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ARTIFICIAL BIAS IN A SAMPLE OF KANGAROO INCISORS FROM DEVIL'S LAIR, WESTERN AUSTRALIA

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ABSTRACT

Discrepancies in the numbers of various kinds of teeth of the Western Grey Kangaroo (*Macropus fuliginosus*) among material excavated from Devil's Lair are demonstrated by comparing them to three other marsupial species. Some of these discrepancies can be related to biological characteristics of this species, but the greatest discrepancy, that between numbers of lower incisors and numbers of any other teeth, cannot. The most likely explanation is that the ancient human occupants of Devil's Lair were selectively removing lower incisors from the animals for use as implements or ornaments.

INTRODUCTION

Devil's Lair is a small limestone cave near Augusta, Western Australia. It contains a deep, mainly sandy floor deposit in which excavations have revealed the presence of many bone and stone artifacts and of large quantities of bone, much of which is fragmented. These and other archaeological features suggest that humans occupied the cave at least intermittently, for the period 27,000-6,000 years B.P. (layers 28-9; Balme, Merrilees & Porter, 1978) and it is probable that most of the bone material from that part of the deposit represents prey of human hunters.

Disproportions in the quantities of different skeletal parts of the Western Grey Kangaroo (*Macropus fuliginosus*) from Devil's Lair have been noted by Baynes, Merrilees & Porter (1976). I have re-examined and extended their data by considering all *Macropus fuliginosus* material recovered from excavations up to and including 1976 (Dortch & Merrilees, 1973; Baynes, Merrilees & Porter, 1976; Balme, Merrilees & Porter, 1978). Comparative

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data on the Western Brush Wallaby (*Macropus irma*), the Brush-tail Possum (*Trichosurus vulpecula*) and the Common Ringtail (*Pseudocheirus peregrinus*) are also included. Through quantification of this data it is hoped to show the extent of the disproportions and to offer some explanations for the uneven representation.

Descriptions of these animals have been given by Ride (1970) and his nomenclature is followed. All four species are diprotodonts and have a pair of long lower incisor teeth. No Devil's Lair species matched *M. fuliginosus* in size but *M. irma* was included because it is the extant macropod in Devil's Lair nearest in size to *M. fuliginosus* and its dental characteristics were the closest comparison. The two possums were included because they are the two largest non-macropod species in the deposit whose dental characteristics offered the closest comparison to *M. fuliginosus.* The adult dental formula for both *Macropus fuliginosus* and *Macropus irma* is $I\frac{3}{1}$, $C\frac{0}{0}$, $PM\frac{1}{1}$, $M\frac{4}{4}$ and for *Trichosurus* and *Pseudocheirus* the adult dental formula is $I\frac{3}{2}$, $C\frac{1}{0}$, $PM\frac{1}{1}$, $M\frac{4}{4}$ (the second lower incisor of both the possums is extremely rudimentary).

MATERIALS

Total numbers of selected teeth of the four species considered from excavations up to and including 1976 are shown in **Table 1.** For *Pseudocheirus peregrinus*, premaxillae with or without their incisors have been counted since the upper incisors of this species are small and fragile and may pass through the sieves or escape detection during sorting.

Table 1 shows less variation in the numbers obtained for skeletal elements of *T. vulpecula* and *P. peregrinus* than for *M. fuliginosus* and *M. irma*, in which not only lower incisors but also (less markedly) premolars and molars are not as well represented as upper incisors.

Distribution of each of the four species for layers of stratigraphically reliable context is shown in **Table 2.** The pooled mean age of the three earliest dates shown in Table 3 of Balme, Merrilees & Porter (1978) as 33,150, has now been recalculated to 32,800 shown in **Table 2** (R. Gillespie pers. comm.).

