KENYA BLACK RHINOCEROS

METAPOPULATION WORKSHOP

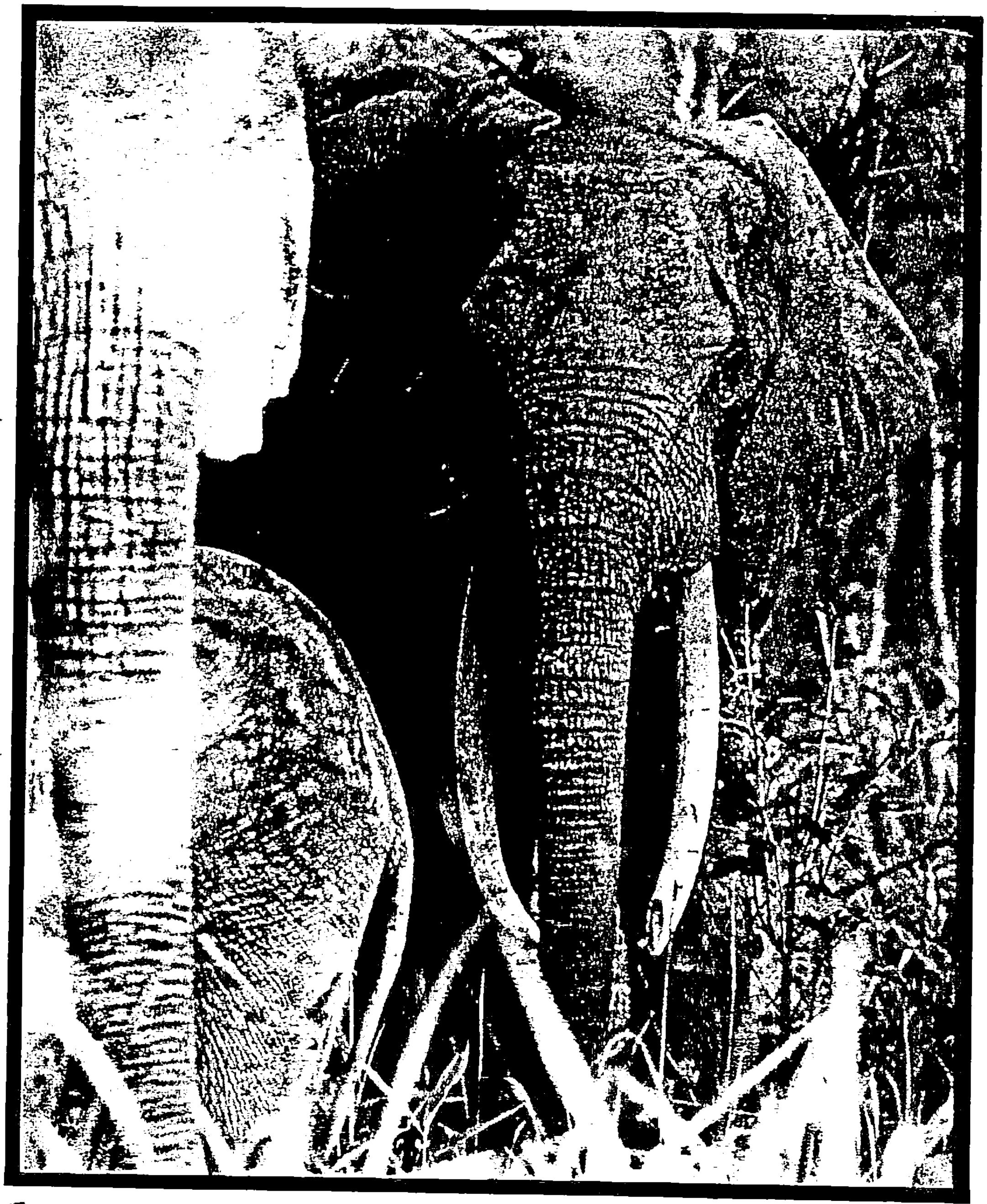
BRIEFING BOOK

SECTION 6
OTHER BLACK RHINO POPULATIONS

Pachyderm

A PUBLICATION OF THE AFRICAN ELEPHANT AND RHINO SPECIALIST GROUP

1991 NUMBER 14



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Produced and funded by
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African Rhinoceroses: Challenges continue in the 1990s

