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Patterns of depletion in a black rhinoceros population in Luangwa Valley, Zambia

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Summary

Black rhinos in Luangwa Valley, Zambia have been subjected to heavy illegal hunting since the late 1970s. A study population monitored by individual recognition decreased at an instantaneous rate of $-0{\cdot}29\ yr^{-1}$ between 1981 and 1985. Two-thirds of skulls found throughout Luangwa Valley between 1979 and 1985 were axed, indicating death from poaching. All age- and sex-classes of rhino were equally susceptible to being shot, presumably due to the high market-price of rhino horn.

Résumé

Depuis la fin des années soixante-dix, les rhinocéros noirs de Luangwa Valley dans la Zambie sont chassés illegalement. Entre 1981 et 1985 leur population a diminué d'une façon inquiétante. Deux tiers des crânes trouvés dans la région entre 1979 et 1985 avaient été fendus à coups de hache, ce qui démontre qu'ils avaient été tués illegalement.

Introduction

The black rhinoceros (*Diceros bicornis* L.) has decreased rapidly in numbers throughout much of its range since the 1970s (Western & Vigne, 1985). The most important cause of this decline has been the dramatic rise in the price of rhino horn, which has resulted in an unprecedented wave of illegal hunting amongst the formerly numerous black rhino populations remaining in the conservation areas of East and Central Africa (Martin, 1982). Unfortunately, black rhinos are exceedingly hard to count accurately from the air because they live at low densities in thick bush and are mainly solitary and nocturnal (Goddard, 1967a). Hence, the extent of the recent decrease in black rhino numbers is derived mainly from qualitative estimates (Western & Vigne, 1985), with the important exception of the decline documented in Amboseli (Western, 1982).

The present study aims to provide a quantitative description of the rate of decrease in an important population of black rhinos in Luangwa Valley, Zambia that was subjected to heavy illegal hunting in the late 1970s and early 1980s (Leader-Williams, 1985). As the most accurate method of counting rhinos is by individual recognition (Klingel & Klingel, 1966; Goddard, 1967b; Hitchins, 1968; Hamilton & King, 1969; Western & Sindiyo, 1972; Mukinya, 1973), two separate

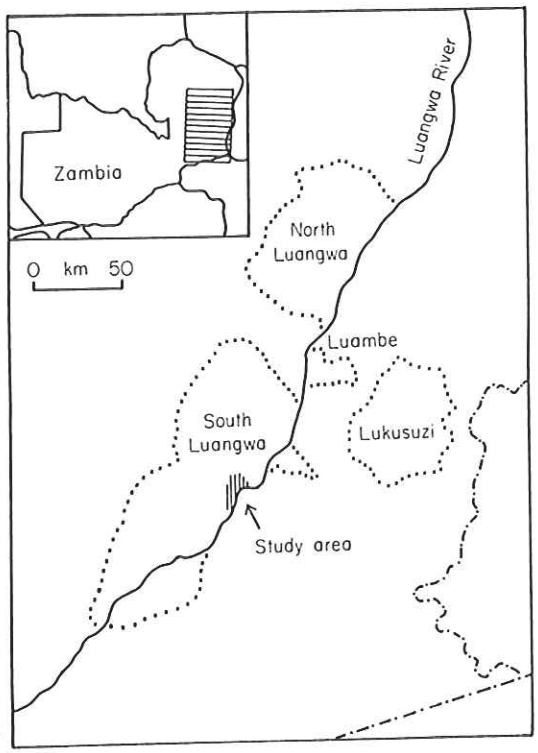

Fig. 1. Map of Luangwa Valley, showing the location of the national parks and of the study area near Mfuwe.

approaches were adopted: (1) intensive counts of known rhino were made within a relatively small study area; (2) extensive surveys of mortality throughout Luangwa Valley were undertaken using finds of skulls collected by anti-poaching patrols (Leader-Williams, 1985). These data permitted the accurate assessment of the rate of decline in the study population to be compared with the patterns of mortality throughout the rest of Luangwa Valley. Furthermore, differences in the age structure of rhinos that died from natural causes as compared with deaths from illegal hunting allow the patterns of depletion in this population of rhinos to be contrasted with patterns of exploitation observed amongst other large mammals, notably elephants and whales.