Uneven representation of the Devil's Lair material

In any archaeological or palaeontological bone sample of Macropodinae, variation in the representation of different teeth could occur because of natural tooth eruption, progression and replacement during an animal's

lifetime. For example, over-representation of incisors compared to cheek teeth could be because incisors erupt first in an individual's lifetime. An unerupted tooth is fragile, sometimes amounting to little more than a hollow shell of enamel. Many unerupted mammal teeth are therefore unlikely to survive as fossils and in an individual the earliest erupted teeth are likely to survive best.

To take account of this effect, I have compared the Devil's Lair Grey Kangaroo and Brush Wallaby teeth with specimens preserved intact in skulls or dentaries from the same region as Devil's Lair. Such comparisons make it possible to remove from the Devil's Lair sample all those incisors that can be construed as deriving from animals so young that their cheek teeth had not erupted at the time of their deaths. **Table 3** shows the Devil's Lair sample so modified.

Table 1: Numbers of some skeletal elements from four marsupial species represented in Devil's Lair.

Skeletal element	*Macropus fuliginosus*	*Macropus irma*	*Trichosurus vulpecula*	*Pseudocheirus peregrinus*
left premaxilla				67
right premaxilla				68
LI^1	56	18	81	
RI^1	42	16	96	
LI^2	29	8		
RI^2	42	15		
LI^3	26	15		
RI^3	37	19		
$LP^{3\&4}$	12	5		
$RP^{3\&4}$	13	4		
$LP_{3\&4}$	20	2		
$RP_{3\&4}$	13	5		
LM^1	15	12	110	157
RM^1	8	11	88	131
LM_1	13	6	119	172
RM_1	11	2	101	181
LI_1	4	1	113	151
RI_1	3	1	103	136

To prevent animals represented by both deciduous and unerupted permanent premolars being counted twice, all deciduous premolars are included in the table but only fully erupted permanent premolars (i.e. having roots and showing some signs of wear) are included.

Table 2: Minimum numbers of individuals of four marsupials in stratigraphically reliable context, 1973-1976 excavations, Devil's Lair.

	Radiocarbon date year B.P.	Western Grey Kangaroo								Western Brush Wallaby								Brush-tail Possum				Ringtail Possum			
	320	I^1	I^2	I^3	$P^{3\&4}$	$P_{3\&4}$	M^1	M_1	I_1	I^1	I^2	I^3	$P^{3\&4}$	$P_{3\&4}$	M^1	M_1	I_1	I^1	M^1	M_1	I_1	Premaxilla	M^1	M_1	I_1
A under C																									1
A under E																		2	2	1	2				
D																					1	1	2		
F																						1	2		1
G	6490		1															1			1				1
H		1	1															4	3	3	1		3	3	
I		1																			1			2	3
K (inc. occupation floor)	12050	1	2					1										3	4	3		2	4	6	7
L																				1	1				
Hearth 2		1				2									1			3		5	3	5	5	6	7
M (inc. orange and brown mottling)	11960	1		3						1								5	10	12	12	9	5	13	8
Hearth z																									
HP			1																						
'below HP'																									
MM			1								1									2	2	1	1	2	3
Hearth y						1				1		1				1		1	1	2	1		1		
Sub MM				1														1			2				
N							1											1			1				
N with small amounts of O																									1
O		6	2	8		3		1	1	4		2		1	1			6	8	6	8	5	3	12	9
O+P mixed																					1			1	1
P								1	1	1					1						2		2	2	1
Q		1	3		2							1			1			5	5	4	3	2			2
T			2															1	1	1					
T and U mixed												1											1		
U										1								1		1					
U and V mixed							1											2	1	4			3		
V								1										3	1	2	4		4	1	1
W																									
W and X mixed																							1		
X			1								1							2		2	1	1	1		
X and Y mixed																						1	1		
Y				1														1				1	1		
Z		3	2	3				1								1				1		1	3	2	1

Table 2 (cont.)