C.G. Gakahu

Despite the concern expressed and the measures taken by conservationists and wildlife authorities, the status of African rhinos has worsened during the last decade. The black rhino, *Diceros bicornis*, has continued to rapidly decline in number, resulting in further fragmentation and extinction of populations. Today most countries have fewer black rhinos than they had three years ago; the deaths represent a great loss of unique genes and adaptation to local environment. However, Kenya, Namibia, South Africa and Zimbabwe have stable populations and, although on the decline in Botswana and towards extinction in Mozambique, the southern white rhino *Ceratotherium simum simum* has continued to show an overall increase. The northern white rhino *Ceratotherium simum cottoni* is now extinct in Sudan and Uganda but its 1984 population of 20 individuals in Garamba, Zaire, has gone up to 26.

Numbers, distribution and the trend of population, are vital data for conservation of rhinos. In 1981 Hillman provided the first scientifically-based continental estimates for African rhinos. These figures were updated by Western and Vigne in 1984, who estimated 8-9,000 black, 3,920 southern white and 20 northern white rhinos.[1] Another survey conducted in 1987 estimated 3,800 black rhinos, 4567-4635 southern white and 22 northern white.[2] The survey reported here looks at the fate and performance of African rhinos in the last six years. The survey was conducted by the African Elephant and Rhino Specialist Group (AERSG) of IUCN with funding from Wildlife Conservation International.

Surveys

Questionnaires were sent out to 30 individuals in rhino range states. The questionnaire requested information on numbers, distribution range, density, recent population trends, and aspects of rhino horn trade. Other information concerned overall management needs and problems. Population estimates data were ranked using the following categories:- A. aerial or ground census; B. non-scientific reconnaissance survey; C. informed guess.

Levels of reliability of data as percentages of all the returned questionnaires for the three species are as follows:-

Species	A	B	C
Black	55	20	35
Southern White	68	16	16
Northern White	100	-	-

Category A estimates for black rhinos were all from southern Africa and Kenya in eastern Africa. The northern white rhino is extinct except for the single Garamba population in Zaire, hence the 100% score in category A.

Rhino Numbers

The national estimates and trends of black and white rhinos in Africa since 1980 are summarized in the Table. Black rhino numbers have dropped from 8,800 in 1984 to 3,390 in 1990, a 61% decline in 6 years or 20% per year. In some countries like Sudan, Uganda, Mozambique and Somalia the species has become extinct. These local extinctions had been predicted in surveys conducted within the last ten years.[3,4,5,6,7,8]

Another significant feature is the change in the location of the large populations. In 1984 Tanzania had the largest number of animals and accounted for 35.5% of the continental total; this has dropped to only 5.5%. Similarly Zambia's 18% in 1984 has become 1.2% today. A contrary change has occurred in southern Africa. South Africa and Zimbabwe accounted for 19% and 7.3% in 1984 while today their respective figures are 50.1% and 18.5%. This positive shift is not due to increased numbers but because of decline in most of the other African countries.

Regionally, in 1984, southern Africa represented 52%, eastern Africa 44% and west-central 3% of the continental total. These proportions have shifted to 82%, 17% and 1% respectively. Finally, it is worth noting that 90% of all remaining black rhinos are to be found in Zimbabwe, S. Africa, Namibia and Kenya. Alongside the drastic decline in numbers the species range has contracted considerably. This has isolated small populations in the once expansive and ecologically diverse black rhino range in Africa. However , it is worth noting that the overall continental rate of decline has dropped in the last three years as shown by the flexing of the curve in Fig.2.

