain 1969) correspond closely with the species frequency fluctuations, providing independent evidence of environmental change. Low  $\text{CaCO}_3$  and high sand and grit percentages in the Tshangula and Earlier Bambata levels suggest strong flushing inside the cave, reflecting a moister external climate. A drier climate for the intervening Later Bambata levels may be inferred from the high  $\text{CaCO}_3$  content and low sand/grit content. From this it may be concluded that the spread of the 'exotic' species may have been promoted by moister as well as cooler conditions.

The Tshangula 'wet period' at Redcliff may correspond with the concentration of roof rock identified by Cooke as the 'rockfall'.

Table 18. The frequency of suids versus bovids and equids at Redcliff. Comparison is made between the Tshangula and Earlier Bambata levels because these were most similar environmentally. Frequency estimates are based on the number of teeth. Chi-square value = 5.88;  $p = 0.02-0.01$ .

	Tshangula	Earlier Bambata
Suids	16 (7%)	7 (3%)
Bovids and Equids	213	273

Contemporaneous rockfalls have been found at other cave sites in Zimbabwe, including Pomongwe, Bambata, Zombepata, Inyanga, and Duncombe Farm (Cooke 1971, 1973, 1978). However, it is not clear whether a true 'rockfall' occurs at all of these sites, whether it represents one episode or many, or when the supposed episode(s) occurred (Volman 1981). Walker (1980) links the 'rockfalls' indirectly to climatic change. He speculates that people were

absent from the area for a long period, probably because of climatic deterioration (colder and perhaps drier). During their absence, weathering processes resulted in the accumulation of coarse lags that appear to be rockfalls. Walker's suggestion of aridity agrees well with evidence that parts of Africa were drier during the last glacial maximum (Livingstone 1975). However, it may conflict with evidence from Redcliff pointing to moister conditions, depending on whether the Redcliff rockfall corresponds with the Tshangula wet period (Brain 1969) or in fact occurred prior to the Tshangula occupation (Cooke 1978).

Other evidence for Late Quaternary environmental change in southern Africa north of the Limpopo is sparse, but does not contradict the Redcliff data. At Lunda in north-east Angola (Clark 1963) and Kalambo Falls in northern Zambia (Clark 1969) cooler/wetter periods were recorded. On the other hand, abundant and well-preserved pollen from a core in Lake Ishiba Ngandu (northern Zambia) showed virtually no vegetational change over the past 22 000 years (Livingstone 1971). However, this is not evidence for a stable climate, since even very substantial changes in rainfall in this area might not lead to vegetational changes that are detectable by pollen analysis.

#### Cultural Implications of the Redcliff Species Frequencies

Faunal collections from Cape coastal sites indicate that MSA peoples in that area exploited terrestrial and marine resources less effectively than their LSA successors (Klein 1980a). The Redcliff assemblage is one of the few collections which permits this idea to be tested outside the Cape, although it is less than ideal because of the uncertain status of the Tshangula and the possibility of hyaena input in these levels.

At Redcliff, as in most other archaeological sites, large carnivores are poorly represented, probably reflecting human avoidance of dangerous prey. Carnivores are better represented in the Tshangula levels than in the Bambata ones but this may only reflect the fact that many bones in the Tshangula levels were introduced by hyaenas. The rarity of the very largest ungulates (elephant, hippopotamus and rhinoceros) throughout the Redcliff profile may also indicate human avoidance of these prey species. However, even if these animals were hunted, it is likely that most of their bones were left at the kill/butchery site.

In the southern Cape, MSA sites are poor in suids and richer in eland than LSA sites occupied under broadly similar environmental conditions. Since suids are among the fiercest prey when attacked and eland are among the most docile, the implication may be that LSA people captured fierce animals much more frequently than their predecessors (Klein 1980a). At Redcliff, eland are uncommon throughout, probably because they were never common in the area, but suids are more abundant.

It may not be reasonable to compare the Tshangula and Later Bambata levels in suid contents, because there is evidence that these levels formed under different climates. However, the Earlier Bambata and Tshangula levels probably accumulated under similar conditions and differences between them in suid abundance are more likely to reflect differences in behaviour. Table 18 shows that suid bone fragments are in fact more common in the Tshangula levels. The percentage difference is small but the absolute difference is significant at the 0.05 level (Chi-square = 5.88). But when minimum individual estimates are used (Table 19), there is

Table 19. The frequency of suids versus bovids at Redcliff. Comparison is made between the Tshangula and Earlier Bambata levels because these were most similar environmentally. Frequency estimates are based on the minimum number of individuals. Chi-square value = 0.46;  $p > 0.05$ .

