

# Reproduction, population characteristics and management of the black rhinoceros *Diceros bicornis minor* in the Hluhluwe/Corridor/Umfolozi Game Reserve Complex

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Over a period of thirteen years (1961–1973) data were collected from a black rhinoceros population in KwaZulu, South Africa. The study population was subdivided into three sub-populations; those in the Hluhluwe and Umfolozi Game Reserves and that in the inter-connecting Corridor of state land. The results were related to similar findings in rhinoceros populations in East Africa. Spermatogenesis in black rhinoceros in the Hluhluwe/Corridor/Umfolozi Game Reserve Complex commences between the age of seven and eight years. The age of first conception ranged between 5.08 and 11 years. Black rhino are polyoestrous and the mean duration of the oestrous cycle is 35 days. There is evidence that the duration of this cycle in pubertal females is more variable than that in parous animals. There appears to be a bimodal seasonal reproductive pattern, with birth peaks in midsummer and midwinter. The population density ranges from 0.1/km<sup>2</sup> in Umfolozi to 0.7/km<sup>2</sup> in Hluhluwe, the densest population yet recorded. In spite of a preponderance of males, the adult sex ratio did not deviate significantly from parity. Most of the known natural deaths were attributed to horn wounds sustained during fighting. Evidence is presented that hyaena predation was a major factor in calf mortality in Hluhluwe. Rates of increase of the sub-populations are discussed and conclusions regarding the future trend of these are made. A management policy is suggested bearing in mind the likely trend in the sub-populations and the current plight of the species.

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Data van 'n swartrenosterbevolking in KwaZulu, Suid-Afrika, is oor 'n tydperk van dertien jaar (1961–1973) versamel. Die studiebevolking is verdeel in drie sub-bevolkings, naamlik die van Hluhluwe, Umfolozi en die gebied wat hierdie twee verbind. Die bevindings is vergelyk met soortgelyke bevindings in renosterbevolkings in Oos-Afrika. Spermatogenese in die drie sub-eenhede begin tussen die ouderdom van sewe en agt jaar en die eerste bevrugting is aangeteken in diere tussen 5,08 en 11 jaar. Swartrenosters is polioestreu en die gemiddelde duur van die estrussiklus is 35 dae. Daar is aanduidings dat die lengte van die siklus in geslagsonvolwasse koeie meer varieer as in die volwasse koeie. Dit blyk dat daar 'n bimodale voortplantingspatroon is met pieke van geboortes in die middel van die somer en die winter. Bevolkingsdigtheid wissel van 0,1/km<sup>2</sup> in Umfolozi tot 0,7/km<sup>2</sup> in Hluhluwe wat ook die hoogste digtheid is wat nog aangeteken is. Ten spyte van 'n oormaat manlike diere kon dit nie bewys word dat die geslagsverhouding afwyk van gelykheid nie. Meeste van die natuurlike vrektes kon toegeskryf word aan wonde wat gedurende gevegte deur die horings veroorsaak is. Bewyse word ook verskaf dat hiëna-predasie 'n belangrike mortaliteitsfaktor onder kalwers was. Groeikoerse in die sub-bevolkings word bespreek en gevolgtrekkings word uit hierdie tendense gemaak. 'n Bestuursbeleid word voorgestel wat huidige tendense in die sub-bevolkings en die huidige stand van die spesies in ag neem.

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## Introduction

Demographic characteristics of populations, and the physical condition of individuals provide basic keys as to how a population is reacting to its environment and what management is required if it is considered necessary to change the *status quo* in any desired direction. Where destructive sampling of a population is possible, such as in a culling operation, these data may be readily obtained. Where data of this sort cannot be collected, the necessary information can only be obtained by detailed long-term observation of the species. The black rhino in KwaZulu is a species which falls into this latter category.

From observation alone, the demographic parameters which can be measured are sexual maturity, calving interval, calf survival and sex/age composition of the population. In this paper the data collected over 13 years by P.M. Hitchins are examined and interpreted and recommendations are made for the future management of the black rhino in the Hluhluwe/Umfolozi Game Reserve Complex.

