Re-appraisal of Black Rhinoceros Subspecies

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INTRODUCTION

One research priority of the current action plan of AERSG is to "examine the taxonomic status of presently described subspecies of black rhino so as to provide a sound basis for ordering priorities for action amongst the now geographically separated populations in Africa". This does not imply that conservation efforts should be delayed while tile rhino taxonomy is being clarified, but simply that an attempt has to he made to consider genetic variation in a systematic way when developing future action plans.

The most comprehensive recent paper on black rhino classification is that of Groves (1967), in which seven subspecies are described according to skull dimensions. However, the sample size on which this classification was based was very small; a total of only 74 adult skulls were measured (and of these over half were **Diceros bicornis minor** and **D.b. michaeli**). An unpublished revision of the subspecies by C.P. Groves (in litt., November 1985), based on measurements of about twice the number of skulls, has not greatly altered his original classification, although he no longer regards **D.b. bicornis** as one of the extinct subspecies. However, his conclusions remain tentative since three of his suubspecies still have less than 10 representative skulls, and the clinal variation within subspecies such as **D.b. minor** has not been clearly establisbed.

By measuring as many as possible of the skulls of rhino that have been poached or have died naturally in African wildlife areas, the issue of rhino taxotnomy could be investigated in much more depth. This paper is essentially to outline a standard procedure for the measurement pf skulls and to make a plea to all those in a position to collect such data to please do so and to submit the information to the AERSG office in Harare. All sources of information will be acknowledged in ensuing reports. The morphometric studies will hopefully be complemented by biochemical studies on rhino blood, using techniques such as mitochondrial DNA sequencing.

AGE DETERMINATION

It is obviously important to ensure that any skull measurements used to differentiate subspecies are those of adult animals; only skulls in which the third molar is erupted and in wear need be measured. Further approximate age determination of skulls can be carried out quickly in the field by studying the degree of attrition of the adult maxillary dentition.

This age determination is made possible through the work of Hitchins (1978), who outlined age criteria for black rhino in Zululand based on tooth eruption and wear. He assigned chronological ages to his different age classes through reference to a limited number of known-age animals and to incremental lines in tooth cementum. In each upper premolar and molar, depressions between the cups (the prefossette and the postfossette) gradually become isolated holes as the cups erode, and finally disappear altogether; the successive stages of wear of these features serve as a fundamental criteria in Hitchins' system.

As an extension of Hitchins descriptions of age classes, each stage of wear of the prefossette and the postfossette can be assigned a numerical value, as shown in Figure 1. A total "tooth wear index" can be calculated for a skull by adding up the wear values assigned to the postfossettes of teeth in the row PM^2"– M^2, on either the left or the right side of the maxilla. (PM^1 and M^3 do not have the