	Tshangula	Earlier Bambata
Suids	3 (9%)	2 (5%)
Bovids and Equids	32	40

no detectable difference in suid percentages between the two periods. The results are thus equivocal and the Redcliff data cannot be used to confirm inferences drawn from the Cape materials. There is of course the further problem that some of the suid bones

in the Tshangula levels may have been introduced by carnivores.

The Tshangula and Earlier Bambata levels also contrast in the variety and number of small bovids (steenbok/grysbok, duiker, klipspringer and oribi), which are more common in the Tshangula levels (Fig. 5, Table 20). Again, this may indicate a change in

Table 20. The frequency of small bovids (duiker, oribi, klipspringer, steenbok/grysbok) versus other bovids, equids, and suids at Redcliff. Comparison is made between the Tshangula and Earlier Bambata levels because they were most similar environmentally. Frequency estimates are based on the number of teeth. Chi-square value = 16.39;  $p < 0.001$

	Tshangula	Earlier Bambata
Small Bovids	17 (7%)	1 (0.4%)
Other Bovids, Equids, and Suids	239	281

human behaviour, but it might only reflect the fact that brown hyaenas, leopards, or both contributed much of the bone in the Tshangula levels. Both carnivores would bring in mainly smaller ungulates (Mills & Mills 1977; Brain 1981). Perhaps in favour of a human behavioural or possibly environmental change is the fact that the later Pleistocene LSA levels at both Pomongwe and Nswatugi are richer in small bovids and ground game than the underlying MSA levels (Walker 1980). The problem is not resolvable with the present data.

#### Cultural Implications of the Redcliff Age Distributions

Age profiles of the ungulate species in an archaeological site constitute a valuable source of information on the nature of human predation patterns and hunting ability. Ungulate teeth, which are the most appropriate elements for constructing age profiles, are fortunately common at Redcliff. The method used to derive the age distributions presented here is based on the assumption that crown height decreases systematically with age, according to a mathematical model suggested by Spinage (1971) and elaborated by Klein *et al.* (in press). For any given tooth, the model may be expressed as follows:

$$AGE = (AGE_{pel} - AGE_e) [(CROWN HEIGHT - CHO)/CHO]^2 + AGE_e$$

where  $AGE_{pel}$  = the potential ecological longevity of an individual  
 $AGE_e$  = the age at which the tooth erupts, and  
 $CHO$  = the initial (unworn) crown height of the tooth.

$CHO$  must be determined empirically from appropriate teeth in each sample, while  $AGE_{pel}$  and  $AGE_e$  are estimates derived from wildlife biology publications.

Since no single tooth is present throughout the entire life of an animal, age profile construction requires crown height measurements on both a permanent and a deciduous tooth. The lower third molar ( $M^3$ ) was chosen as a permanent tooth for the Redcliff ungulates because it is easily identified even when the teeth are isolated. The only exception is Bond's springbok, where I used  $M^2$  since few measurable  $M^3$ s were recovered. For the deciduous tooth,  $dP^4$  was chosen as it is also relatively easy to identify and is also the most robust deciduous tooth. However, compared to permanent teeth, even  $dP^4$ s are probably severely under-represented in the Redcliff sample, due to their generally greater fragility. Thus, the paucity of juveniles in the Redcliff bovid and equid age profiles probably in part reflects post-depositional factors and identification problems, and not the fact that juveniles were originally absent.

Age distributions for all Redcliff ungulate species represented by large enough samples are presented in Fig. 6. The class interval chosen for all the histograms is 10% of potential ecological longevity. Use of a standardized class interval such as this makes it easy to compare age profiles of species with different lifespans. The Kolmogorov-Smirnov test was used to test whether observed differences between the age profiles are statistically significant. For each species, age profiles were calculated for the Bambata levels