## Study area

The complex is situated in central KwaZulu, in the Zululand Thornveld of the Tropical Forest type (Acocks 1953). It is 94 000 ha in extent and comprises Hluhluwe Game Reserve (14 250 ha) in the north, Umfolozi Game Reserve (47 750 ha) in the south, and the inter-connecting Corridor (3 200 ha) situated between the two game reserves. This complex forms a single unit bounded by a game-proof fence.

Hluhluwe is more hilly than the Corridor and Umfolozi. Altitude ranges from 90 m to 850 m. The vegetation has changed considerably (Bourquin & Hitchins 1979) since it was first described by Henkel (1937). Apart from the semi-deciduous forests all other communities are regarded as secondary, their form having been influenced by over-utilization and fire. Over most of the reserve the vegetation is a thicket mosaic with the dominant woody plants being *Acacia karroo*, *Acacia caffra*, *Acacia nilotica*, *Dichrostachys cinerea*, *Euclea divinorum*, *Maytenus* spp. and *Spirostachys africanus*. There is abundant perennial surface water in the major rivers and the small streams have perennial surface water in most years. The mean annual rainfall is 985 mm.

The topography of the Corridor is generally less rugged than Hluhluwe, and the vegetation, although similar in composition, is generally more open.

Umfolozi Game Reserve is part of two large valleys carved out by the Black and White Umfolozi Rivers. The

topography is undulating with an altitude of 45 m – 579 m. The vegetation is mainly open woodland in which *Acacia* species predominate. Conditions are more xeric than in Hluhluwe and the northern parts of the Corridor and the mean annual rainfall is 686 mm.

### Materials and Methods

Most of the data were collected by direct observations of courtship, mating and newborn calves. Characteristic horn and ear shapes enable individual recognition of black rhino (Klingel & Klingel 1966; Goddard 1966; Hitchins 1969), and this method was used between June 1961 and July 1973 to help record the breeding history and movements of 328 animals in the study area. Age classes assigned to animals were those described by Hitchins (1970).

The onset of oestrus was readily detected by the attendance and courtship behaviour of an adult male. As in horses (Fraser 1968) female black rhino show overt oestrus by frequent urination in small quantities, followed by rhythmic contractions of the vulva.

Most of the black rhino deaths in the Hluhluwe/Umfolozi Complex were recorded and where possible a post mortem was carried out to determine the cause of death. Dead animals were aged on the basis of their dentition (Hitchins 1978). In 1961 a die-off of the black rhino took place in Hluhluwe and the possible cause of the deaths was investigated with assistance from the State Department of Veterinary Services. Material available for histological investigation included the testes of one seven-year-old and one eight-year-old male and the ovaries of a 12-year-old female.

In dealing with the results and in the management recommendations we have considered the animals as being three contiguous sub-populations. These sub-populations were defined on the basis of population density and habitat and corresponded to the study areas (Hluhluwe, Corridor and Umfolozi) described above.

### Results and Discussion

#### Reproduction

##### *Puberty and sexual maturity*

**Males.** Spermatogenesis had not commenced in the seminiferous tubules of the seven-year-old male, but was evident in those of the eight-year-old animal. Although physiological maturity is reached by eight years no male less than nine years of age was observed holding a territory or mating. However, Goddard (1970) observed a single known-age male mating at the age of 4 years 5 months in East Africa.

**Females.** Goddard (1970) found that the youngest age at which females were mated was 3 years 8 months and they were 5 years 10 months old when they produced their first calves. In Hluhluwe none of the 20 known-age females less than six years old were known to have mated. Of a further 10 known-age females older than six years, one was mated at 7 years 1 month and one at 8 years 2 months. The younger female, however, had still not produced a calf by the time she was 10 years 6 months old and the older female which had to be destroyed when 12 years 2 months old was found to be in her first pregnancy. The almost full-term foetus indicated that she had conceived for the first time at the age of 10 years 9 months.

Two known-age females from the Corridor and Umfolozi produced calves at the ages of 6 years 5 months and 8 years

5 months, respectively. Another three cows less than seven years old had yet to produce their first offspring. It is therefore suggested that females of the Corridor and Umfolozi sub-populations attained sexual maturity at a younger age than the Hluhluwe sub-population.