	Radiocarbon date year B.P.	Western Grey Kangaroo								Western Brush Wallaby								Brush-tail Possum				Premaxilla	Ringtail Possum		
	320	I^1	I^2	I^3	$P^{3\&4}$	$P_{3\&4}$	M^1	M_1	I_1	I^1	I^2	I^3	$P^{3\&4}$	$P_{3\&4}$	M^1	M_1	I_1	I^1	M^1	M_1	I_1		M^1	M_1	I_1
Z, 1 and 2 mixed																									
1																					1		1	1	
2		1	2																1	4	1			2	2
2 and 3 mixed																									
3																		1		1			1		
3 and 4 mixed		1															1	1		1	2				2
4		2	4	1			1	1	1									3						2	3
5																				2	1				
6		1	1	1		1							1					5	3	4	8	5	9	6	8
6 and 7 mixed																				1			1		
7	19000	2		1		1		1										2	2	6	3	7	6	4	5
7 and 8 mixed																									
8																		1		2	1			2	2
8 and 9 mixed										1														1	1
9-upper brown part	19250	5	2				1			1		1							2	3	2	4	8	8	6
9-lower			1	1		1	1			1	1		2						3	2	1	1	5	10	9
10a																				1		1	3		1
10b																									
10b and 10c mixed																									
10c	20400		2																2		1		2	3	
10d and 10e			1	1											1			2	4	7	5	2	3	7	2
11			3	2				2		3	1	2	1						3	2	8	8	16	14	10
11 and 12 mixed																						1	3	2	3
12																				1				1	
11, 12 and 13 mixed				1														1		1		4	3	5	1
13				2		1									1					1	1	3	3	11	11
14			1											1					1	3			2	4	4
15				1									1						2	1			1	3	2
14, 15 and 16 mixed											1									1				2	1
16				1								1													
16 and 17 mixed																									
17		2		1		1		1												1					1
16, 17 and 18 mixed																							1		
18 (inc. hearth)	(31400)		1	1		1		1		1		2								1				3	2
19			1																					1	1
20		1					2				1	2											2	1	1
21		3	2	1							2	2								1		1			
22																				1		1		1	1
23		1											1		1				1			1	1	1	1
24													1	1										1	1

Table 2 (cont.)

	Radiocarbon date year B.P.	Western Grey Kangaroo								Western Brush Wallaby								Brush-tail Possum				Ringtail Possum			
	320	I^1	I^2	I^3	$P^{3\&4}$	$P_{3\&4}$	M^1	M_1	I_1	I^1	I^2	I^3	$P^{3\&4}$	$P_{3\&4}$	M^1	M_1	I_1	I^1	M^1	M_1	I_1	Premaxilla	M^1	M_1	I_1
25		2									2	2			1			1				2			1
26		4								1	1	1				1							2		
26 and 27 mixed																									
27 (inc. hearth)			1												1										
27 and 28 mixed	(24600														1										
28 (inc. hearth)	(27700		1							1														1	1
28 and 29 mixed																									
29			1								3												3		
29 and 30-upper mixed																						1			
30-upper																							2	1	
30-upper and 30-lower mixed																								1	1
30-lower	32480																					3	6	2	4
30-lower and 31 mixed																							1		
31	35160								1														4		3
31 and 32 mixed																									
32																								3	1
32 and 33 mixed																									
33																									
33 and 34 mixed*																									
34																						2			
34 and 35 mixed																								2	1
35																									
35 and 36 mixed																								1	
37																									
38	31800									1															
38 and 39 mixed																									

* pooled mean 32800

Table 3: Numbers of some *Macropus fuliginosus* and *Macropus irma* teeth from Devil's Lair (incisors of juvenile individuals excluded).

Tooth	*M. fuliginosus*	*M. irma*
LI^1	19	9
RI^1	17	13
LI^2	17	8
RI^2	22	11
LI^3	15	11
RI^3	22	14
$LP^{3\&4}$	12	5
$RP^{3\&4}$	13	4
$LP_{3\&4}$	20	2
$RP_{3\&4}$	13	5
LM^1	15	12
RM^1	8	11
LM_1	13	6
RM_1	11	2
LI_1	4	1
RI_1	3	1

To prevent animals represented by both deciduous and unerupted permanent premolars being counted twice, all deciduous premolars are included in the table but only fully erupted permanent premolars (i.e. having roots and showing some signs of wear) are included.