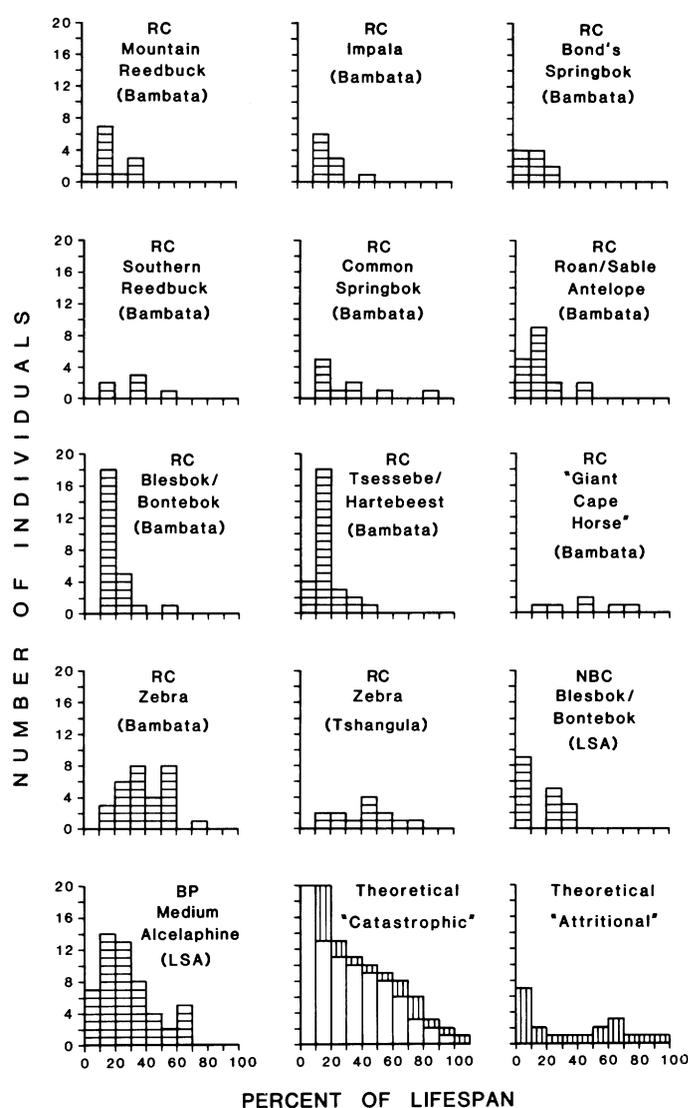


Fig. 6. Age profiles of the most common ungulates from Redcliff (RC), of blesbok/bontebok from Nelson Bay Cave (NBC), and of the medium alcelaphine from Boomplaas Cave (BP). Lower right: Theoretical 'catastrophic' profile (white bars), and its complementary 'attritional' profile (vertical stripes).

and the Tshangula levels. However, in the Tshangula levels, only the zebra sample was large enough to provide a potentially interpretable profile. The Tshangula profiles would be more problematic in any case, since the bones were probably accumulated by both people and carnivores.

Theoretical 'catastrophic' and 'attritional' profiles, based on empirical observations (cf. Deevey 1947; Kurtén 1953; Voorhies 1969; Spinage 1972; see also Klein 1982b) are also presented in Fig. 6. A catastrophic profile represents the population structure of a live herd. It is characterized by successively fewer individuals in progressively older age classes, resulting in a 'down-staircase' shape. An attritional profile is the complement of a catastrophic one. It reflects the number of individuals that die naturally in each age class. In contrast to a catastrophic profile, it is relatively poor in prime age adults and richer in old ones. It is usually said to be 'U' shaped, the two peaks reflecting high mortality in the very young and the old. Both attritional and catastrophic profiles are rich in juveniles, and thus, the bias against juveniles at Redcliff will not affect the assessment of whether a particular profile resembles an attritional or catastrophic distribution.

The theoretical profiles provide only a baseline for interpretation, and archaeological samples need not resemble either type, although available data suggest that Stone Age samples tend to pattern along these lines (e.g. Klein 1978c; Klein *et al.* 1981).

Moreover, it is not always easy to distinguish attritional from catastrophic profiles. The second peak of an attritional profile may be very slight and may not be detectable unless sample size is very large. This is because mortality need not rise dramatically in later life (Klein 1982b). Further departures from the theoretical profiles may result from problems with the age estimation formula. Although the basic form of the age estimation model is certainly valid, further studies of known-age animals may allow refinement for greater accuracy.

For several species even the Bambata profiles are based on samples that are too small for secure interpretation. Among these species, there is the suggestion that the mountain reedbuck, impala, Bond's springbok, and perhaps southern reedbuck profiles resemble a catastrophic distribution, in that most of the individuals are prime age adults. The common springbok and 'giant Cape horse' profiles, on the other hand, may be attritional, but larger samples of all these species are clearly necessary to demonstrate meaningful differences.