##### *Oestrous cycle*

Oestrus was considered to be the period from the first day of attendance by a bull to the time of copulation. This period lasts 6–7 days ( $n=5$ ) and is characterized at the onset by frequent tail-erecting by the females, the voiding of urine in small amounts followed by rhythmic contractions of the swollen vulva. Five observations involving three different females, which were followed during the whole oestrous period, showed that males do not attempt to copulate with females after the first day of copulation. This suggests that duration of receptivity (period of copulation) was only one day.

The length of the oestrous cycle was regarded as being the interval between two successive observations of overt oestrus. The lengths of 10 oestrous cycles were recorded for four mature (parous) females and intervals ranged from 26 to 46 days ( $\bar{X} = 35$  days, S.D. = 7.7). The mean interval falls within that listed for captive animals (Dittrich 1967; Yamamoto 1967; Gowda 1967). There was some evidence that during puberty and before first conception the intervals between overt oestrus were erratic. A known-age female was first seen to mate at eight years old. This was followed by overt oestrus and mating at intervals of 79, 72, 84 and 67 days. It was only after this cow's second calf that her oestrus intervals became regular and occurred at intervals of 21 days. Similar observations on the irregularity of the intervals between successive oestrous cycles in a young captive animal were made by Greed (1967).

##### *Mating*

Copulation was seen 47 times. The frequency with which this occurred was 2–7 times during daylight hours (no observations were made at night). The duration of copulation varied between 12 and 43 min while the number of ejaculations depended on the duration of copulation. These ranged from twice in 12 min to nine times in 43 min.

##### *Calving interval*

The calving intervals for 37 of the known animals were recorded as being the interval between sightings of the female with successive neonate calves. Calving intervals in the Hluhluwe sub-population varied between 20 and 89 months ( $\bar{X} = 44.5$ ;  $n = 32$ ) and in the combined Corridor/Umfolozi sub-population between 22 and 55 months ( $\bar{X} = 30.6$ ;  $n = 13$ ). The difference between the two populations was significant ( $p < 0.01$ ); but in view of the comparatively small number of observations the results can only be tentatively regarded as being indicative of sub-population differences in fecundity. Where the calving interval exceeded 40 months it was assumed that the female had aborted or the neonate had not survived long enough to be recorded. When these data were excluded, the mean calving intervals for cows in the sub-populations were not significantly different (Hluhluwe 32 months, Corridor/Umfolozi 28 months). However, if mean calving interval and the ratio of calves/year/female is calculated in the same manner as Goddard (1967) and Western & Sindiyo (1972), it is apparent (Table 1) that the recruitment of calves to the Hluhluwe

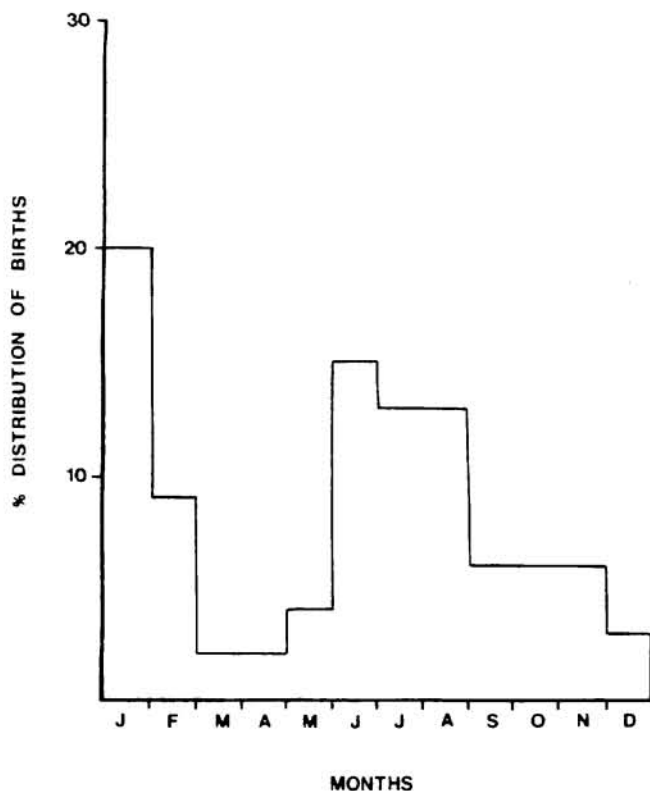
**Table 1** Mean calving interval and calves/year/female of various black rhino populations. Calculations are based on the total number of years a given number of females were observed and the number of calves born during that number of years