The high proportion of juvenile incisors in the deposit can also be explained in terms of the animal's biology. Almost all female kangaroos captured would be accompanied by at least one young. By analogy with the Eastern Grey Kangaroo, females old enough to have produced two young and carrying a pouch young less than 100 days old would also be accompanied by a juvenile (Kirkpatrick, 1965b). Such a family unit would provide a set of adult upper incisors, a set of juvenile upper incisors and many would also be represented by unerupted incisors.

In many macropods (including the kangaroo and wallaby discussed here) the molars, which erupt sequentially, move progressively forward in the jaw until one by one, they fall from the front of the molar premolar tooth row. Thus it is possible that premolar and molar teeth of older animals represented in the deposit would not all be present.

Furthermore, tooth replacement occurs in both macropods and phalangerids. Each of the four marsupials discussed here have two upper and

two lower deciduous premolars which are replaced by one upper and one lower premolar. Replacement usually occurs before all the molars have erupted. According to Tyndale-Biscoe (1973), all the premolars of the Red Kangaroo are shed during the first third of the animal's lifetime. Tooth replacement is slightly faster on the Eastern Grey Kangaroo than the Red Kangaroo (Kirkpatrick, 1965a), thus by analogy with the Eastern Grey Kangaroo, if the age distribution of kangaroos from Devil's Lair were normal, the number of premolars would be expected to be only one third the number of incisors. However, the high incidence of juvenile individuals from the deposit suggests a higher proportion than this can be expected.

On the basis of my own examinations of modern Western Australian Museum specimens, tooth replacement seems to be slower in the Brush Wallaby than the Grey Kangaroo. Thus under-representation resulting from tooth replacement is probably not as important as for the Grey Kangaroo.

The greatest discrepancy shown in **Table 3** is between the numbers of *M. fuliginosus* upper incisors and lower incisors. Actually the discrepancy between upper and lower incisors is much greater than suggested in **Tables 1** and **3** in which there is an implication that many of the left teeth represented come from the same individuals as many of the rights. However, attempts to match each right and left first upper incisor of the Western Grey Kangaroo from trenches 2, 5, 7, 8, and 9 show that very few of the teeth are from the same individual. Each right and left first upper incisor was examined for wear and general morphology in an effort to find matching pairs. Of the 60 teeth examined (32 left and 28 right), no matches were entirely convincing although two possible pairs were found.

The implication of this study is that the number of individuals of Grey Kangaroo represented in the whole deposit (**Table 1**) is probably closer to 98 (LI^1 56 and RI^1 42) than 56, and that of the 196 lower incisors therefore expected from the sample, only seven have been found.

In all incisor bearing kangaroo specimens from the fossil and modern collections of the Western Australian Museum, upper and lower incisors were generally found to be in about the same stage of eruption in the same individual. Thus, unless dentaries do not preserve as well as maxillae in a cave environment, the number of lower incisors should be at least as great as the number of first upper incisors.

To test the possibility that maxillae may preserve better than dentaries in caves, counts of Western Grey Kangaroo premaxillae, maxillae and dentaries were made on collections from two caves near Devil's Lair not suspected of having an archaeological component (cave AU12 near Augusta and Dingo or

'Boy Scout cave'). The results in Table 4 suggest that dentaries are selectively preserved with respect to maxillae and even more so when compared to premaxillae. Thus it seems reasonable to expect numbers of lower incisors to be at least as great as first upper incisors.

Table 4: Numbers of some skeletal parts of *Macropus fuliginosus* from two non-archaeological sites near Devil's Lair.