The remaining Redcliff profiles are somewhat easier to interpret, and two very different patterns emerge. The first, corresponding roughly to a catastrophic pattern, characterizes the blesbok/bontebok, tsessebe/hartebeest, and possibly also the roan/sable antelope. The Redcliff profiles, particularly those of the alcelaphines, do differ from the idealized catastrophic profile in that they seem to be somewhat biased towards a higher percentage of young adults (in the second 10% of lifespan). There is a very marked drop from the second 10% of lifespan to the third, making the 'down-staircase' shape very steep. It is unclear, however, whether this might reflect sampling error, or a problem in the age estimation formula.

Alcelaphine age profiles are also available from LSA levels at Nelson Bay Cave (Klein 1978c) and Boomplaas Cave (Klein 1978a). In making comparisons the first 10% of lifespan should not be taken into account because these young individuals are so severely under-represented at Redcliff. The Nelson Bay blesbok/bontebok profile is difficult to interpret, but may also be catastrophic, as suggested by Klein (1978c). The Boomplaas medium-size alcelaphine profile also resembles a catastrophic distribution, but it differs significantly (at the 0,01 level) from the Redcliff catastrophic profiles. It does not exhibit the sharp drop after the second 10% of lifespan, has a greater number of older individuals, and almost seems to combine characteristics of both catastrophic and attritional age profiles. This may indicate that a variety of hunting methods were practiced at Boomplaas, some of which yielded mainly the most vulnerable individuals (the very young and the old), while others yielded individuals of all ages.

The catastrophic profiles of the Redcliff alcelaphines indicate that the Bambata inhabitants were capable of taking prime age adults as well as the more vulnerable very young and old individuals. This in turn suggests that the hunters focused on entire groups, obtaining them in such a way that all animals, regardless of age, had the same chance of getting killed. It is possible that they were driving the animals into pens or traps, a suggestion supported at least for blesbok by the fact that modern blesbok are particularly susceptible to driving (Sydney 1965; Bigalke 1974).

This predation strategy was suggested by Klein (1978c) for blesbok/bontebok at Nelson Bay and may pertain to all the archaeological alcelaphine profiles discussed here. Hunting in a way that obtains large numbers of prime age reproductive adults will eventually reduce the prey population, perhaps even to the point of extinction. Such a predation strategy could only have operated over time if the hunters rarely encountered herds in a suitable position for driving.

The second type of age profile found at Redcliff is that exhibited by the zebra. The zebra profiles resemble a conventional attritional mortality profile in which there are more individuals in the older age classes and fewer prime age adults. This pattern is particularly strong in the Bambata sample, but is also apparent in the smaller Tshangula sample, and perhaps also in the Bambata 'giant Cape horse' sample. Both zebra profiles are statistically distinguishable (at the 0,05 level) from the Redcliff alcelaphine and hippotragine profiles. It is apparent that the MSA people at Redcliff dealt with equids in a very different way than they did alcela-

phines and perhaps hippotragines. Rather than driving whole groups, the MSA hunters, like other predators, were largely restricted to the most vulnerable individuals. Perhaps zebra and also the 'giant Cape horse' were less amenable to driving than bovids, while prime age equid adults were largely immune to other hunting methods. Alternatively, the equids may have been scavenged. Unfortunately, in order to distinguish active hunting from scavenging on the basis of an archaeological attritional age profile, one needs well-preserved samples which have not been subject to extensive post-depositional destruction (Klein 1982a).

Unlike a predation strategy that would net large numbers of reproductive adults, the predation pattern evidenced by an attritional profile would not reduce the breeding population. In this context, it is interesting to compare the Bambata equid profiles with the Tshangula profile to see if this predation strategy changed over time. This would be a particularly interesting inquiry to pursue in the case of the 'giant Cape horse', which became extinct at the end of the Pleistocene. However, the Redcliff samples are too small for meaningful comparison. In the case of the zebra, both the Bambata and the Tshangula profiles are attritional. This could indicate either that LSA hunters employed a predation strategy similar to that of their MSA predecessors, or that many of the Tshangula zebra were brought to the site by hyaenas. An attritional profile is to be expected of a bone assemblage accumulated by carnivore predator/scavengers, and the present data do not allow a choice between alternatives.

### Summary and Conclusions

Numerous stone artefacts and bones preserved in the deposits at Redcliff Cave provide a record of both Bambata and Tshangula occupation of the site. The majority of the bone remains are derived from the Bambata levels. During this time period the site was probably inhabited primarily by people, but during the succeeding Tshangula period it is probable that other animals, particularly hyaenas, also occupied the cave when people were absent and contributed to the bone assemblage.