Locality	Mean calving interval (months)	Calves/year/female	Source
Hluhluwe	63	0,19	This study
Corridor	42	0,28	This study
Umfoloji	36	0,33	This study
Ngorongoro	48	0,25	Goddard 1967
Olduvai	46	0,26	Goddard 1967
Tsavo	40	0,30	Goddard 1970
Amboseli	48	0,25	Western & Sindiyo 1972
Addo	26	0,46	Hall-Martin & Penzhorn 1977

population is lower than elsewhere in Africa, the mean calving interval in the at times stable Hluhluwe population (Hit-chins 1976) being 63 months. In contrast, the increasing populations in the Corridor and Umfolozi have relatively short calving intervals of 42 and 36 months respectively.

#### Reproductive seasonality

Observations of mating and of calves less than one month old (Figure 1) showed that reproduction occurred throughout the year. Of the 72 matings recorded, 65% took place between October and December. However, as not all matings result in conception, it is perhaps more realistic to regard the distribution of known births as indicative of reproductive seasonality rather than the distribution of mating observations. The distribution of the 128 neonate sightings (Figure 1) suggests a bimodal distribution of births.



**Figure 1** Percentage distribution of neonate black rhino calves recorded in the Hluhluwe/Corridor/Umfoloji Complex between 1961 and 1973.

The monthly distribution of conceptions which resulted in these birth peaks indicate one conception peak in October and November and another between April and July, with parturition peaks in midsummer (January/February) and over the middle of winter (June to August).

In other black rhino populations in southern Africa, those in the Kaokoveld (Joubert & Eloff 1971) and Addo (Hall-Martin & Penzhorn 1977) each showed a parturition peak in the late summer, towards the end of the rainy season. In East Africa, with a bimodal rainfall pattern, the question of any reproductive seasonality is obscure. Klingel & Klingel (1966) reported a peak of births in December to May, during the rainy season, in Ngorongoro. This was not confirmed by Goddard (1967). In Tsavo, Schenkel & Schenkel-Hulliger (1969) describe a parturition peak between July and August during the dry season.

In square-lipped rhinoceros *Ceratotherium simum* in Umfolozi, Owen-Smith (1973) describes a bimodal distribution of births. He found peaks in March and July, although some births did occur throughout the year. These peaks he believed were a result of peaks in oestrus in November and February, stimulated by increase in grass quality as a result of differences in the rainfall pattern within the rainy season. The dicotyledon food of the black rhino does not react as sensitively to changes in the amount of rainfall as do grasses (Rushworth 1975), the latter being the staple diet of the square-lipped rhino. While the spring conception peak may be a response to an improved nutritional state, the autumn conceptions occur when food quality is declining.

Bimodal reproductive patterns occur in a number of African bovids (Anderson 1979) and it has been suggested that their proximate cue is the regular bimodal pattern of some light stimulus with the ultimate factors determining the amplitude of their breeding peaks being the feedbacks operating at or shortly after parturition.

Owen-Smith (1973) has suggested that the bimodal pattern of conception found in square-lipped rhino in the Hluhluwe/Umfoloji Complex is a consequence of peaks in ovarian activity in November and February, these peaks being influenced by the bimodal pattern of rainfall within the main rainy season. While this may hold for square-lipped rhino it is not apparent in black rhino. As described above, October/November conceptions take place when forage conditions are optimal but those in the period April/June take place when quantity and apparent quality of browse is declining. For this reason we believe that, unlike the square-lipped rhino, conception peaks in the black rhino are cued by light perhaps in a similar manner to that discussed by Anderson (1979).