Materials and Methods

Study area

Luangwa Valley is a rift valley occupying 63,000 km^2 in NE Zambia. The Valley contains four national parks and seven game management areas (Fig. 1). It comprises extensive areas of largely wooded alluvial soils which can support a high biomass of heavy animals, mainly elephants and buffalo (Naylor *et al.*, 1973; Bell, 1982), as well as the backcountry comprising poorer Karoo soils. In the early 1970s, Luangwa contained a contiguous population of *c.* 100,000 elephants

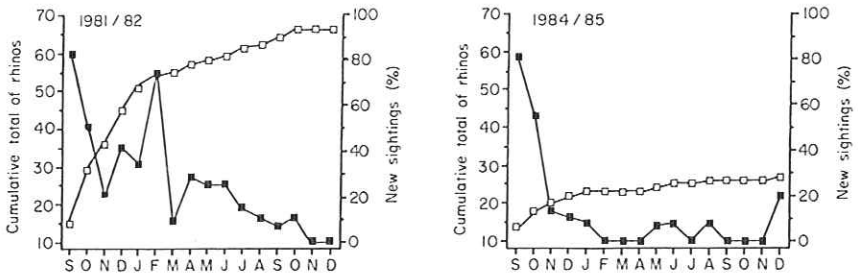

Fig. 2. Cumulative total of new rhinos (open squares) and percentage of new rhinos amongst total resightings (solid squares) observed in the Mfuwe study area during 1981/82 and 1984/85 (data for 1981/82 from Leader-Williams, 1985).

(Caughley & Goddard, 1975) and was estimated to have between 6000 and 12,000 rhinos, though the latter were not counted accurately (Naylor *et al.*, 1973).

Individual recognition of rhinos

An individual recognition file of rhinos occupying a 200 km^2 study area around Mfuwe in South Luangwa National Park (Fig. 1) was maintained between September 1981 and December 1985. Over one year of survey (until December 1982) was required to be confident that all rhinos initially in the study area had been catalogued (Fig. 2). The subsequent decrease in rhino numbers was monitored by re-opening the recognition file in each successive September. Datum points were available for each of 1981/82 (Leader-Williams, 1985), 1982/83 and 1984/85. The decrease in rhino numbers appeared to fit an exponential curve and the instantaneous rate of decrease was calculated as the slope of the regression of $\log_e$ rhino numbers on year.

Rhinos in the study area were classified into four categories according to sex- and age-class: (1) calf; (2) adult female accompanied by a calf; (3) unaccompanied subadult or adult female; (4) subadult or adult male. Differences in population structure were compared using a *G*-test (Sokal & Rohlf, 1981).

Collection and ageing of skulls

All rhino skulls encountered throughout Luangwa Valley by anti-poaching patrols between August 1979 and December 1985, and in the study area by research patrols, were returned to Mfuwe. Their place of collection and the known or estimated year of death were recorded. Skulls were divided into two categories: (1) axed skulls, bearing marks on the nose where poachers had cut off the horns together with part of the underlying nasal bones, resulting from death due to illegal hunting; (2) intact skulls that resulted from deaths due to either natural or unknown causes; (this category also possibly includes deaths subsequent to wounding by poachers who were unable to retrieve the horns (Leader-Williams, 1985)). All skulls were aged by patterns of tooth eruption and wear using the criteria developed by Hitchins (1978) for black rhinos in Zululand. This method divides rhinos into a continuous series of ascending age classes from I to XVII. Differences between frequencies of axed and intact skulls and of rhinos in different age classes were compared using *G*-tests.

Table 1. Numbers of rhino in the study area, 1981–85

Category of rhino	1981/82	1982/83	1984/85
Males	37	24	17
Unaccompanied females	18	9	15
Females with calves	11	8	5
Total + calves	66 + 11	41 + 8	27 + 5

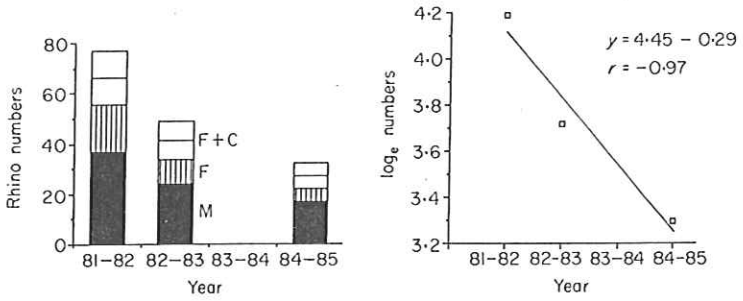

Fig. 3. Total numbers and sex- and age-class (M = subadult and adult males; F = unaccompanied subadult and adult females; F + C = accompanied females and calves) of rhinos living in the Mfuwe study area between 1981 and 1985 and the instantaneous rate of decrease of the study population calculated from log$_e$ of adult and subadult rhino numbers.