The evidence for environmental change in Zimbabwe and immediately adjacent areas is sparse. The faunal sequence from Redcliff is important in that it suggests significant later Pleistocene climatic change in this region. Changes in the abundance of 'historic' versus 'exotic' species through the three major divisions of the Redcliff profile probably reflect climatic change from a cooler/wetter period during the Earlier Bambata to a warmer/drier period in the intervening Later Bambata, and back to a cooler/wetter phase during the Tshangula. The Bambata changes probably occurred prior to 40 000 years ago, while the Tshangula period may date to approximately 20-30 000 B.P.

The faunal assemblage from Redcliff has also provided information on Middle Stone Age hunting ability. Like other Stone Age peoples of southern Africa, the inhabitants of Redcliff seem to have avoided dangerous carnivores and concentrated primarily on ungulates. The three most common species throughout the sequence are zebra, tsessebe/hartebeest, and blesbok/bontebok, all of which were probably abundant nearby. There is some evidence that Tshangula people took more suids, small bovids, and ground game than earlier inhabitants, but this will require checking at other sites.

The age profiles of blesbok/bontebok and tsessebe/hartebeest suggest hunting by driving into surrounds or other traps where individuals of all ages would be captured in proportion to their live abundance. The age profiles of the equids suggest that hunting was mainly by stalking individuals, resulting in the capture of relatively few prime adults and proportionately more older ones. Fresh data from other sites will be necessary to determine whether there may have been significant differences in hunting methods between the Middle Stone Age and the Later Stone Age in Zimbabwe.

### Acknowledgements

The author wishes to thank R. G. Klein, A. Turner, and an anonymous reviewer for helpful comments on earlier drafts of this paper. Q. B. Hendey kindly provided facilities to study the Redcliff material in the Department of Cenozoic Palaeontology at the South African Museum. Support for this research came from the

Hinds Fund for Evolutionary Biology (University of Chicago) and the National Science Foundation (Washington).