	Cave AU 12 near Augusta	Dingo 'Boy Scout' cave W1 71
premaxillae	2	2
maxillae	11	2
dentaries	13	7

The apparent discrepancy between numbers of first upper incisors and other teeth of Brush-tailed Possum and between the number of premaxillae and other skeletal structures of the Ringtail could not be reconciled. It is suspected that some of the Brush-tailed Possum first incisors may have been mis-identified as rat kangaroo upper first incisors. Ringtail premaxillae are fragile and the low numbers recorded may be a result of selected preservation. Thus, comparisons of numbers of lower incisors were made with numbers of upper first molars and there is no apparent discrepancy between these two structures. However, the discrepancies between the numbers of lower incisors and upper incisors of the Western Grey Kangaroo and Brush Wallaby remain striking.

The bone artifacts from Devil's Lair

A number of bone artifacts have been recognised from layers at Devil's Lair dating from about 30,000 years ago to 6,000 years ago. Many of these are just splinters but others show that bone was used by the human occupants of Devil's Lair to perform a variety of functions. These include invasively flaked or scratched pieces and several bone points. Some of these points are quite small (one apparently made on a bird fibula is only 14 mm long) but at least two are modified macropod fibulas (Dortch & Merrilees, 1972; Dortch & Merrilees, 1973).

Two artifacts whose probable function is decorative have also been excavated. The first is a small length of polished bone with rounded ends which has been interpreted as a bead and the second, a small pointed fragment with a perforation at one end has been suggested to be a needle

or bodkin or perhaps part of a necklace or headband (Dortch & Merrilees, 1973).

A few tooth artifacts have also been reported and so far all are macropod lower incisors. Most of these have been interpreted as artifacts because they have narrow, relatively deep incisions (Dortch & Merrilees, 1972) but at least one has been worked at its proximal end (Dortch & Merrilees, 1973).

Other archaeological evidence for the use of macropod teeth by Aborigines

Archaeological evidence for special use of kangaroo and wallaby incisors by Aborigines also occurs at two sites excavated by Carmel White in Arnhem Land. In the Padypadiy deposit, which dates from about 3,000 years B.P. to present, White (1967) has recorded the presence of ground kangaroo lower incisors throughout the deposit. From Malangargerr she has excavated two wallaby incisors bearing use gloss (one worn and broken) in contexts dating from 6,000 years B.P. to present (Mulvaney, 1975).

At Durras North, New South Wales, Lampert has only found one tooth of the 96 other wallaby teeth expected from the number of individuals estimated by the eight wallaby lower incisors excavated (Lampert, 1966). Three of the lower incisors have broken tips and Lampert has concluded that wallaby lower incisors were probably used either as ornaments or tools at Durras North.

Ethnographic evidence for the use of teeth by Aborigines

Ethnographic reports show that the use of teeth as tools and ornaments is widespread. In Australia wallaby and kangaroo lower incisors were particularly important and ethnohistorical data on their use records a variety of functions. For south-western Australia Nind (1832) noted this special importance by recording in an account of kangaroo butchering techniques of the Aborigines of King George Sound that the first operation was the extraction of lower incisors which were used to sharpen spear points.

As ornaments, lower incisors have been described from all over the continent. An ornament worn by both male and female Queensland Aborigines made by fixing the kangaroo incisors in a more or less oval shaped base of spinifex or beefwood cement has been recorded by Roth (1897). Spencer (1922) has described similar decorations as well as necklaces, forehead bands and other head ornaments. The Western Australian Museum ethnological collection contains many such ornaments.

McCarthy (1970) noted that although the mandible of various marsupials with their lower incisor intact was used as engraving tools and drills, possum and macropod lower jaws were especially used for such functions. The incisor has been described as a scraper by Roth (1904) for the Cape York people who broke the tooth after heating it and then used it either *in situ* in the lower jaw or bound on a wooden handle to sharpen speartips or cut grooves.

