The Game Ranger

Official Mouthpiece of the Game Rangers Association of Africa

CENSUS AND MARKING SYSTEMS FOR BLACK RHINOCEROS *DICEROS BICORNIS* WITH SPECIAL REFERENCE TO THE ZULULAND GAME RESERVES.

P.M. HITCHINS

DECEMBER 1990

INTRODUCTION

The black rhinoceros has been listed as one of the World's most endagered mammals by the International Union for the Conservation of Nature. From over 100 000 black rhinoceros prior to the 1960's, the total population has decreased to about 3 500 animals. The major reason for this decline is poaching for it's horn, which is used for medicinal purposes in the Far East and as dagger handles in North Yemen.

In order to ensure the safety and survival of the remaining wild populations a detailed knowledge of their ecology and response to management actions is required. Some of the most vital information is the population dynamics of these animals from different areas. In order to achieve this goal, long term records of individually identified black rhinoceros is required.

Individual rhinoceros **Diceros bicornis** (Linnaeus, 1758) have been recognised from their natural features since the early fifties: in Zululand the famous 'Matilda', with a magnificent anterior horn, continually harassed tourists in the northern area of Hluhluwe Game Reserve; in the south of Hluhluwe, the notorious 'Poking Polly' was well known by staff for her extreme aggression, had both horns of the same length but the posterior horn was off-set by about 15 degrees to the vertical. Likewise in East Africa the famous long-horned black rhinoceroses from Amboseli Game Reserve, 'Gertie' and 'Gladys' were extremely characteristic and known throughout the world.

It was not until late 1961 that individual recognition of black rhinoceros was pursued by the author in greater detail to obtain data primarily on rhinoceros movements and the reproductive history of mature females in Hluhluwe Game Reserve (Hitchins 1968, 1969, 1970, 1976; Hitchins and Anderson 1983). This method has been continued over the years and has been applied to other game reserves in Zululand and elsewhere with a record of some 500 individually recognisable black rhinoceros.

Other workers in Africa have also used the individual recognition method to monitor various aspects of black rhinoceros biology (Klingel and Klingel 1966; Goddard 1966, 1967a; Hamilton and King 1969; Western and Sindiyo 1972; Mukinya 1976; Hall-Martin and Penzhorn 1977; Leader-Williams 1985). In addition to natural features black rhinoceros have been marked using ear tags (Hamilton and King 1969; Hanks 1969), radio transmitters (Anderson and Hitchins 1971; Hitchins 1971), horn branding (Hanks 1969) and collars (Thomson 1974).

Assessment of black rhinoceros numbers from aerial counts are unreliable as they are extremely difficult to see from the air (Goddard 1967b; Hitchins unpublished). In the Mwabvi Game Reserve in Malawi a number of aerial passes were made over the same dense vegetation creating a greater disturbance than on a single pass and a rhinoceros missed on one circuit thus stood increasing chances of being seen on subsequent passes (Parker 1976).

Estimates of black rhinoceros populations have been derived using stratified random sampling. These estimates were corrected by factors varying from 1,5 to 7, which were based on evidence provided by Goddard (1967b; Western 1982; Borner 1983). In spite of their considerable inaccuracies, aerial censuses have, so far, provided the only way to make some sort of estimate of rhinoceros numbers in large areas (Goddard 1969).

This paper considers the various census and marking methods that have been used on black rhinoceros in Africa with special reference to the author's experiences since 1961.

Fig. 2 : The Black Rhinoceros *Diceros Bicornis.*

Authors Address: P.O. Box 291
BADPLAAS
1190

Editor: K. Coetzee
P. Bag X658
OUDTSHOORN
6620

Fig. 1 : Mature female and 14 month old calf : note posterior horn slightly longer than anterior horn, tear pattern in left ear and absence of ear fringes.

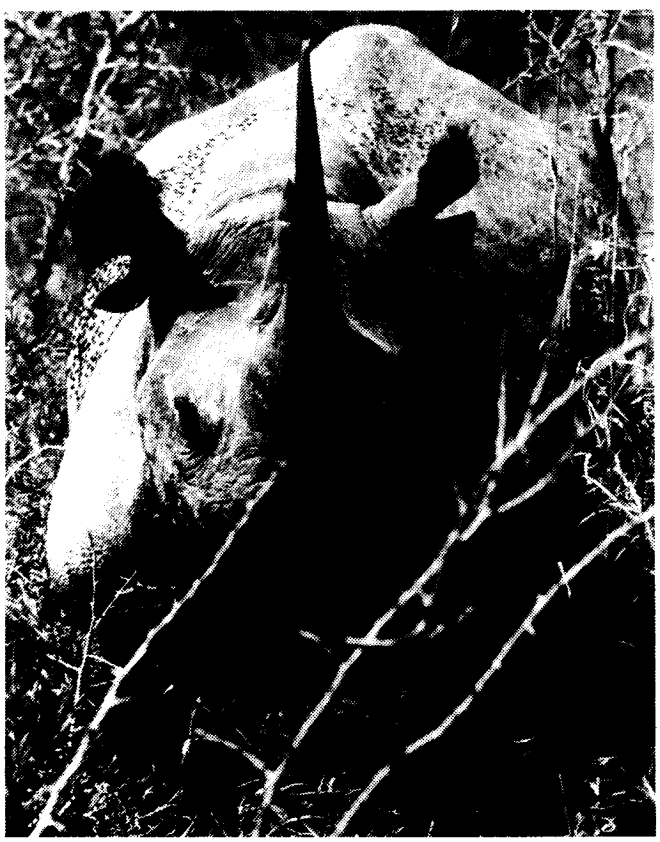


Fig. 2 : Mature male, anterior horn longer than posterior horn, both ears with tears of different shape, note ear hair fringes.