In the evolution of parturition peaks, the peaks should occur at a time most suitable for the survival of mother and offspring (Sadleir 1969). The peak of black rhino births in midwinter takes place at what we regard as the least favourable period. This may perhaps be a consequence of the lengthy gestation period and calving intervals. Most mature African bovids breed at least once a year (Mentis 1972). This frequency results in sufficient feedback to provide an overriding influence in shaping the breeding seasons. While conceptions in the black rhino may be cued by light, the prolonged gestation period (455 days) and calving interval are such that any feedback of recurrent calf mortality is probably too infrequent to enable the species to evolve a breeding season where most births will occur at an optimal period.

An alternative hypothesis is that environmental conditions at birth in black rhino are not critical enough to compel the evolution of clear reproductive seasonality.

With increase in maternal weight the relative total weight of newborn young, irrespective of litter size, decreases approximately as a 2/3 exponent of female weight (Western 1979). Although the immediate demand on the female is comparatively less than in smaller animals, the duration of maternal care is longer. Lactation in black rhino persists for up to 15 months. This obviously covers a number of seasons so it is difficult to see how one season can be optimal enough to shape a specific breeding season through the feedback of 'calf survival'.

#### Population characteristics

##### Density

At the conclusion of field work in 1973 the population in the Complex was 328 animals. Of these, 199 were in Hluhluwe, 69 in the Corridor and 60 in Umfolozi. The number in Hluhluwe had declined from 300 in 1961 when the density was the highest recorded; 1,1/km<sup>2</sup> (Hitchins 1976). Despite a decrease in density of 34%, it is still probably the highest in Africa at 0,7/km<sup>2</sup>. Densities in the Corridor (0,4/km<sup>2</sup>) and Umfolozi (0,1/km<sup>2</sup>) were somewhat lower.

##### Population composition

The age and sex composition of the sub-populations in 1973 is shown in Table 2 with comparative data from other studies. As was found elsewhere (Goddard 1967, 1969; Western & Sindiyo 1972; Mukinya 1973) the adult sex ratio did not differ significantly from parity. Between 1963 and 1972 86 neonates were sexed (51 males, 35 females) and this ratio again did not differ statistically from parity.

**Table 2** The age and sex composition (%) of different black rhinoceros populations

	Adult male	Adult female	Immature Calf		Source
Hluhluwe <sup>a</sup>	43	39	15	3	This study
Corridor <sup>a</sup>	39	35	14	12	This study
Umfolozi <sup>a</sup>	42	30	17	12	This study
Mkuzi	23	18	—	15	Hitchins 1976
Ngorongoro	34	27	19	20	Goddard 1967
Olduvai	30	26	24	20	Goddard 1967
Tsavo	32	27	13	28	Goddard 1970
Amboseli	34	27	—	39	Western & Sindiyo 1972
Masai-Mara	39	32	—	29	Mukinya 1973

<sup>a</sup>Sub-populations

Throughout the area and in all age classes, except the sub-adults in the Corridor, males exceeded females, which is also evident in the adult sex ratios of East African populations (Table 2) and in the Indian rhinoceros (Laurie 1978).

In a species such as black rhino where adults are generally solitary, males territorial, and each territory overlapped by the home ranges of more than one female (Hitchins 1971), one would expect fewer males than females in a population. That this is not the case in black rhino is curious, and it again poses the question of the role of apparently surplus males (Jewell 1973).

#### Mortality

The deaths recorded during the study period and their causes where known are summarized in Table 3.