The increase in southern white rhino reported by Western and Vigne in 1984 has been maintained in South Africa, Namibia and Kenya. The species population in Zimbabwe remained stable but declines were recorded in Swaziland and Botswana. South Africa, Zimbabwe and Namibia have 97% of the continental total. The introduced Kenyan population in sanctuaries has grown at the rate of 16% per annum from 25 to 65 individuals over the last 10 years. Southern white rhino total population in Africa now stands at 4,745 compared to 3,841 in 1980, an increase of 2.35% per annum. The northern white rhino has decreased by over 97% in the last decade although the Garamba population, which had dropped to 20 individuals by 1984, now stands at 26.

Trends in Population Sizes

The size distribution of existing black rhino populations displays a larger proportion of even smaller populations than the 1984 survey. No population has more than 400 individuals. In 1980 75% of the continental populations had less than 100 individuals: this has gone up to 80% today. Fig 3. shows percentage cumulative frequencies of populations of various sizes in 1980 and in 1990. The two curves are significantly different (Kolmogorov-Smirnov 2-sample test: $D=0.666$, $P=0.001$, $N=24$), with the shift left due to an increase in the proportion of small size populations. The percentage frequencies of the number of black rhinos within various population sizes in 1980 and 1990 is shown in Fig 4. The difference between the two curves is also significant when subjected to the same test ($D=0.666$, $P=0.001$, $N=24$). Fig 4 shows that