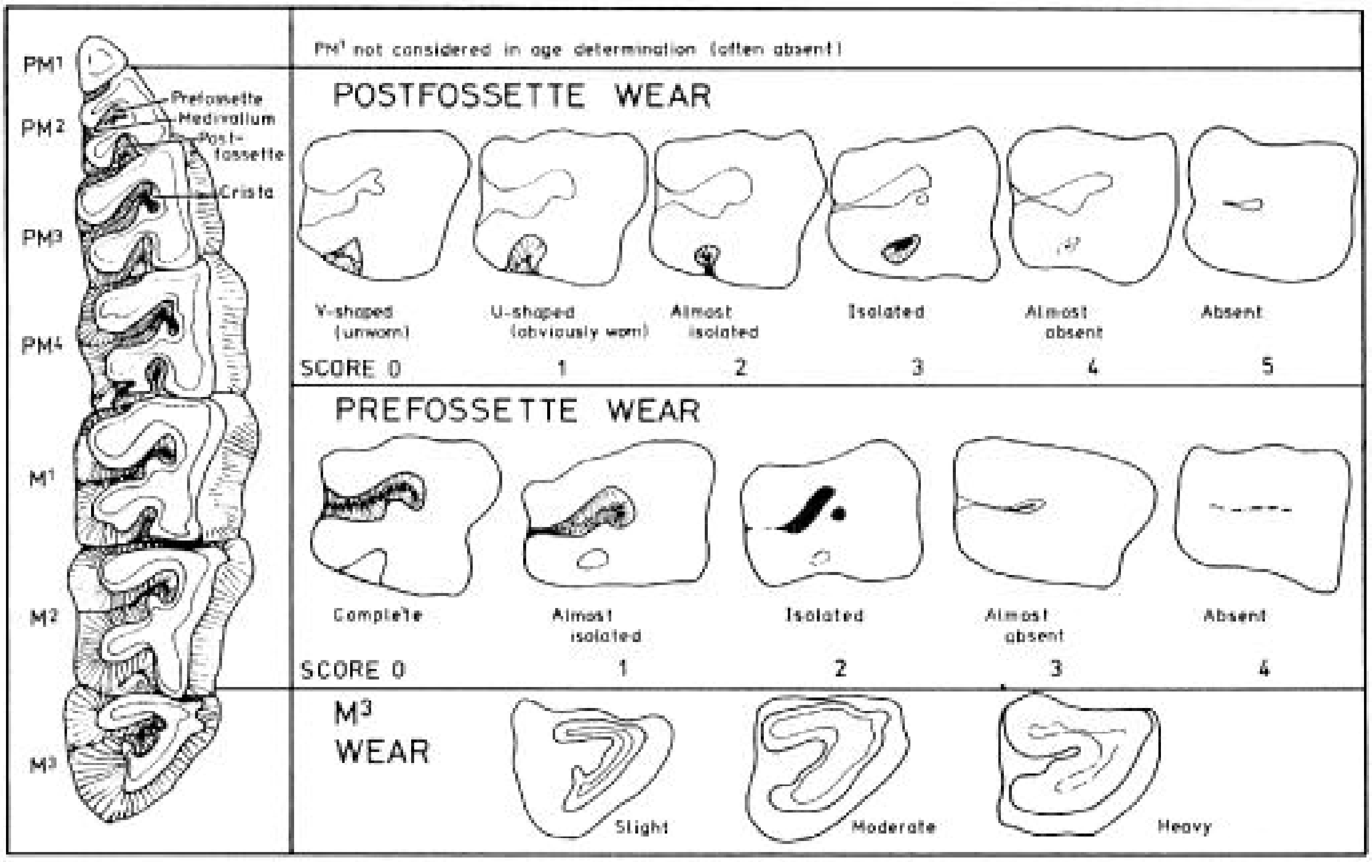

Figure 1. Stages of wear of maxillary teeth. For age determination, score wear of prefossette and postfossette of each tooth in row PM^2-M^2 (either side) and add up scores to get tooth wear index, which can be related to approximate age in Figure 2.

same wear pattern as the other teeth, and the former is often missing anyway, so the wear of these teeth is not incorporated in the index). Hitchins' age classes, with the relevant ageing criteria and tooth wear indices for maxillary dentition, are presented in summarized form in Table 1.

Using Hitchins' information on chronological ages corresponding to different stages of tooth wear, the relationship between age and tooth wear index can be plotted (Figure 2). The relationship is not very precise because there is overlap in the ages Hitchins assigned to his different age classes, and because the tooth wear index for each age class has a range of values; nonetheless, it seems that the age of a skull can be determined to'±4 years from its maxillary tooth wear index. Fortuitously, between the ages of about 22-33 years, the tooth wear index has the same numerical value as the approximate age.

The rough relationship between age and tooth wear depicted in Figure 2 may not pertain to all rhino populations in Africa, since diets and consequently tooth wear will vary. If the tooth wear patterns of any known-age animals elsewhere in Africa can be studied, the relationship may then be replotted if necessary.

SEXUAL DIMORPHISM

Joubert (1970) found no evidence of sexual dimorphism in the skulls of black rhino in Namibia, and Foster (1965) was also unsuccessful in finding a criterion to determine the sex of rhino skulls at Tsavo, Kenya. Through their lack of reference to rhino sexual dimorphism, Groves (1967) and Goddard (1970) imply that this does not exist at a level that can be measured in skulls. Hence it is presumed that skulls do not necessarily have to be sexed in order for their measurements to be used as a basis for classifying rhino subspecies, but further information on sexual dimorphism is required.