METHODS

1. **Individual recognition by natural physical characteristics.**

A number of characteristics combined together enable an observer to identify individual mature and immature rhinoceros (Figs. 1 and 2).

These are as follows:

- Sex
- Horns: conformation and shape, size in relation to one another (anterior and posterior), an estimated length is always recorded using the animal's ear as an index, the horn length is recorded as a number or portion of the ear length for both horns. The average ear length of mature black rhinoceros in Zululand is 202 mm (n=28). Grooves, notches, breaks, splits or cracks are also noted.
- Ears: present or absent; tears, notches, nicks and ear hair fringes. Care must be taken in recording ear characteristics with special reference as to which is the animal's left or right ear, if facing or moving away from the observer.
- Tail: straight or bent, portion or whole absent, tail hairs present or absent.
- Scars: these do not include skin lesions caused by the parasite **Stephanolaria dinniki** (Hitchins and Keep 1970).
- Wrinkles around the eyes and between the nostrils are an excellent method of recording individual characteristics, but photographs must be taken of the individual for accurate documentation of these features.

With the exception of wrinkles, all the features listed together with date and locality were recorded on a printed field card as shown in Figure 3. Immature animals were aged according to Hitchins (1970).

MORTALITY:

Date: _____ **Skull No:** _____

Locality: _____

Cause: _____

25.12.79 on arm
29.12.79 on arm
known since August 1971
8.9.80 ant. horn 36.5 post horn 7.5 — whole horn badly split + cracked.

SEX: ♂ AGE: MATURE

CODE NO KNP 24 (C 37)

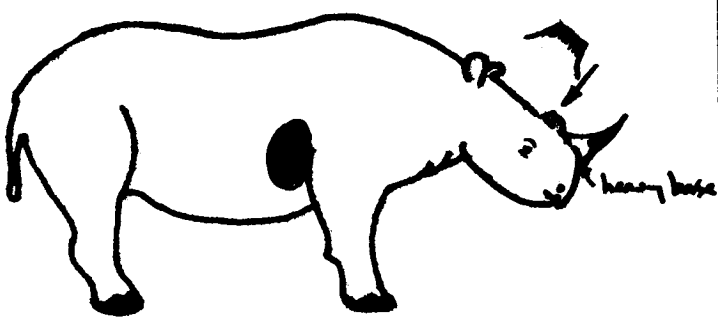
DATE: 25.12.79 LOCALITY: M'Selweni

caught 8.9.80 : destroyed KNP

¼	post.
1¼	ant.

PHOTOGRAPHS YES

REF: 71/34/9



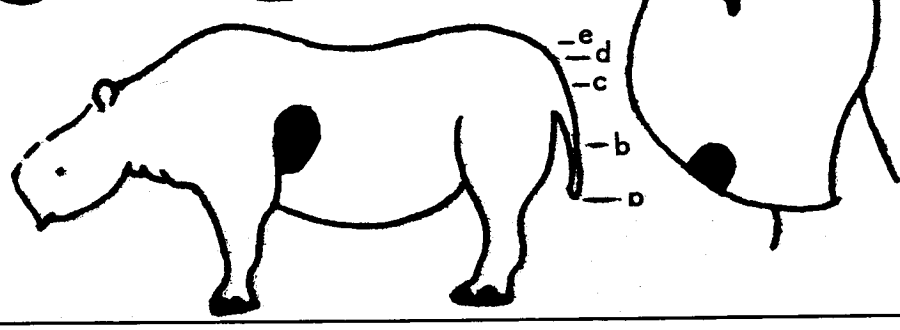


Fig. 3 : Individual field record card.

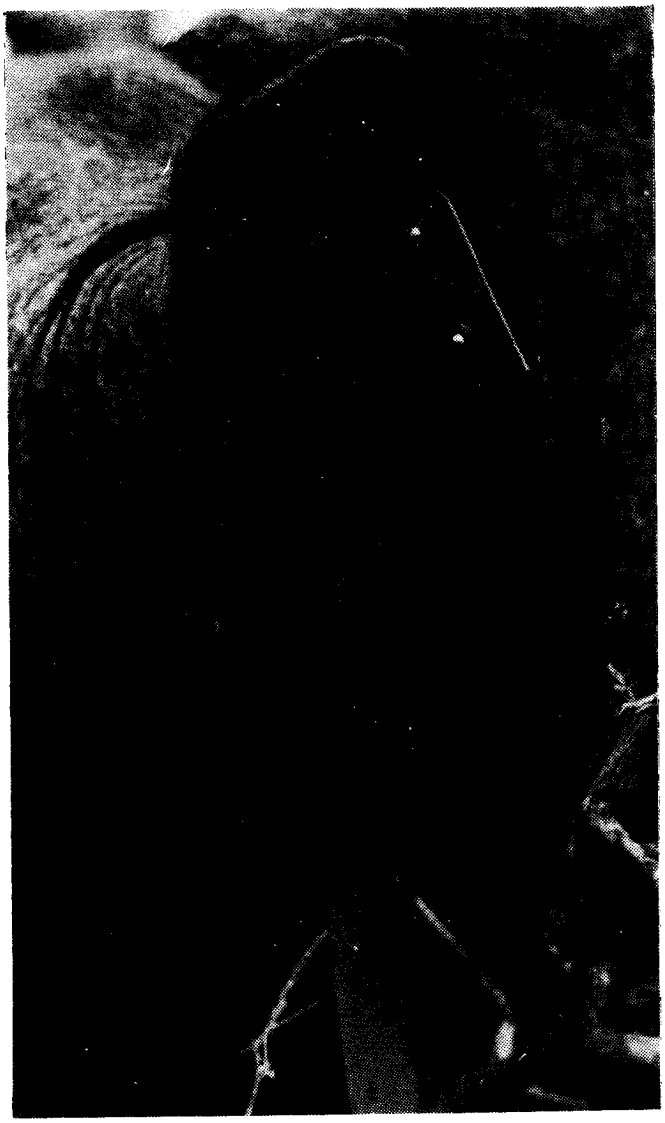


Fig. 4 : Artificial marking : alluminium plate and sterkolite streamer attached with a "Jess" knot.