**Table 3** Causes of mortality of black rhinoceros in Hluhluwe Game Reserve between 1952 and 1972

Cause of death	Adult			Immature & calves			Total
	Male	Female	Unsexed	Male	Female	Unsexed	
1961 die-off	13	19	4	6	3	1	46
Unknown	9	15	19	1	2	8	54
Horn wounds	11	5	1	4	—	2	23
Accidents	1	2	2	1	—	1	7
Poor condition	2	1	—	—	—	—	3

##### The 1961 die-off

Between 11 July and 27 October, 46 rhino died in the north-east Hluhluwe. Once the first deaths were reported regular searches were made for other dead animals. Only five were found while still fresh enough for detailed pathological investigation. These results (Neitz 1962) were inconclusive as to the cause of death. The deaths occurred where the highest density of rhino in the Complex was found (1,7/km<sup>2</sup>). However, there was no indication that mortality was due to nutritional stress as all the animals appeared to be in good condition. Furthermore, deaths occurred in all sex and age classes (Table 4). This is in contrast to population crashes due to nutritional stress recorded in large herbivores (Robinette *et al.* 1957; Klein 1968; Child 1972; Anderson 1978) where mortality was biased towards one segment of the population. A feature common to most of the deaths was that all but two were found within 500 m from water.

**Table 4** Sex/age composition of the black rhino which died during the die-off in 1961 in Hluhluwe

	Adults			Immature			Total
	Male	Female	Unsexed	Male	Female	Unsexed	
<i>n</i>	13	19	4	6	3	1	46
%	28,3	41,3	8,7	13,0	6,5	2,2	100

Three animals were seen shortly before they died, and all three collapsed onto their forequarters when they attempted to charge observers. Another individual, a male of approximately six months old, exhibited partial paralysis of the forelegs shortly before death. It was concluded that although the cause of death remained unknown it was probably the same in all animals.

##### Natural deaths

**Fighting.** Of the 88 animals known to have died from natural causes, 16 died from horn wounds received during intraspecific fighting (Figure 2). More adult and sub-adult males (*n* = 11) died as a result of fighting than females (*n* = 5). However, this difference was not significant, perhaps being a feature of the small sample size.



Figure 2 Black rhinoceros male in Hluhluwe Game Reserve showing severe horn wounds in left shoulder, left rump and both hind feet. Minor horn wounds between the hind legs.

Minor injuries, in particular torn ears, are frequently sustained during fighting. These tears are clearly distinguished from the mutilations caused by hyaenas and probably reflect the degree of intraspecific conflict within the population. These tears were only recorded in animals over four years old. When tested, data (Table 5) showed that there was no significant difference in the incidence of torn ears between males in each sub-population. By inference therefore, the degree of fighting within the sub-population was much the same. Females exhibited fewer torn ears than males, the difference being significant in Umfolozi ( $p < 0,05$ ) but not so in either the Corridor ( $\chi^2 = 3,27$ ) or Hluhluwe ( $\chi^2 = 3,67$ ). Overall, the difference in torn ears, and hence fighting, was significantly greater in males than in females ( $p < 0,001$ ).

**Accidental deaths.** Accidental deaths accounted for seven animals; three of these were the result of falls and the remainder were the result of drowning in deep parts of two of the perennial rivers.

**Predation.** In the Complex the only predators capable of

killing rhino are the lion *Panthera leo*, hyaena *Crocuta crocuta* and crocodile *Crocodilus niloticus*. There have been no records of lion or crocodile predation on black rhino although both species have been recorded killing square-lipped rhino in the Complex. Although no actual attacks of hyaena on rhino calves have been witnessed, there is strong circumstantial evidence to suggest that this occurs frequently in Hluhluwe and to a lesser extent in the Corridor (Table 6).

Between 1963 and 1970 a number of black rhino in Hluhluwe and the Corridor exhibited mutilations of the pinnae (Figure 3) and many were completely or partially tail-less. Close investigation of animals where pinnae were absent showed obvious scar tissue indicating that the pinnae

Table 5 The distribution of torn ears amongst adult black rhino in the Hluhluwe/Corridor/Umfolozi Complex sub-populations

	<i>n</i>	<i>n</i> torn	% torn
Hluhluwe males	72	32	44,4
Hluhluwe females	69	20	30,0
Corridor males	25	11	44,0
Corridor females	21	5	23,8
Umfolozi males	23	14	60,8
Umfolozi females	16	3	18,8
All males	120	57	47,5
All females	106	28	26,4

Table 6 Observation substantiating the predation on black rhino calves by spotted hyaena