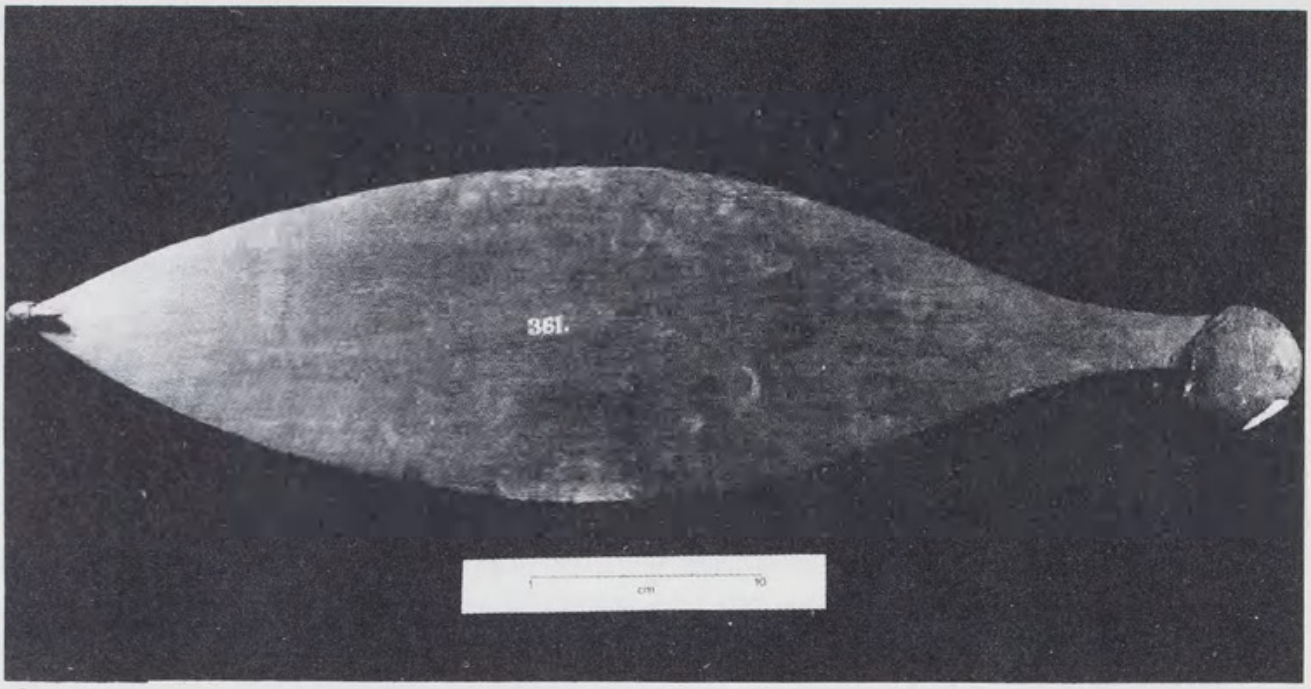
Another record of the incisor's use as a scraper comes from Mrs Hassell's descriptions of a tool used by the Aboriginal women of the Wheelman tribe, south-west Australia. Hassell (1936, p. 691) says that the women used a knife consisting of 'a stick with a kangaroo tooth embedded at one end. It was used in scraping skins, cutting sinews, and for skinning. The women were able to skin a kangaroo with it as rapidly as a man with a European knife'. The 'front tooth' in an engraving tool also described by Mrs Hassell probably refers to a lower incisor (Hassell, 1936; p. 692).

Although records vary as to the function of kangaroo incisors attached to spearthrowers, it is still the most commonly reported use of them. According to Eyre (1845, vol. 2, pp. 306-307) the Australian throwing stick is more or less the same throughout the continent. Although varying slightly in width or shape all are characterised by a mounted kangaroo tooth in the proximal end to act as a hook. However, Smyth (1878) records that in Victoria, throwing sticks sometimes had a carved wooden hook and in Western Australia they always had a wooden hook.