2. Artificial marking.

Over the years various methods of marking animals were used to assist game scouts and others to report on sightings of black rhinoceros as non-involved personnel had great difficulty in recognising individual black rhinoceros from natural features in the dense bush country of the Zululand game reserves. Artificial ear marking was carried out on a limited basis as the most suitable method still had to be determined.

(i) Ear tags and ear streamers

Various types of ear tags were used; jumbo roto tags, circular plastic tags, metal tags (Ketchum) and rubber cattle tags. All were applied using conventional applicators as are used in the cattle industry. In addition home-made aluminium and fibre-glass discs were also used due to loss of ear tags in the earlier days. An industrial nylon weave covered with a polyvinyl hide (Sterkolite) streamer was also tried either attached to an ear tag or tied with a Jess knot through a hole punched through the animal's ear (Figs. 4,5 and 6).

Fig. 5 : Artificial marking : jumbo roto tag, ketchum metal tag with coloured plastic disc and ketchum metal tag.

Fig. 6 : Mature male black rhinoceros with "visotag" in left ear.

(ii) Ear notching

Individual black rhinoceros that were immobilized for various reasons (snare removal, translocation, fitting of radio transmitters) that had no characteristic ear tears were artificially marked by clipping triangles (2 cm) out of different parts of their ears allowing for easier recognition. Notch patterns were kept simple to avoid confusion in the field (Fig. 7). The notch combinations allowed a total of 110 males and 110 females to be marked (see also Brooks 1989).

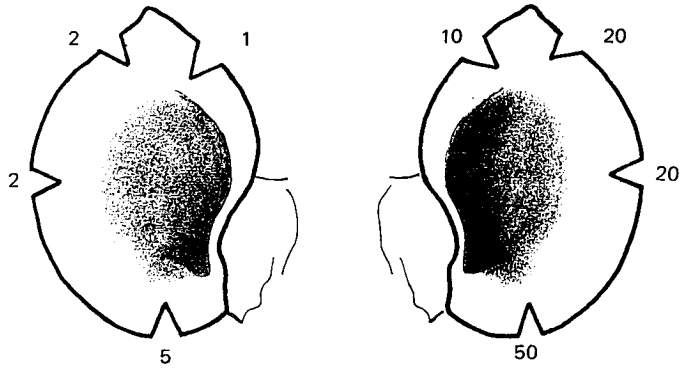


Fig. 7 : Ear notch pattern with number combinations.

(iii) Radio transmitters

Radio transmitters implanted into the posterior horn of black rhinoceros (Fig. 8 and 9.) have been described in detail elsewhere (Anderson and Hitchins 1971; Hitchins 1971). In addition, radio transmitter collars were tried on black rhinoceros in the Kruger National Park (A. Hall-Martin **pers. comm.**) and in the Pilanesberg Game Reserve. In both cases transmitters were attached to heavy machine belting collars which were fixed around the animal's neck by using steel bolts. In the Pilanesberg collars, a weak joint was built into the collar using a strip of hide; this was to eliminate the possibility of an animal being snared accidentally on a branch that might pass between the neck and collar.

Fig. 9 : Posterior horn plus radio transmitter covered with fibreglass.

Fig. 8 : Posterior horn with radio transmitter and loop aerial in position before application of fibre-glass covering.

3. **Census techniques.**

Using the recognisable features described above details of individual black rhinoceros were obtained initially from extensive foot patrols. During routine square-lipped rhinoceros **Ceratotherium simum simum** (Burchell, 1817) counts in the Hluhluwe/Umfolozi Game Reserve complex from 1967 to 1970 using fixed wing aircraft, the number of black rhinoceros seen were also recorded. The methodology has been described by Vincent (1969). Counting speed was determined by the **actual** flying time (counting time), over the counting blocks and excludes all other flying time not involved in counting animals. The counting speed is given as the number of hectares covered by the observers per minute.

With the availability of a helicopter from 1970 to 1973, details of individual black rhinoceros were recorded from the helicopter. These data were used to support or add to the information collected from foot patrols. During the period the flying techniques were similar to those of the fixed wing aircraft except that the average altitude above the ground was about 100 meters. In addition, with fewer crew than the fixed wing aircraft, one of the counters recorded all the black rhinoceros data. When a black rhinoceros was seen the helicopter was manoeuvered so that the individual's characteristics could be recorded. When using this technique care must be taken in sexing young animals (less than 1 year old), as when put to flight they tend to keep their tails tightly between their legs with the result that the tail tip can be confused as a penis when seen from the side. Care should also be taken in recording the ear characteristics. This is done either from the front or from behind and confusion can result from the animal's left or right side in relation to the observer.

In 1985 and 1986 data on individual black rhinoceros were collected from specially organised flights (helicopter) restricted between 06:45 and 12:30 hours on warm days when rhinoceros favour exposed ridges. Irregular flight paths were used, and not parallel strips as in conventional aerial counting (Swank, Watson, Freeman and Jones 1969). Black rhinoceros respond quickly to disturbance, so the rapid approach method used resulted in a high proportion of the population being observed before disappearing into thick bush. Characteristics of all black rhinoceros observed were recorded from the air.

RESULTS

1. **Individual recognition.**

The horn, ear and tail characteristics of the living black rhinoceros population in the Hluhluwe/Umfolozi game reserve complex in 1973 and in 1985 is shown in Table 1.

TABLE: 1 Horn, ear and tail characteristics of the living adult black rhinoceros population in the Hluhluwe/Umfolozi game reserve complex in 1973 and 1985.