Case	Date	Observations
1	15.11.69	Cow with approximately weekold calf.
	5.1.70	Same cow, right pinna of calf missing and obvious scars visible.
2	22.6.70	Cow seen with calf only a few hours old.
	24.6.70	Calf with cow but left ear and side of calf's neck severely mutilated.
	17.7.70	Cow no longer accompanied by calf.
3	22.6.70	Cow seen with calf about one week old.
	26.9.70	Cow and calf together. The latter in poor condition, right pinna and tail recently removed and lacerations on hind quarters.
	30.10.70	Cow no longer accompanied by calf.
4	18.9.70	Cow with calf approximately two weeks old.
	11.12.70	Cow with calf, right pinna of latter missing.



Figure 3 Two-day-old black rhinoceros calf (24 June 1970) with left ear and neck severely mutilated by spotted hyaena, Hluhluwe Game Reserve.

had been removed rather than the animals born earless. Where tails were damaged or missing, obvious scars were always visible. As no lion were present at the time in Hluhluwe, hyaena were suspected of being the cause of these attacks. During 1970 observations were made on the progressive mutilation of four young calves, two of which subsequently disappeared (Table 6). These data confirm Goddard's (1967) findings that black rhino calves are vulnerable to hyaena predation when less than three months old.

At this stage no estimate can be made of the impact of hyaena predation on the black rhino population. However, if a calving interval in excess of 40 months is accepted as indicative of the death of a neonate, then neonate mortality in Hluhluwe is in the order of 69% (22 of 32 calving intervals were greater than 40 months). Data from known animals (Table 7) showed that mortality of calves less than six months old was significantly higher ( $p < 0.05$ ) in Hluhluwe than in the Corridor, and significantly higher ( $p < 0.05$ ) in the Corridor than in Umfolozi.

#### Unnatural deaths

Of the 15 unnatural deaths, one animal was destroyed in the interests of human safety, seven killed by poachers and seven died during capture. Four of the poached animals were killed outside the game reserve.

**Table 7** Estimates of black rhino mortality determined from recognizable animals in Hluhluwe Game Reserve between 1961 and 1972

	Number of animals	Animal years	Deaths	% per annum
Adult males	68	247.5	18	7.3
Adult females	79	375.5	13	3.5
Immature and calves	95	299.7	17	5.7

#### Mortality of known individuals

Estimates of mortality between 1961 and 1973 made from the histories of known adults in Hluhluwe (Table 7) suggest that males have a higher mortality rate than females. As males exceed females in the population this cannot be correct and demonstrates that the conclusions drawn exclusively from found carcasses are open to question.

#### Population change

The rates of increase of the sub-populations were compared by calculating from the known data for each. These data were known numbers and sex and age structure in 1968, the age specific mortality, mean age of sexual maturity and mean calving interval for each sub-population. The formula from which the percentage increase was calculated had the form

$$100 \times \frac{(a + b + c + d + e)}{x} - (x) \text{ where}$$

$a$  = number of adult males less annual adult male mortality

$b$  = number of adult females less annual adult female mortality

$c$  =  $\frac{b}{\text{mean calving interval}}$  less calf mortality

$d$  = number of immature individuals less annual immature mortality

$e$  =  $\frac{\text{number of immature females reaching sexual maturity}}{\text{mean calving interval}}$  less calf mortality

$x$  = total known population in 1968.

When calculated in this manner, the increase over one year was 5.3% for the Hluhluwe population and 11% for the Corridor/Umfolozi populations, a figure twice as great.

Given a constant rate of increase of 5.3%, the Hluhluwe population should have been 308 animals by 1980. We do not, however, believe that the population was as high as this, and Brooks (1979) believes that population density has not changed since 1972. Our conclusion from this is that the rate of increase of 5.3% per annum has not been maintained and, as no increase in mortality has been recorded (Brooks 1979), population stability has been achieved by a drop in recruitment.

If the 11% growth rate is applied to the Corridor and Umfolozi populations, these should have reached 143 and 124 respectively, in 1981. These figures are again considered high but it is quite likely that the populations were about 100 in each area. They were certainly higher than at the conclusion of the fieldwork of this study.