Table 1. Summary of criteria outlined by Hitchins (1978) for age determination of black rhino in Zululand, showing derivation of tooth wear indices corresponding to Hitchins' age classes. (Criteria in brackets have been inferred from Hitchins outline)

HITCHINS' AGE CLASS	TOOTH	POSTFOSSETTE Wear	Score	PREFOSSETTE Wear	Score	OTHER FEATURES (Not scored)	TOOTH WEAR INDEX
x	PM2	U-shaped	1	(Complete)	0	Crista absent	
	PM3	U-shaped/almost isolated/isolated	1-3	(Complete)	0	Crista worn/absent	
6-12 yrs	PM4	v-shaped/U-shaped	0-1	(Complete)	0		2-5
	Ml	v-shaped	0	(Complete)	0	Crista absent	
	M2	v-shaped	0	(Complete)	0	Crista disappearing	
	M3					Erupting/not in wear	
XI	PM2	U-shaped/almost isolated	1-2	Almost Isolated	1		
	PM3	U-shaped/almost Isolated/isolated	1-2	(Complete)	0	Crista worn/absent	
7-13 yrs	PM4	V-shaped/U-shaped	0-1	(Complete)	0		4-8
	Ml	U-shaped	1	(Complete)	0		
	M2	V-shaped	0	(Complete)	0	Crista absent	
	M3					Sight wear	
XII	PM2	(U-shaped/almost isolated	1-2	(Almost isolated)	1		
	PM3	Almost Isolated/Isolated	2.3	(Complete)	0		
9-15 yrs	PM4	U-shaped	1	(Complete)	0	Crista absent	7-11
	M1	Almost isolated/isolated	2-3	(Complete)	0		
	M2	(V-shaped/U-shaped)	0-1	(Complete)	0		
	M3					Light to moderate wear	
XIII	PM2	Isolated	3	Almost Isolated/isolated	1-2		
	PM3	Almost isolated/isolated	2-3	Almost isolated/isolated	1-2		
13-19 yrs	PM4	Almost isolated/isolated	2-3	(Complete)	0		
	M1	(Almost isolated/isolated)	2-3	(Complete)	0		
	M2	V-Shaped/U-Shaped	0-1	(Complete)	0		
	M3					Moderate wear	11-17
XIV	PM2	(Isolated)	3	(Almost isolated/isolated)	1-2		
	PM3	(Isolated)	3	(Almost isolated/isolated	1-2		
18-24 yrs	PM4	isolated/almost absent/absent	3-5	(Complete/almost isolated)	0-1		
	M1	(Isolated/almost absent)	3-4	(Complete)	0		
	M2	U-shaped/almost isolated/isolated	1-3	(Complete)	0		
	M3					(Moderate to heavy wear)	15-23
XV	PM2	(Isolated/almost absent)	3-4	Isolated(/almost absent)	2-3		
	PM3	Isolated (/almost absent)	3-4	Isolated	2		
23-31 yrs	PM4	Isolated(/almost absent/absent)	3-5	Almost isolated	1	Medivallum disappearing	22-31
	M1	Absent	5	Almost Isolated	1		
	M2	U-shaped/almost isolated/isolated/ almost absent/absent	1-S 2-3	Almost isolated	1		
	M3					Heavy wear	
XVI	PM2	Absent	5	Absent	4	Medivallum absent	
	PM3	Absent	5	(isolated)	2	Medivallum absent	32-37
29-37 yrs	PM4	Absent	5	(Almost isolated/isolated)	1-2		
	M1	Absent	5	(Almost Isolated/isolated)	1-2		
	M2	Isolated/almost isolated/absent	3-5	(Almost isolated(/isolated)	1-2		
	M3					Heavy wear	
XVII	PM2	(Absent)	5	(Absent)	4		
	PM3	Absent	5	Isolated	2	Medivallum absent	
33-41 yrs	PM4	Absent	S	Isolated	2	Medivallum absent	39-41
	M1	Absent	5	Absent	4	Medivallum absent	
	M2	Absent	5	(Isolated/almost absent	2-3		
	M3					Heavy wear	