		MALES				FEMALES			
		1973		1985		1973		1985	
		N	%	N	%	N	%	N	%
HORNS:	anterior longer than posterior	117	97,5	58	100,0	85	80,2	46	66,7
	anterior equal to posterior	3	2,5	–	–	15	14,1	20	29,0
	anterior shorter than posterior	–	–	–	–	6	5,7	3	4,3
EARS:	normal	55	45,8	28	48,3	78	73,6	49	71,0
	torn or nicked	57	47,5	29	50,0	28	26,4	16	23,2
	mutilated or absent	8	6,7	1	1,7	–	–	4	5,8
TAIL:	normal	99	82,5	55	94,8	101	95,3	65	94,2
	deformed, broken	15	12,5	–	–	2	1,9	2	2,9
	mutilated or absent	6	5,0	3	5,2	3	2,8	2	2,9

(i) Horns

Males generally have the anterior horn longer than the posterior horn with a small percentage (2,5 percent) in 1973 with the anterior horn equal to the posterior horn. Females on the other hand have a higher proportion with both horns equal (14,1 percent in 1973; 29,0 percent in 1985) and a few with the anterior horn shorter than the posterior horn (5,7 percent in 1973 and 4,3 percent in 1985).

Habitat plays an important role in horn length, mass and conformation. In forests and heavily wooded areas horns are generally longer whilst in open woodland/savannas the horns are shorter and appear to be heavier.

Broken or damaged horns in the central complex are rare: 1,8 percent of the adult population in 1973 and 0,8 percent in 1985. Broken horns are restricted to males only: in 1973 two males had their anterior horn tips broken off, one had a longitudinal split down the length of the anterior horn and one had its posterior horn completely knocked off which regrew and reached a length of 10 cm two years later. In 1985 a single male had a portion of it's posterior horn broken off. These horn breakages are probably all related to territorial fighting as all observations involved territorial males (Hitchins 1971).

(ii) Ears

Torn or nicked ears are more frequently observed in males than in females; 47,5 percent and 50,0 percent in 1973 and 1985 respectively as compared to 26,4 percent and 23,2 percent for the same period in females. This characteristic is also related to fighting between territorial males.

It has been shown that spotted hyaena **Crocuta crocuta** are responsible for removing or mutilating

the ear pinnae of black rhinoceros (Hitchins 1986b). In 1973 3,5 percent of the mature animals (sexes combined) showed this characteristic and 3,9 percent in 1985 (fig. 10).

Fig. 10 : Immature black rhinoceros male with left ear pinna removed by spotted hyena.

(iii) Tails

The 1973 survey showed 12,5 percent of males with broken or deformed tails as against none in 1985; females were 1,9 percent and 2,9 percent in 1973 and 1985 respectively. Broken and deformed tails in males are also characteristic of territorial encounters; the absence of these features in males in 1985 is probably due to the reduced black rhinoceros density in the central complex (Hitchins and Brooks 1986). Mutilated or absent tails were similar for both sexes combined in 1973 and 1985: 4,0 percent and 3,9 percent respectively.

In 1985 37 males and 37 females were recognised from the 1973 survey. Changes to either their ear teat patterns or horn lengths are shown in Table 2.

Some 21,6 percent of the males showed changes to the original ear condition (Fig. 11) noted in 1973. These changes were either new tears or original tears that had changed shape. Horn length changes in males was not observed. In females, on the other hand, only 8,1 percent showed changes to their ears; one female (2,7 percent) showed a horn change, a shortening of the anterior horn and an increase in length of the posterior horn. A female whose age in 1973 was 8,5 years showed both ear (tears) and horn length changes, the latter to be expected as the animal reached maturity.

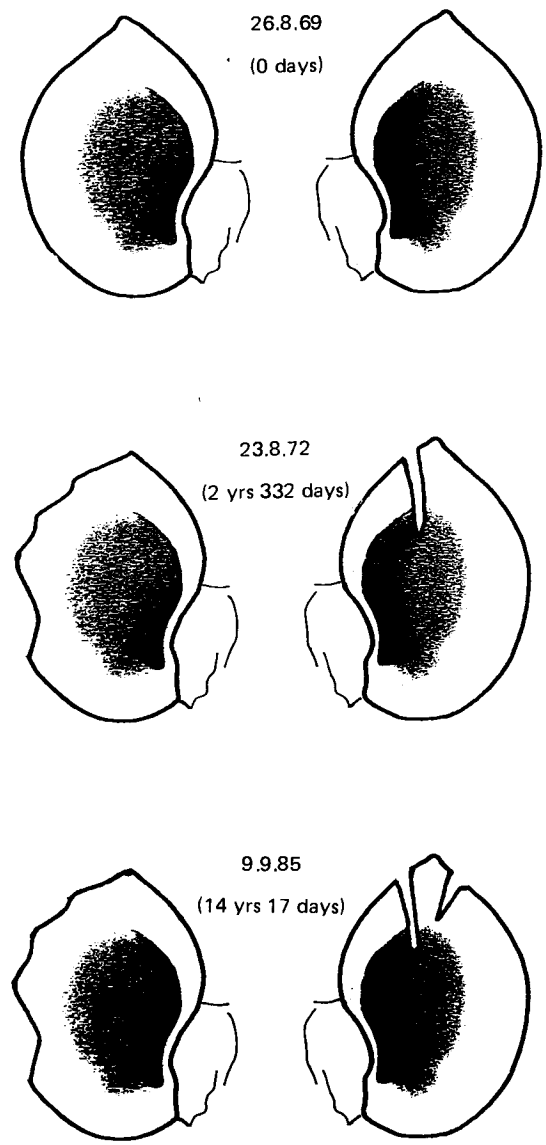


Fig. 11 : Natural change in ear tear pattern of a mature male black rhinoceros.