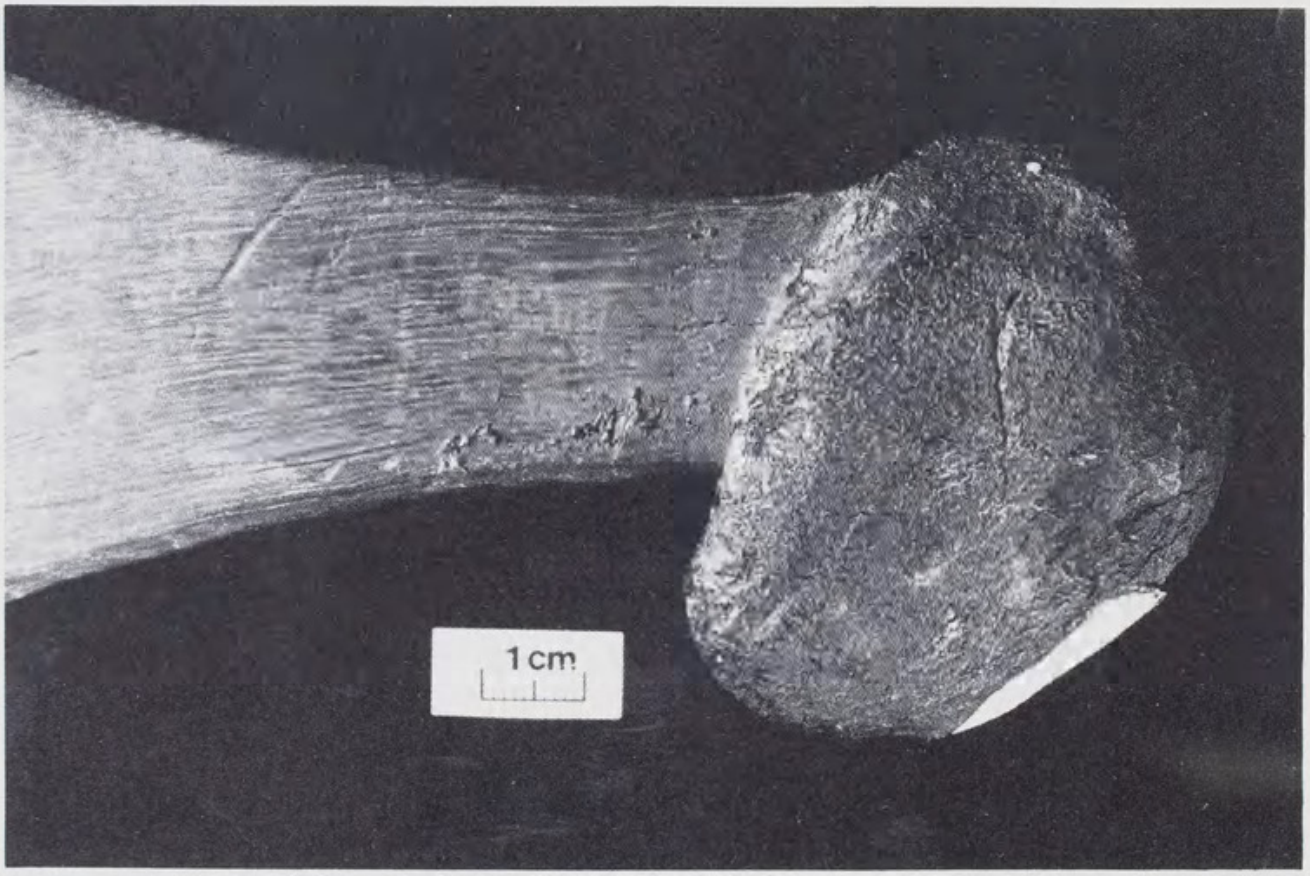
Specific Western Australian accounts for the use of kangaroo teeth in spearthrowers is also confused. Roth (1902) referring to information gathered by F.R. Austin, then the Assistant Surveyor for the South West of Western Australia, reported that spearthrowers from Port Leschenault, Koombana Bay area (where Bunbury now stands) had a kangaroo tooth fixed with gum at the distal end acting as a hook.