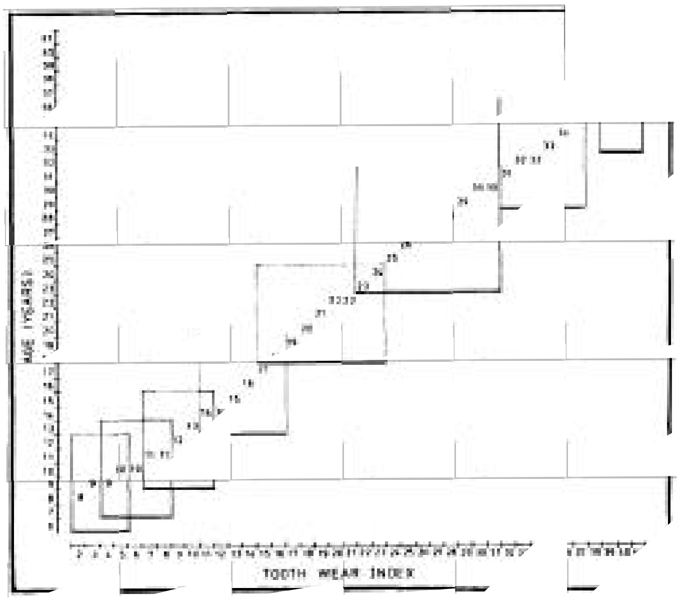

Figure 2. The relationship between tooth wear index and chronological age of Zululand black rhino. Squares represent Hitchins' (1978) age classes (vertical dimension) and corresponding values of the tooth wear Index (horizontal dimension). Having presumed that tooth wear is progressive, a line has been drawn through the centres of the squares and the ages along this line have been indicated, so that approximate age (±4 years) for a given tooth wear index can be ascertained.

SKULL MEASUREMENTS

Measurements should be in millimetres whenever possible; they can be made quite accurately with a steel tape and a couple of rulers, set-squares or straight planks.

Figure 3 shows the various measurements that are required. Most of these are standard for this type of work on skulls (e.g. von den Driesch, 1976), but since some slightly different measurement techniques may have been used by other researchers, additional measurements ("occipital depth"; "condyle depth") are included to cover all possibilities. Essential measurements are indicated with an asterisk.

***Toothrow Length** can be measured on either side (in the cranium, not the lower jaws) and is of six teeth only; it does not include the first premolar, which is often absent anyway. The measurement is from the anterior edge of the second premolar to the posterior edge of the last molar.

M^2 Height is from the anterior crest on the buccal (cheek) side of the second upper molar to the bone directly below; if a gumline is still visible on the tooth, a second measurement can be made from the crest to this line. These measurements are not absolutely essential but t would be useful to have these data to relate them to the tooth wear index.

*** Basilar Length** is the distance from the front lower border of the foramen magnum to the front edge of the premaxilla. If the premaxilla are missing (which has to be checked since these delicate bones do tend to break off) then the measurement should be to the most anterior points of the maxilla, with a note to this effect.