TABLE: 2 Recorded changes to ears and horns in individually known black rhinoceros in the Hluhluwe/Umfolozi complex in 1973 and in 1985.

AREA	MALES			FEMALES			
	No. in 1973	changes 1985		No. in 1973	changes in 1985		
		ears	horns		ears	horns	ears & horns
Hluhluwe	15	4	0	12	1		
Corridor	7	1	0	11	1		
Umfolozi	15	3	0	14	1	1	1
TOTAL	37	8	0	37	3	1	1

The long-term monitoring of black rhinoceros over the last 25 years (1961 – 1985) by individual recognition has shown that this species is strongly sedentary. No records of movements out of their home ranges or territories were observed with the exception of slight increases in home range sizes having been recorded in some females in the Hluhluwe Game Reserve in an apparent response to the reduced availability of food. The tenure of home ranges or territories by individually known black rhinoceros is shown in Table 3.

TABLE: 3 Tenure of home ranges or territories by known black rhinoceros in the Hluhluwe/Umfolozi complex in 1985.

AREA	Hluhluwe	Corridor	Umfolozi
No. adults identified from previous studies	27	18	29
No. known-age individuals	7	5	3
age range (years)	16 – 28	14 – 21	17 – 24
average age (years)	23	17	20
No. other known adults	20	13	26
period known: range (years)	15 – 23	14 – 19	13 – 19
average (years)	18	17	15

2. **Artificial marking.**

(i) Ear tags, streamers, discs.

From 1968 to 1971 a total of 26 rhinoceros were ear marked with various combinations of tags, streamers and discs, of these 14 went to the Kruger National Park (Hitchins **et al.** 1972) and five to Ndumu Game Reserve (Hitchins 1984) where the success of failure of the tags was not monitored.

In Hluhluwe Game Reserve seven tagged animals were monitored to determine success or failure of the marking method and to gauge the identification of individuals by other observers, mainly game rangers and game scouts.

Table 4 illustrates that the 'jumbo roto tag' and ketchum metal tags were the better marking methods with an average life span of 314 and 232 days respectively. The ear streamer (jess knot) and tags with attachments of streamers and discs lasted shorter periods, varying from 28 – 187 days (average 90 – 165 days). The pendulous 'visotag' lasted the shortest period of 58 days (range 33 – 82 days). Finally, metal or fibre-glass discs, although being conspicuous, were also not successful due to necrobiosis of the ear tissue between the discs.

TABLE: 4 Ear tag and streamer loss in the black rhinoceros in Hluhluwe game reserve.

		No. days before loss:	
Marking method	n	Range	Average
Metal or Fibre-glass discs	5	86 – 171	130
Jumbo roto tag	8	81 – 506	314
Ketchum metal tag	5	141 – 473	232
Ear streamer: jess knot	3	132 – 187	165
Jumbo roto tag plus streamer	7	141 – 163	155
Ketchum metal tag plus plastic disc	5	28 – 171	90
Visotag	2	33 – 82	58

In spite of the seven animals being marked in an area regularly visited by both rangers and game scouts, not a single record of a 'tagged' black rhinoceros was reported over a three year period!

(ii) Ear-notching

A total of 39 black rhinoceros were ear-notched using the combinations shown in Fig. 7. Some 22 animals were translocated to other areas and were therefor not monitored. The remaining animals (17) within the Hluhluwe/Umfolozi complex were seen frequently on an **ad hoc** basis. Fourteen (82,3 percent) animals underwent notch pattern changes due to the ear tearing at the notch which altered the individual's ear characteristics. As an example, Fig. 12 shows a male known since 30 September 1972 that was notched on capture on 19 June 1987 (14 years 261 days later). Some 277 days after notching (24 March 1988), the animal was seen with a totally different ear pattern as a result of the ear tearing at the notch.