However, other accounts from the same area describe the function of the kangaroo tooth in the spearthrower as a knife or scraper rather than as a hook. For example, Davidson's Western-Southern type of spearthrower is made of hard wood, is relatively long and bi-convex in cross section, and usually has a gum handle which often contains a stone blade or a tooth knife (Davidson, 1936; p. 474).

In the Bremer Bay area this function is confirmed: 'spears were usually thrown with the aid of a meera or spearthrower, generally made of "raspberry jam" wood . . . the peg was a small wooden pin about one half



A



B

FIG. 1

A: South-west Australian spearthrower showing position of kangaroo lower incisor at distal end (WAM 361).

B: Enlargement of distal end of spearthrower showing lateral positioning of kangaroo incisor in gum.

inch long fastened to one end with gum and kangaroo sinew. The other end of the meera had a piece of gum for a handle. A kangaroo tooth was often embedded in the gum for use as a knife' (Hassell, 1936; p. 691). Moore (1842) reports a similarly mounted incisor which was used for a variety of purposes including scraping the points of spears.

All intact South West spearthrowers in the Western Australian Museum collection have a wooden hook and all except one have either lost the knife/scraper from the gum handle or have never had one. The only specimen which had anything set in its gum contained a kangaroo lower incisor (WAM 361 — see **Fig. 1**).

The lateral positioning of the tooth suggests it was a scraper and the tip of the tooth is virtually unmarked while the exposed side of the tooth is heavily worked suggesting the tooth has always been mounted lengthways. None of the ethnographic accounts record the positioning of the lower incisor in the gum.

DISCUSSION

Uneven representation of various skeletal elements has been found on both archaeological and non-archaeological sites. Goede and Murray (1977) believe the relative scarcity of small mammal remains and small skeletal parts of larger mammals from Pleisto Scene cave, north-west Tasmania is a result of differential preservation in favour of larger bones. The cave does not appear to have been used by humans, but some effects by scavengers or carnivores were suspected.

Archer (1974) has demonstrated by laboratory experiments and from field studies that differential transportation of bones by water can occur. Although it is possible that differential transportation has occurred in Devil's Lair and indeed has been suggested to have occurred in the lower part of the deposit (Balme, Merrilees & Porter, 1978), it seems unlikely to be the sole cause of the relative scarcity of kangaroo and wallaby lower incisors.

Brain's (1967) comparisons of the relative proportions of skeletal parts in the food remains of the Topnaar Hottentot villagers showed that some structures survive destructive treatment better than others. It is possible that trampling and crushing may have destroyed some of the small or more delicate bones in Devil's Lair, but it is difficult to envisage such actions selectively destroying a durable skeletal element such as the lower incisor of a kangaroo or wallaby.

The major predators of kangaroo at Devil's Lair are the Tasmanian Tiger (*Thylacinus cynocephalus*) and Man. The Tasmanian Devil (*Sarcophilus harrisii*) may also have contributed to the kangaroo sample by occasionally capturing a young, wounded or sick animal, but it is doubtful that it could catch a healthy adult kangaroo. Reworking of the food refuse of these animals by smaller carnivores is also possible, but although any of the carnivores may have selected bone in such a way that the bone sample is non-random, only Man is likely to have selected lower incisors to such an extent.

CONCLUSION

A number of artifacts made out of kangaroo and wallaby bones (some on lower incisors) have already been recorded from Devil's Lair. Of the seven Grey Kangaroo lower incisors excavated from the deposit, four have their pointed tips broken off, suggesting perhaps that they were discarded being no longer useful as a tool.

In the light of this and of the available ethnohistorical evidence, the most plausible explanation for the low numbers of kangaroo and wallaby incisors from Devil's Lair is deliberate selection of the incisors by the early occupants of the cave. Kangaroo remains are consistently present in the cave from layer 29 to layer G representing a span of some 20,000 years (**Table 2**). The scarcity of kangaroo and wallaby incisors from these layers suggest that humans in the Devil's Lair region have been using the teeth as tools or ornaments from about 27,000 to at least 6,000 years ago.

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