Table 2. Numbers of skulls collected in Luangwa Valley, 1979–85

		Axed	
Locality	Intact (N)	(N)	(%)
Study area	21	36	63
Luangwa Valley less study area	33	72	68
Total	54	108	67

Results

Rate of decrease and population structure

Numbers of adult and subadult rhinos living in the study area (Fig. 1) decreased between 1981/82 and 1984/85 (Fig. 2). The total numbers and population structure of rhinos during this study period are shown in Table 1. The correlation coefficient of log$_e$ rhino numbers and year (Fig. 3) suggests that an exponential curve provides a good fit to the data. The instantaneous rate of decrease of adult rhinos was $-0{\cdot}29$ yr^{-1} between 1981 and 1985. This decrease was accounted for entirely by finds of skulls in the study area (Table 2). In spite of this decrease, there was no change in the overall population structure (Fig. 3) between years ($G = 0{\cdot}43$, d.f. $= 4$, $P > 0{\cdot}10$

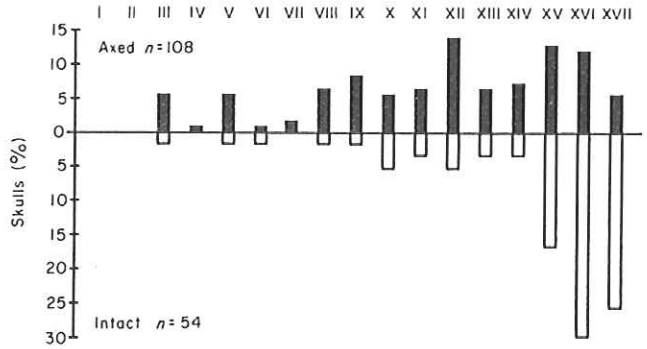

Fig. 4. Age classes (after Hitchins, 1978) of axed and intact rhino skulls collected throughout Luangwa Valley during 1979 to 1985.

for males vs females vs calves; $G=0{\cdot}59$, d.f. $=2$, $P>0{\cdot}10$ for accompanied vs unaccompanied females).

Age structure

A total of 162 skulls were returned to Mfuwe between 1979 and 1985 (Table 2). There was no significant difference ($G=0{\cdot}49$, d.f. $=1$, $P>0{\cdot}10$) between the frequency of axed and intact skulls in the samples collected in the study area and throughout the rest of Luangwa Valley. Therefore, both samples were combined and showed that 67% of the rhinos had axed skulls and died from poaching. Assuming that intact skulls represented natural mortalities only, poaching caused the overall mortality rate of rhinos to increase by a factor of at least three during the study period.

The age structure (Fig. 4) of intact skulls showed that most deaths (72%) occurred in the oldest three age classes (XV to XVII) which had very worn teeth. In contrast, the age structure of axed skulls differed markedly from that of intact skulls (in order to fulfil the requirements of the G test, the small samples of rhinos in the different age classes were combined into five groups each containing three successive age classes, i.e. III–V . . . XV–XVII: using these groups, the age structure of axed and intact skulls differed with $G=26{\cdot}52$, d.f. $=4$, $P<0{\cdot}001$). Thus, axed skulls were spread more evenly across different age classes and included a high proportion (12%) of calves in age classes $<$ V (Fig. 4).

Discussion

This study provides a quantitative description of the rate of decrease of a black rhino population in one of Africa's major rhino strongholds (Naylor *et al.* 1973). Even by the late 1970s Luangwa was still believed to hold one of the largest remaining populations of black rhino, estimated at *c.* 2500–3500 animals (Douglas-Hamilton *et al.*, 1979). The rate of decrease in the small study population between 1981 and 1985 (Fig. 3), calculated from the most accurate method available for counting rhinos, shows the devastating impact made by illegal hunting. An instantaneous rate of decrease of $0{\cdot}29\ yr^{-1}$ far exceeds the recruitment rate of $0{\cdot}07$–$0{\cdot}11\ yr^{-1}$ achieved by black rhino populations when not hunted illegally (Goddard, 1967b; Hitchins & Anderson, 1983; Hall-Martin, 1986). Furthermore,

the lack of difference between ratios of axed to intact skulls (Fig. 4) found in the study area and over the rest of the Valley suggest that patterns of rhino mortality did not differ throughout the Luangwa Valley.

The pattern of depletion of rhinos is of equal importance to their high rate of decrease. The lack of change in the age and sex structure of the study population during its decline (Fig. 3) and the wide spread of age classes in which axed skulls occur (Fig. 4) show that poachers are indiscriminate about which rhinos they shoot. Clearly the high and ever-increasing market value of rhino horn (Martin, 1982) makes it worthwhile to shoot even small rhinos to axe off their horns (Fig. 4). This pattern of depletion differs from that observed amongst other over-exploited populations of large mammals, including elephants and whales, in which depletion has usually been age- and size-structured. Hence, the largest animals are shot first to maximize catch per unit effort (Brooks & Buss, 1962; Laws, 1962; Laws, Parker & Johnstone, 1975; Gambell, 1976; Pilgram & Western, 1986). As all sex and age classes of the black rhino are susceptible to being shot illegally, any potential for future recruitment is seriously curtailed. If the rate of decrease documented here continues, then rhinos will be close to extinction within a decade in Luangwa Valley, as has occurred throughout much of the species' range elsewhere in East and Central Africa (Western, 1982; Western & Vigne, 1985).

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