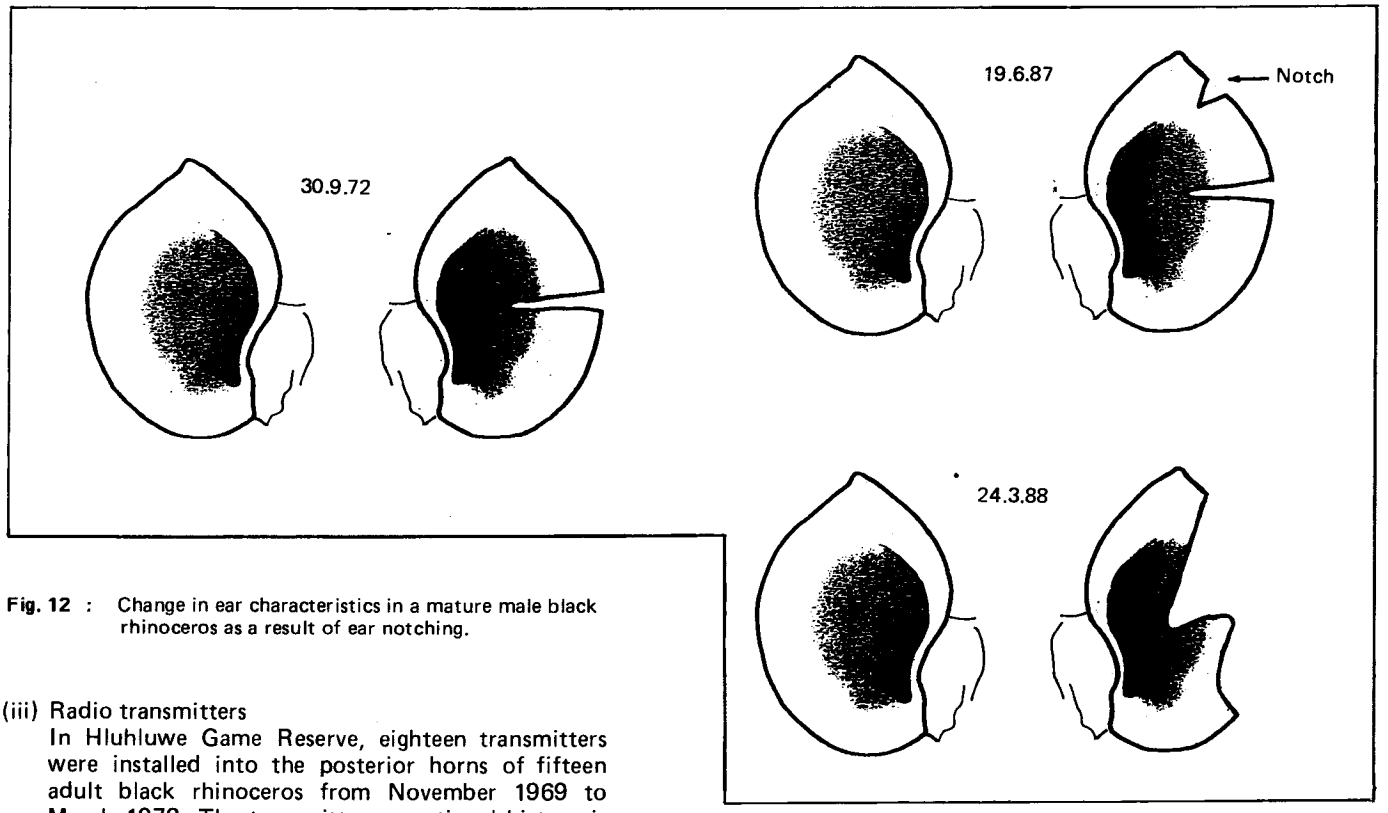


Fig. 12 : Change in ear characteristics in a mature male black rhinoceros as a result of ear notching.

(iii) Radio transmitters
In Hluhluwe Game Reserve, eighteen transmitters were installed into the posterior horns of fifteen adult black rhinoceros from November 1969 to March 1972. The transmitter operational history is given in Table 5.

TABLE: 5 Operational history of radio transmitters installed into black rhinoceros in Hluhluwe game reserve.

Sex	Transmitter	Date installed	Date stopped	No. days
M	A*	13.11.69	20. 3.70	129
	J	28.12.70	28. 6.71	183+
M	B*	4.12.69	15. 3.70	102
	G	28.09.70	28. 6.71	274+
M	F	23. 9.70	28. 6.71	279
F	C*	10.11.69	8.12.69	29
		12. 1.70	13. 5.70	122
		19. 5.70	26. 1.71	253
F	D	30.12.71	28. 6.71	181+
F	E*	12. 1.70	12. 1.70	0
	H	23. 9.70	17.12.70	86
M	K	28. 9.71	19.11.71	53
M	L	28. 9.71	3. 3.72	157+
M	M	28. 9.71	7.12.71	71
M	S	23. 3.72	18. 4.72	27
M	R	23. 3.72	30. 6.72	100+
M	Q	7. 4.72	30. 6.72	85+
M	T	14. 2.72	30. 6.72	137+
F	P	13. 2.72	30. 6.72	138+
F	O	13. 2.72	13. 6.72	138+

* prototype transmitters: 1 x battery as against 2 batteries in the modified transmitters.

\+ transmitters still working at termination of telemetric study

The maximum continuous period of operation was achieved by transmitter G with a period of 274 days. However, transmitter C achieved 404 days without removal, but required minor tuning and additional fibre-glass covering on two occasions. Transmitter E ceased operating shortly after implantation as the rhinoceros, on awakening from the immobilizing drugs, charged and made contact with a vehicle parked some distance away, damaging the transmitter. Transmitter S operated for 27 days in a male before it was killed in a fight. The horn and transmitter were recovered and continued working indoors for a further 84 days. A transmitter implanted in a horn, kept indoors, worked continuously for 580 days.

Transmitter failure in the field was related directly to the lateral abrasions on the fibre-glass covering the horn by the everyday activities of the rhinoceros. This resulted in the loop antenna, or tuning hole, being exposed to the elements and moisture penetrating the transmitter.

3. **Census techniques.**

The results of systematic flights over the Hluhluwe/Umfolozi complex in both fixed wing and rotor wing aircraft are summarized in Table 6; it shows the counting speed in hectares covered per minute by the observers and the percentage of the total black rhinoceros population detected. The percentage of the black rhinoceros detected from the air is far lower in fixed wing aircraft, 12,2 percent (range 4,9 to 18,1) than in helicopters, 44,8 percent (range 9,8 to 60,0). Black rhinoceros respond rapidly to disturbance and are therefor more easily flushed by helicopters than by the quieter, faster-moving fixed-wing aircraft.

TABLE: 6 Fixed and Rotor wing aircraft counts in the Hluhluwe/Umfolozi complex from 1967 to 1973 showing percentage of the total black rhinoceros population detected.

FIXED-WING AIRCRAFT: 1967 – 1970

Area	No. counts	Counting speed (ha/min)		% population detected	
		Range	Average	Range	Average
Hluhluwe	5	123 – 183	159	4,9 – 18,1	12,9
Corridor	4	200 – 299	271	8,3 – 16,0	11,6
Umfolozi	3	169 – 343	283	5.0 – 11,1	7,4
TOTAL	12	123 – 343	227	4,9 – 18,1	12,2

ROTOR WING AIRCRAFT (HELICOPTER): 1970 – 1973

Hluhluwe	4	20 – 37	28	37,5 – 60.0	47,2
Corridor	4	37 – 63	49	9,8 – 39,4	28,3
Umfolozi	4	40 – 63	50	51,7 – 60,0	55,3
TOTAL	12	20 – 63	43	9,8 – 60,0	44,8

The specific flights flown randomly in search of black rhinoceros in 1985 and 1986 are summarized in Table 7. The results using this technique are better than those using a helicopter on systematic, parallel flight paths as the average percentage of black rhinoceros detected is 65,0 as compared to 44,8 at faster counting speeds; 165 ha/minute as against 43 ha/minute. The high percentage of black rhinoceros detected in the Corridor (124,4 and 136,4) is due to local movement of black rhinoceros from the Umfolozi Game Reserve.