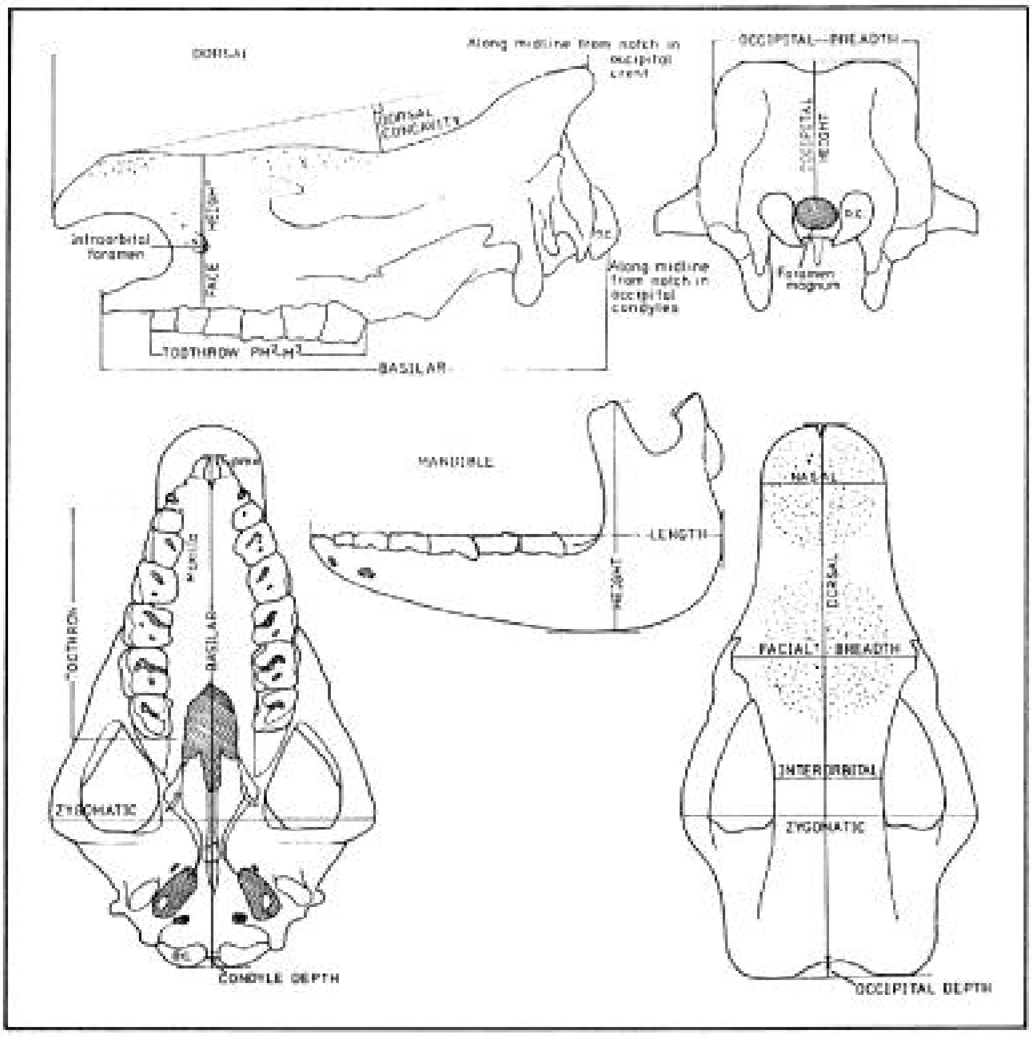

Figure 3. Required measurements of black rhino skulls. (see also Appendix 1).

Condyle Depth is the distance from the posterior edge of the occipital condyles to the front lower border of the foramen magnum.

*** Dorsal Length** is a midline measurement from the rim of the occipital crest to the front of the nasals. Sometimes there is a bump in the centre of the occipital crest, but the measurements should nonetheless be taken on the midline, including this bump.

Occipital Depth is the depression between the wings of the occipital crest, measured horizontally on the midline of the skull (i.e. an extension of the dorsal length).

*** Zygomatic Breadth** is the greatest width of the skull.

*** Interorbital Breadth** is the narrowest distance between the orbits.

Facial Breadth (anterior interorbital breadth) is the width across the roughened area that bears the posterior horn. This appears to be a particularly variable dimension, possibly with little statistical significance, because of the very irregular growth of bone on either side of the skull in this area.

*** Nasal Breadth** is the width across the roughened nasal boss that bears the anterior horn.

Face Height is measured from the rim of the tooth sockets perpendicularly across the infraorbital foramen to the upper surface of the nasals.

*** Dorsal Concavity** place a ruler or flat plank on top of the skull, along the midline, so that it rests on the nasal boss and the centre of the occipital crest. The maximum perpendicular distance between this plane and the concave surface of the cranium (between the orbits) is then measured.

*** Occipital Breadth** is the greatest breadth across the back of the braincase.

*** Occipital Height** is measured vertically on the midline from the dorsal edge of the foramen magnum to the highest part of the skull.

Mandible Height is the greatest height of the lower jaw.

Mandible Length is the greatest length of the lower jaw. (The absence of a lower jaw, and hence the impossibility of obtaining the mandible measurements, does not mean that a data sheet is not required for that skull; an incomplete set of data is better than none at all. Similarly, if skulls are damaged, those measurements that can be taken should still be recorded).

OTHER INFORMATION

It is or course important to state the source area of skulls as accurately as possible (preferably in coordinates of latitude and longitude). If the sex of the animal is known (not inferred from the skeletal material) then this should be noted so that the degree of sexual dimorphism can be examined. If the age of the animal at death is known (not inferred from the tooth wear or other such factors) then this should also be noted so that the method of age determination outlined in this paper can be tested.

Intraspecific genetic variation in black rhino may well be a clinal situation, related to fine adaptation of the animals to varying ecological conditions over their geographical range. Such slight ecological adaptations may not be reflected in the skull dimensions or even in any of the biochemical features that will be examined. However, it does seem reasonable to hypothesize that there may be a change in overall skull size, toothrow length or other morphological features, according to rainfall, altitude, vegetation, etc. (as with the African elephant). It is therefore desirable that some basic environmental information is collected to enable ecological classification of rhino populations and to see if habitat factors can in fact be related to subspecific taxonomy. If such information cannot be readily obtained when skulls are first measured, then this should not be allowed to delay the submission of the skull data sheets, since the information can be obtained later from reference works (provided locations can be identified).

