Re-appraisal of Black Rhinoceros Subspecies

Raoul du Toit

Scientific/Executive Officer, African Elephant & Rhino Specialist Group, Box 8437, Causeway. Harare, Zimbabwe

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 An unpublished revision of the subspecies by C.P. Groves (in litt., November 1985), based on measurements of about twice the number of skulls, has not greatly altered his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 knownage 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. (PM¹ and M³ 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	тоотн	POSTFOSSETTE Wear	Score	PREFOSSETTE Wear	Score	OTHER FEATURES (Not scored)	TOOTH WEAR INDEX
x 6-12 yrs	PM2 PM3 PM4 MI M2 M3	U-shaped U-shaped/almost isolated/isolated v-shaped/U-shaped v-shaped v-shaped	1 1-3 0-1 0 0	(Complete) (Complete) (Complete) (Complete) (Complete)	0 0 0 0	Crista absent Crista worn/absent Crista absent Crista disappearing Erupting/not in wear	2-5
XI 7-13 yrs	PM2 PM3 PM4 MI M2 M3	U-shaped/almost isolated U-shaped/almost Isolated/isolated V-shaped/U-shaped U-shaped V-shaped	1-2 1-2 0-1 1 0	Almost Isolated (Complete) (Complete) (Complete) (Complete)	1 0 0 0	Crista worn/absent Crista absent Sight wear	4-8
XII 9-15 yrs	PM2 PM3 PM4 M1 M2 M3	(U-shaped/almost isolated Almost Isolated/Isolated U-shaped Almost isolated/isolated (V-shaped/U-shaped)	1-2 2.3 1 2-3 0-1	(Almost isolated) (Complete) (Complete) (Complete) (Complete)	1 0 0 0	Crista absent Light to moderate wear	7-11
XIII 13-19 yrs	PM2 PM3 PM4 M1 M2 M3	Isolated Almost isolated/isolated Almost isolated/isolated (Almost isolated/isolated) V-Shaped/U-Shaped	3 2-3 2-3 2-3 0-1	Almost Isolated/isolated Almost isolated/isolated (Complete) (Complete) (Complete)	1-2 1-2 0 0	Moderate wear	11-17
XIV 18-24 yrs	PM2 PM3 PM4 M1 M2 M3	(Isolated) (Isolated) isolated/almost absent/absent (Isolated/almost absent) U-shaped/almost isolated/isolated	3 3 3-5 3-4 1-3	(Almost isolated/isolated) (Almost isolated/isolated (Complete/almost isolated) (Complete) (Complete)	1-2 1-2 0-1 0	(Moderate to heavy wear)	15-23
XV 23-31 yrs	PM2 PM3 PM4 M1 M2 M3	(Isolated/almost absent) Isolated (/almost absent) Isolated(/almost absent/absent) Absent U-shaped/almost isolated/isolated/ almost absent/absent	3-4 3-4 3-5 5 1-S 2-3	Isolated(/almost absent) Isolated Almost isolated Almost Isolated Almost isolated	2-3 2 1 1 1	Medivallum disappearing Heavy wear	22-31
XVI 29-37 yrs	PM2 PM3 PM4 M1 M2 M3	Absent Absent Absent Absent Isolated/almost isolated/absent	5 5 5 3-5	Absent (isolated) (Almost isolated/isolated) (Almost Isolated/isolated) (Almost isolated(/isolated)	4 2 1-2 1-2 1-2	Medivallum absent Medivallum absent Heavy wear	32-37
XVII 33-41 yrs	PM2 PM3 PM4 M1 M2 M3	(Absent) Absent Absent Absent Absent	5 5 5 5	(Absent) Isolated Isolated Absent (Isolated/almost absent	4 2 4 2-3	Medivallum absent Medivallum absent Medivallum absent Heavy wear	39-41



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 (\pm 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.

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 * 0'		07 M ³ wear SLIGHT/MODERATE/HEAVY		
Tooth wear	POSTFOSSETTE	PR	EFOSSETTE			
index	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)			19 Face height			
* 11 Basilar length			* 20 Dorsal concavity _			
12 Condyle depth			* 21 Occipital breadth			
* 13 Dorsal length			* 22 Occipital height _			
14 Occipital depth			23 Mandible height _			
* 15 Zygomatic breadth			24 Mandible length_			
* 16 Interorbital breadth _						
17 Facial breadth						
* 18 Nasal breadth						
25 Altitude			26 Mean annual rainfal	I		
27 Habitat						
28 Notes						