TABLE: 7 Specific, random helicopter flights in search of black rhinoceros in the Hluhluwe/Umfolozi complex in 1985 and 1986

Area	No. counts	Counting speed (ha/min)		% population detected	
		Range	Average	Range	Average
Hluhluwe	2	142 – 166	154	50,7 – 76,8	63,8
Corridor	2	164 – 173	169	124,4 – 154,5	140,0
Umfolozi	2	141 – 201	171	23,5 – 32,2	28,0
TOTAL	6	141 – 201	165	23,5 – 136,4	65,0

The percentage of the total population detected can be further adjusted into more realistic terms by individual recognition. Extensive ground surveys (3 590 km walked) during 1985 (Hitchins 1986a) resulted in determining a population size of 191 black rhinoceros in the Hluhluwe/Umfolozi complex. Of these, 172 were individually recognized and the presence of a further 19 were known but not seen.

Using the **individually recognized black rhinoceros**, the percentage of the population seen from the random flights (Table 7) are adjusted as shown in Table 8.

TABLE 8 : Comparison of unadjusted and adjusted percentages of a black rhinoceros population in the Hluhluwe/Umfolozi complex in 1985/1986.

Area	%POPULATION DETECTED				Difference
	Unadjusted		Adjusted		
	Range	Average	Range	Average	
Hluhluwe	50,7 – 76,8	63,8	44,9 – 50,7	47,8	16,0
Corridor	124,4 – 154,5	140,0	68,3 – 102,3	85,9	54,1
Umfolozi	23,5 – 32,2	28,0	23,5 – 32,2	28,0	0
TOTAL	23,5 – 136,4	65,0	23,5 – 102,3	47,6	17,4

When disturbed, black rhinoceros can cover considerable distances and often cross into areas still to be counted from the air, resulting in duplicating the number of animals seen. The data in Table 8 illustrates these differences; Hluhluwe and Corridor a reduction of 16,0 percent and 54,1 percent respectively, with an overall reduction of 17,4 percent. The importance of duplicating numbers of animals counted is clearly illustrated using the black rhinoceros as an example in aerial censuses.

DISCUSSION

The individual recognition of black rhinoceros had been used for some 28 years with advantages and disadvantages over other methods.

Dealing with the advantages: it documents permanently the characteristics of the whole population, and it is a means of continuous monitoring of the population and also incorporates the gathering of other biological data. The greatest disadvantage of the method is time: that is the time taken for a worker to familiarize himself with the method, and the identification of the various characteristics under difficult and often dangerous conditions. In the Zululand reserves only a single worker has managed the technique. Team efforts have been attempted with little success, especially in the dense heavily wooded thickets. Due to the time factor, projects of this nature are naturally expensive especially using helicopters for supplementing data gathered on foot.

In the Hluhluwe/Umfolozi complex changes in horn length and conformation are rare. Hamilton and King (1969), however, reported horn changes in a translocated population to Nairobi National Park in Kenya where there was a marked habitat change from the area of capture. Changes in ear characteristics over a 12 year period were far higher in males than in females (21,6 percent and 8,1 percent respectively), and like the other features, such as broken horns, broken tails and scars around the neck, flanks and rump are indicative of territorial conflicts.

Artificial marking of black rhinoceros has short term benefits only, and is not effective for long term monitoring of a population. The advantages of ear tags, streamers and discs lie in that they do assist in recognizing individuals and are more often than not easier to record than small natural nicks and tears. Choice of colour is an important consideration. In the complex light, bright colours (white, yellow, light orange) were better than the darker colours like red, blue and green.

Ear notching had the advantage of creating tears in untorn ears making identification of the individual rhinoceros easier. However, it must be borne in mind that familiarity with the population is essential, as depending on habitat and territorial disputes in males, the ear pinna is susceptible to damage resulting in changes to the notched pattern.

Radio transmitter implants are the most superior method of monitoring a population and the gathering of other biological data related to rhinoceros ecology. Collar transmitters in both the Kruger and Pilanesberg National Parks were failures primarily due to the collars falling off over the animal's head (A.J. Hall-Martin and K. Hillman-Smith **pers. comm.**).

The most important disadvantage of artificial marking is that capture is required. Capture losses do occur and these have got to be weighed up against the advantages of the method to be employed. Ear tags, streamers and the like can be conspicuous to tourists; most tags are relatively short-lived and are not always obvious as black rhinoceros spend time in wallows and dust bowls covering the tags with mud and sand. Streamer and disc attachments on to tags shorten the longevity of the tag. Radio transmitters are short-lived with an expected life span of some two years before the animal has to be re-immobilized and a new transmitter fitted.

Population estimates of black rhinoceros using fixed-wing aircraft are unreliable in wooded habitats with only 12,1 percent of the population being recorded (range 4,9 to 18,1). This species is difficult to detect from the air especially in poor light and when seen against the sun. Helicopters give a far better result (44,8 percent of total population, range 9,8 to 60,0) due to the noise factor which stimulates the animals to move out of cover ahead of the approaching aircraft. An additional and extremely important advantage of using a helicopter is its maneuverability enabling an observer to record the characteristics of the individual rhinoceros. These data can also be used in monitoring the demography of the population.

Without the recognition of individual rhinoceros, helicopter counts have an error of some 17,4 percent when 65,0 percent of the population is detected. This, or similar factors should also be applied to the fixed-wing counts which make them almost valueless as a censusing technique.