The main points in these results are that population growth was substantially higher in the Corridor and Umfolozi than in Hluhluwe. It is believed that the already lower rate in Hluhluwe has decreased even further to a point where the population is probably stable.

#### Conclusions

Factors such as the relatively late attainment of female sexual maturity, calving interval longer than any other population and high calf mortality infer that the Hluhluwe population is at or near its asymptote. The populations in the Corridor and Umfolozi are more vigorous and have a rate of calf recruitment about twice that of Hluhluwe.

While hyaena predation has obviously been responsible for a number of neonate deaths in Hluhluwe, factors such as delayed sexual maturity and increased calving interval

point to a factor affecting recruitment in a similar manner to that described for elephant (Laws *et al.* 1975).

### Management

In Natal Game Reserves the management of most ungulate species takes place with conservation of the habitat as the prime consideration. We believe that in the management of an endangered species such as the black rhinoceros, the population should be viewed in an international rather than a 'game reserve only' context. The black rhino is regarded as endangered throughout Africa and recent reports by Hillman & Martin (1979) highlight its decline (90% reduction in the Kenya population over the previous ten years). Our populations therefore can no longer be regarded as being merely representative. They have become vitally important as they are probably the only really secure populations left. For this reason, and disregarding for the present any factors relating to their habitat, we believe that the populations should be managed for a maximum sustained yield with the harvestable surplus being used to establish other nuclei within the range of the subspecies *D. bicornis minor* (Groves, 1967) in southern Africa.

When the sub-populations are considered separately it is evident that two distinct conditions exist. The Hluhluwe population is at the highest recorded black rhino density. It experienced a population crash in 1961 and a gradual decline during the last low rainfall cycle of the late 1960s (Dyer 1976). After some population reduction there was a period of positive growth, which does not, however, appear to have been maintained. The Corridor/Umfolozu populations have been more vigorous than that in Hluhluwe. The rate of population growth has exceeded that of Hluhluwe and the animals, based on subjective criteria, appear in better physical condition. Our hypotheses are that the Hluhluwe population is close to carrying capacity and that it is unlikely that this will increase in the short term. The Corridor/Umfolozu population may be approaching carrying capacity.

Management of the rhinoceros populations must not only consider existing habitat conditions, but likely future conditions which may themselves result from management. At present habitat management is aimed at maintaining their *status quo*. Current climatic conditions, notably the fact that we have now entered a low rainfall cycle (Dyer 1976) indicate that a reduction in fire frequency and intensity can be expected. This means that it is unlikely that we will be able to halt the maturing of fire-controlled scrub species (*Acacia karroo*, *Acacia caffra* and *Dichrostachys cinerea*). The availability of these species as food will decrease with their increase in height. Any change in other more important browse species (Hitchins 1979) will depend largely on the vegetation response to the present culling and burning programmes. Therefore we cannot assume that there will be any short-term improvement in black rhino habitat. Our management recommendations therefore apply only to the period of the impending dry cycle. The long-term management can only be decided once the management goals of desirable habitat types have been decided.

During the predicted dry cycle we anticipate that there will be no improvement in the quantity or quality of black rhino food. Under these conditions we do not foresee any increase in the black rhino populations. If we consider that the current levels have been attained over the recent high rainfall cycle, a decline in the population is not unlikely.

It should be noted that a gradual decrease in the black rhino populations occurred in Hluhluwe over the last (1961 – 1971) low rainfall cycle (Hitchins 1976). We expect this to happen again, but the extent of the decrease will be spread over a wider area as the densities in the Corridor and Umfolozu are substantially higher than they were over the last dry cycle. The decline in the populations will be the result of a decrease in the recruitment rate and probably an increase in calf and juvenile mortality. This process will not result in a dramatic drop in numbers but rather a subtle decline which, if not monitored, may pass unnoticed.

Two alternatives can be adopted in the management of this rhino population. Firstly the population can be allowed to decline and re-stabilize at a level which the habitat can maintain, or the predicted decline can be pre-empted in that the population could be reduced to a level which changed conditions can sustain. In this way the 'surplus' animals are not lost to conservation but can be used to enhance the status of the species.

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