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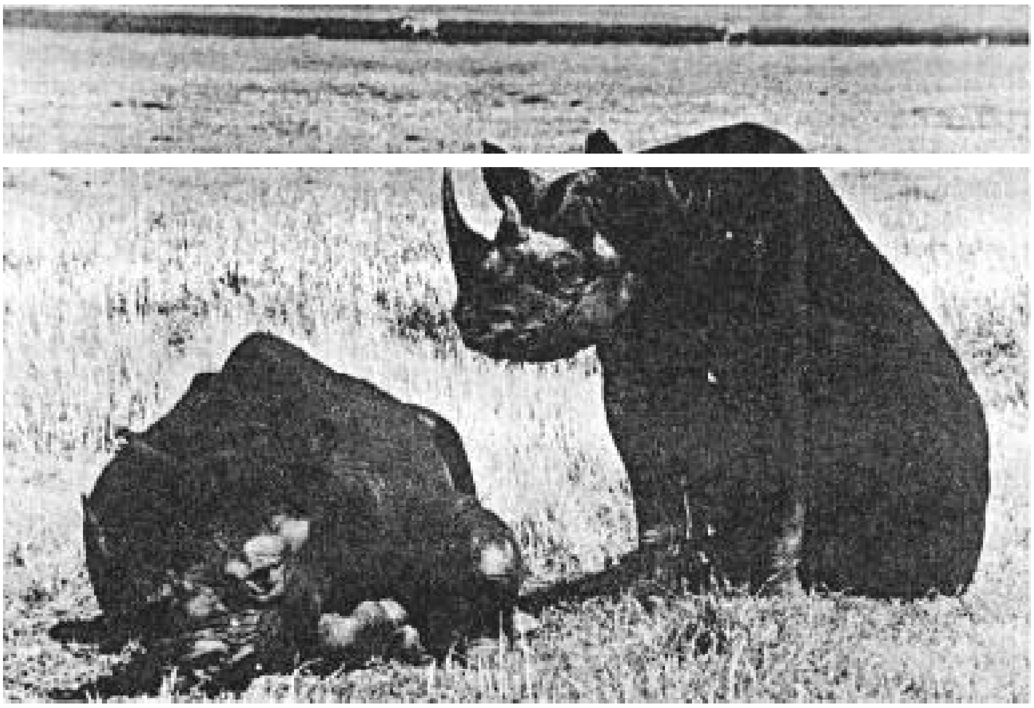

Black rhino, Ngorongoro, Tanzania. W. Dolder/WWF.

APPENDIX 1

AERSG INVESTIGATION OF BLACK RHINO TAXONOMY

RHINO SKULL MEASUREMENTS

* essential data No.______________________________

*01 Measurements by ______________________ 02 Date ____

* 03 Collection _____________________________(Collection Ref. No.) _______________________________

* 04 From (locality) 05 Sex ____________________ 06 known age ____________________ * 07 M^3 wear SLIGHT/MODERATE/HEAVY

Tooth wear index	POSTFOSSETTE	PREFOSSETTE	
	PM^2 ______________________	______________________	
	PM^3 ______________________	______________________	
	PM^4 ______________________	______________________	
	M^1 ______________________	______________________	09 M^2 height (ant. buccal)
	M^2 ______________________	______________________	to bone ________________
			to gumline______________

08 Total index of wear ______________________

* 10 Toothrow length (PM^2-M^3) ____________________________

* 11 Basilar length ____________________________

12 Condyle depth ____________________________

* 13 Dorsal length ____________________________

14 Occipital depth ____________________________

* 15 Zygomatic breadth ____________________________

* 16 Interorbital breadth ____________________________

17 Facial breadth ____________________________

* 18 Nasal breadth ____________________________

19 Face height ____________________________

* 20 Dorsal concavity ____________________________

* 21 Occipital breadth ____________________________

* 22 Occipital height ____________________________

23 Mandible height ____________________________

24 Mandible length____________________________

25 Altitude ____________________________ 26 Mean annual rainfall ____________________________

27 Habitat ____

28 Notes____

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