ACKNOWLEDGEMENTS

This paper is dedicated in memory to two game rangers: the late Norman Deane and Ken Rochat, who both contributed significantly to black rhinoceros conservation.

REFERENCES

ANDERSON, F. and P.M. HITCHINS. 1971. A radio tracking system for the black rhinoceros. **South African Journal of Wildlife Management** 1(1) : 26 – 35

BORNER, M. 1983. Selous aerial survey 1981. **African Elephant and Rhino Group. Newsletter** 1 : 7

BROOKS, P.M. 1989. Proposed conservation plan for the black rhinoceros **Diceros bicornis** in South Africa and the TBVC States. **Koedoe** 32 (2) : 000-000

GODDARD. J. 1966. Mating and courtship of the black rhinoceros (**Diceros bicornis** L.) **East African Wildlife Journal** 4 : 69 – 75.

GODDARD, J. 1967a. Home range, behaviour and recruitment rates of two black rhinoceros populations. **East African Wildlife Journal** 5 : 133 – 150.

GODDARD, J. 1967b. The validity of consensing black rhinoceros populations from the air. **East African Wildlife Journal** 5 : 18 – 23

GODDARD, J. 1969. Aerial census of black rhinoceros using stratified random sampling. **East African Wildlife Journal** 7 : 105 – 114

HALL-MARTIN, A.J. and B.L. PENZHORN. 1977. Behaviour and recruitment of translocated black rhinoceros **Diceros bicornis. Koedoe** 20 : 147 – 162.

HAMILTON, P.H. and J. KING. 1969. The fate of black rhinoceros released in Nairobi National Park. **East African Wildlife Journal** 7 : 73 – 83

HANKS, J. 1969. Techniques for marking large African mammals. **Puku** 5 : 65 – 86.

HITCHINS, P.M. 1968. Some preliminary findings on the population structure and status of the black rhinoceros **Diceros bicornis** Linn. in Hluhluwe Game Reserve, Zululand. **Lammergeyer** 9 : 26 – 28.

HITCHINS, P.M. 1969. Influence of vegetation types on sizes of home ranges of black rhinoceros in Hluhluwe Game Reserve, Zululand. **Lammergeyer** 10 : 81 – 86

HITCHINS, P.M. 1970. Field criteria for ageing imature black rhinoceros **Diceros bicornis** L. **Lammergeyer** 12 : 48 – 55

HITCHINS, P.M. 1971. Preliminary findings in a telemetric study on the black rhinoceros in Hluhluwe Game Reserve, Zululand. pp 69 – 100 **Proceedings of a symposium on Biotelemetry, Pretoria.**

HITCHINS, P.M. 1976. The status of the black rhinoceros, **Diceros bicornis** Linn. in the Zululand game and nature reserves. pp. 54 – 68. **Proceedings of symposium on Endangered Wildlife in Southern Africa, Pretoria.**

HITCHINS, P.M. 1984. Translocation of black rhinoceros (**Diceros bicornis minor**) from the Natal game reserves 1962 – 1983 **Lammergeyer** 33 : 45 – 48.

HITCHINS, P.M. 1986a. On the horn of a dilema. **Quagga** 15 : 9 – 10

HITCHINS, P.M. 1986b. Earlessness in the black rhinoceros – a warning. **Pachyderm** 7 : 8 – 10

HITCHINS, P.M. and M.E. KEEP. 1970. Observations on skin lesions of the black rhinoceros (**Diceros bicornis** Linn.) in the Hluhluwe Game Reserve, Zululand. **Lammergeyer** 12 : 56 – 65.

HITCHINS, P.M. and J.L. ANDERSON. 1983. Reproductive, population characteristics and management of the black rhinoceros **Diceros bicornis minor** in the Hluhluwe/Corridor/Umfolozi game reserve complex. **South African Journal of Wildlife Research.** 13 : 78 – 85

HITCHINS, P.M. and P.M. BROOKS. 1986. Preliminary report on the population size and trend (1973 – 1985) of the black rhinoceros in the Hluhluwe and Umfolozi game reserves, 1985. Internal report: Natal Parks Board. 10 pp. Unpubl.

HITCHINS, P.M., M.E.KEEP and K. ROCHAT. 1972. The capture of black rhinoceros in Hluhluwe Game Reserve and their translocation to the Kruger National Park. **Lammergeyer** 17 : 18 – 30.

KLINGEL, H. and V. KLINGEL. 1966. The rhinoceroses of Ngorongoro crater. **Oryx** 8(5) 302 – 306.

LEADER-WILLIAMS, N. 1985. Black rhino in South Luangwa National Park: their distribution and future protection. **Oryx** 14 : 27 – 33.

MUKINYA, J.G. 1976. An identification method for black rhinoceros **Diceros bicornis. East African Wildlife Journal** 14 : 335 – 338.

PARKER, I.S.C. 1976 Black rhinoceros and other large mammals in the Mwabvi Game Reserve. Report to the Malawi Government. pp. 1 – 43.

SWANK, W.G., R.M. WATSON, G.A. GREEMAN and T. JONES. 1969. Proceedings of the workshop on the use of light aircraft in Wildlife management in East Africa. **East Africa Agriculture and Forestry journal** 24 : 1 – 111.

THOMSON, P.J. 1974. Rhino collars in research. **Wildlife Rhodesia** 5 : 13.

VINCENT, J. 1969. The status of the square-lipped rhinoceros **Ceratotherium simum simum** (Burchell) in Zululand. **Lammergeyer** 10 : 12 – 21.

WESTERN, D. 1982. Patterns in depletion in a Kenya rhino population and the conservation implications. **Biological Conservation** 24 : 147 – 156.

WESTERN. D. and D.M. SINDIYO. 1972. The status of the Amboseli rhino population. **East African Wildlife Journal.** 10 : 43 – 57.