### References

- ANSELL, W. F. H. 1971. Order Artiodactyla. In Meester, J. & Setzer, H. W. eds *The mammals of Africa: an identification manual*. Part 15. Washington D. C.: Smithsonian Institution.
- BIGALKE, R. C. 1974. Ungulate behaviour and management, with special reference to husbandry of wild ungulates on South African ranches. In Geist, V. & Walther, F. eds *The behaviour of ungulates and its relation to management*: 830-52. Morges, Switzerland: International Union for Conservation of Nature and Natural Resources.
- BRAIN, C. K. 1967. Procedures and some results in the study of Quaternary cave fillings. In Bishop, W. W. & Clark, J. D. eds *Background to evolution in Africa*: 285-301. Chicago: University of Chicago Press.
- BRAIN, C. K. 1969. New evidence for climatic change during Middle and Late Stone Age times in Rhodesia. *S. Afr. archaeol. Bull.* **24**:127-43.
- BRAIN, C. K. 1981. *The hunters or the hunted? An introduction to African cave taphonomy*. Chicago: University of Chicago Press.
- BRAIN, C. K. & COOKE, C. K. 1967. A preliminary account of the Redcliff Stone Age cave site in Rhodesia. *S. Afr. archaeol. Bull.* **21**:171-82.
- CLARK, J. D. 1963. Prehistoric cultures of north-east Angola and their significance for tropical Africa. *Museu do Dundo Publ. Culturais* **62**. 2 Vols.
- CLARK, J. D. 1969. *Kalambo Falls prehistoric site*. Vol. 1. Cambridge: Cambridge University Press.
- COOKE, C. K. 1971. Excavations at Zombepata Cave, Sipolilo District, Mashonaland, Rhodesia. *S. Afr. archaeol. Bull.* **26**:104-26.
- COOKE, C. K. 1973. The Middle Stone Age in Rhodesia and South Africa. *Arnoldia* (Rhod.) **6**(20):1-4.
- COOKE, C. K. 1978. The Redcliff Stone Age site, Rhodesia. *Occas. pap. natn. Mus. Rhod. (A) hum. Sci.* **4**(2):43-73.
- DEEVEY, E. S. 1947. Life tables for natural populations of animals. *Quart. Rev. Biol.* **22**:283-314.
- KLEIN, R. G. 1978a. A preliminary report on the larger mammals from the Boomplaas Stone Age cave site, Cango Valley, Oudtshoorn District, South Africa. *S. Afr. archaeol. Bull.* **33**:66-75.
- KLEIN, R. G. 1978b. Preliminary analysis of the mammalian fauna from the Redcliff Stone Age cave site, Rhodesia. *Occas. pap. natn. Mus. Rhod. (A) hum. Sci.* **4**(2):74-80.
- KLEIN, R. G. 1978c. Stone Age predation on large African bovids. *J. archaeol. Sci.* **5**:195-217.
- KLEIN, R. G. 1980a. Environmental and ecological implications of large mammals from Upper Pleistocene and Holocene sites in southern Africa. *Ann. S. Afr. Mus.* **81**:223-83.
- KLEIN, R. G. 1980b. The interpretation of mammalian faunas from Stone Age archaeological sites, with special reference to sites in the southern Cape Province, South Africa. In Behrens-meyer, A. K. & Hill, A. eds *Fossils in the making*: 223-46. Chicago: University of Chicago Press.
- KLEIN, R. G. 1982a. Age profiles as a means of distinguishing hunted species from scavenged ones in Stone Age archaeological sites. *Paleobiology* **8**:151-58.
- KLEIN, R. G. 1982b. Patterns of ungulate mortality and ungulate mortality profiles from Langebaanweg (Early Pliocene) and Elandsfontein (Middle Pleistocene), south-western Cape Province, South Africa. *Ann. S. Afr. Mus.* **90**:49-94.
- KLEIN, R. G., WOLF, C., FREEMAN, L. G. & ALLWARDEN, K. 1981. The use of dental crown heights for constructing age profiles of red deer and similar species in archaeological samples. *J. archaeol. Sci.* **8**:1-31.
- KLEIN, R. G., ALLWARDEN, K. & WOLF, C. in press. The calculation and interpretation of ungulate age profiles from dental crown heights. In Bailey, G. ed. *Hunter-gatherer economies in Late Pleistocene Europe*. Cambridge: Cambridge University Press.
- KURTÉN, B. 1953. On the variation and population dynamics of fossil and recent mammal populations. *Acta zool. fenn.* **76**:1-122.
- LIVINGSTONE, D. A. 1971. A 22 000-year pollen record from the plateau of Zambia. *Limnol. Oceanogr.* **16**:349-56.
- LIVINGSTONE, D. A. 1975. Late Quaternary climatic change in Africa. *Ann. Rev. ecol. sys.* **6**:249-80.
- MILLS, M. G. L. & MILLS, M. E. J. 1977. An analysis of bones collected at hyaena breeding dens in the Gemsbok National Parks (Mammalia: Carnivora). *Ann. Transvaal Mus.* **30**:145-55.
- NIE, N. H., HULL, C. H., JENKINS, J. E., STEINBRENNER, K. & BENT, D. H. 1975. *Statistical package for the social sciences*. New York: McGraw Hill.
- SHEPPARD, J. G. & SWART, E. R. 1971. Rhodesian radiocarbon measurements IV. *Radiocarbon* **13**:42-3.
- SIMPSON, G. G., ROE, A. & LEWONTIN, R. C. 1960. *Quantitative zoology*. Revised edition. New York: Harcourt, Brace & Co.
- SPINAGE, C. A. 1971. Geratodontology and horn growth of the impala (*Aepyceros melampus*). *J. zool. (Lond.)* **164**:209-25.
- SPINAGE, C. A. 1972. African ungulate life tables. *Ecology* **53**:645-52.
- SYDNEY, J. 1965. The past and present distribution of some African ungulates. *Trans. zool. Soc. Lond.* **30**:1-396.
- VOGEL, J. C. 1970. Groningen radiocarbon dates IX. *Radiocarbon* **12**:444-71.
- VOLMAN, T. P. 1981. The Middle Stone Age in the southern Cape. Unpublished PhD. dissertation: University of Chicago.
- VOLMAN, T. P. in press. Early prehistory of southern Africa. In Klein, R. G. ed. *Later Cenozoic environments, ecology and prehistory in southern Africa*. Rotterdam: A.A. Balkema.
- VOORHIES, M. R. 1969. Taphonomy and population dynamics of an early Pliocene vertebrate fauna, Knox County, Nebraska. *Univ. Wyoming spec. contrib. Geol.* **1**:1-69.
- WALKER, N. J. 1980. Later Stone Age research in the Matopos. *S. Afr. archaeol. Bull.* **35**:19-24.