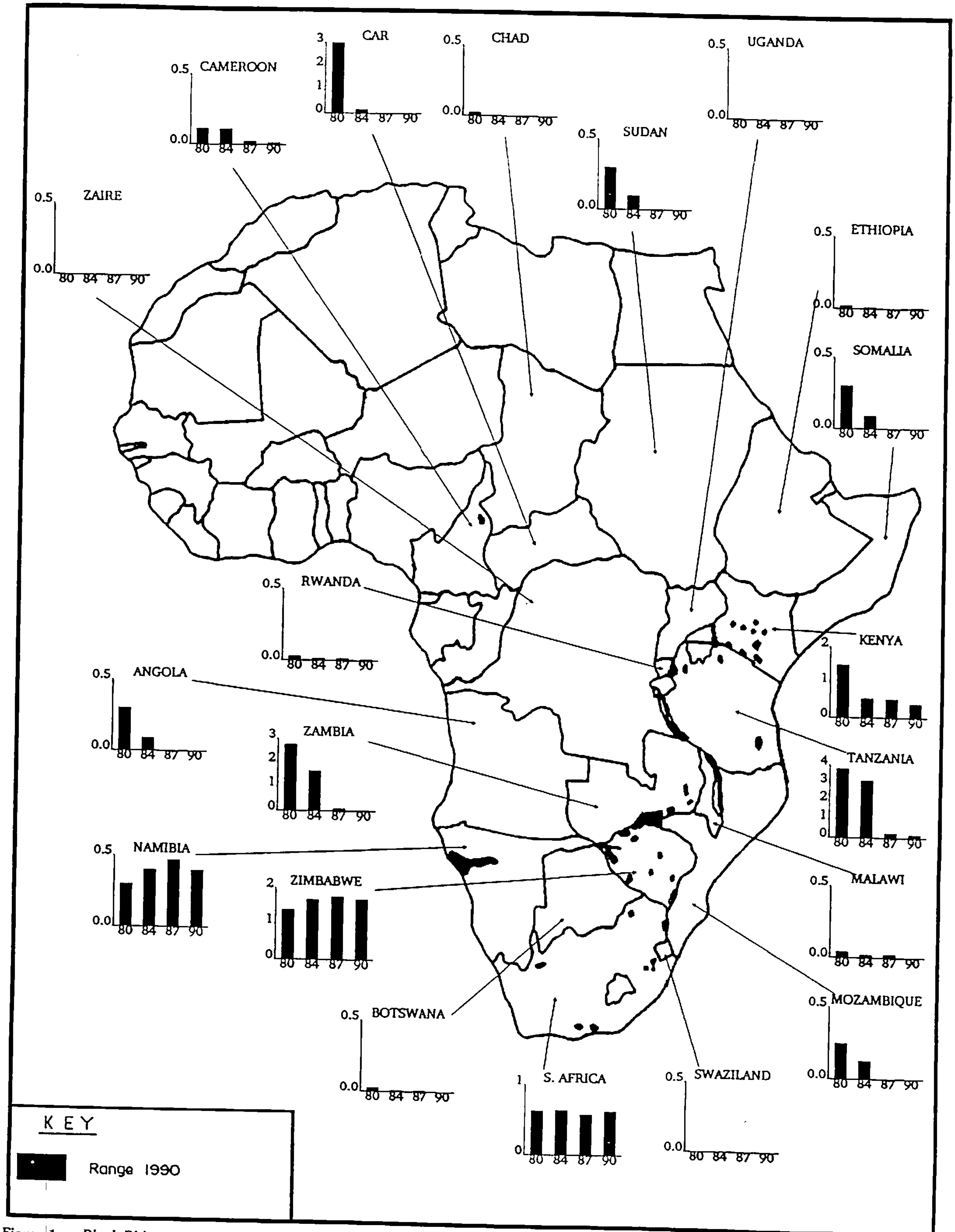

Figure 1. *Black Rhino range and trends in 1990. Each graph covers 1980 – 1990: vertical axis in thousands*

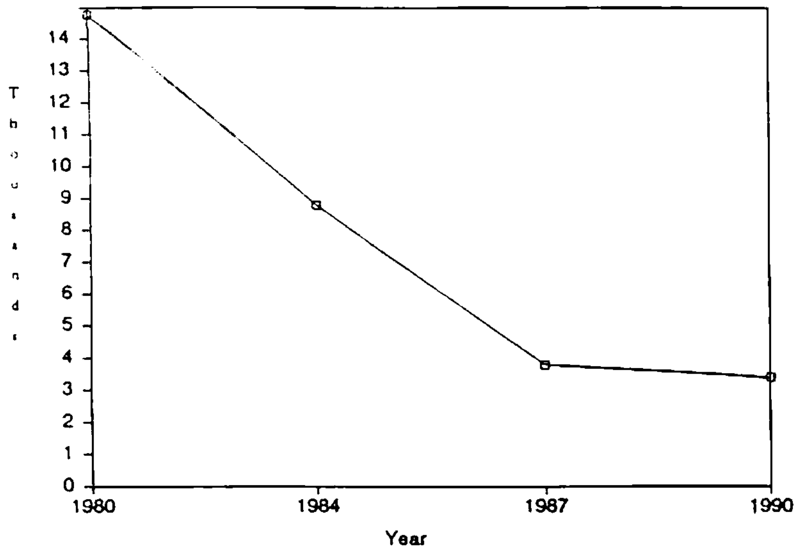

Figure 2. *Estimates of Black Rhinos in Africa between 1980 and 1990*

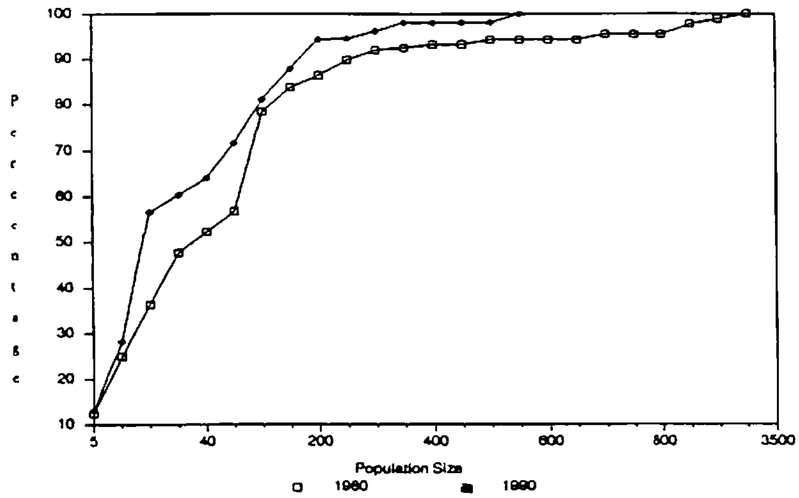

Figure 3. *Cummulative frequency curves of Black Rhino populations showing the change between 1980 and 1990*

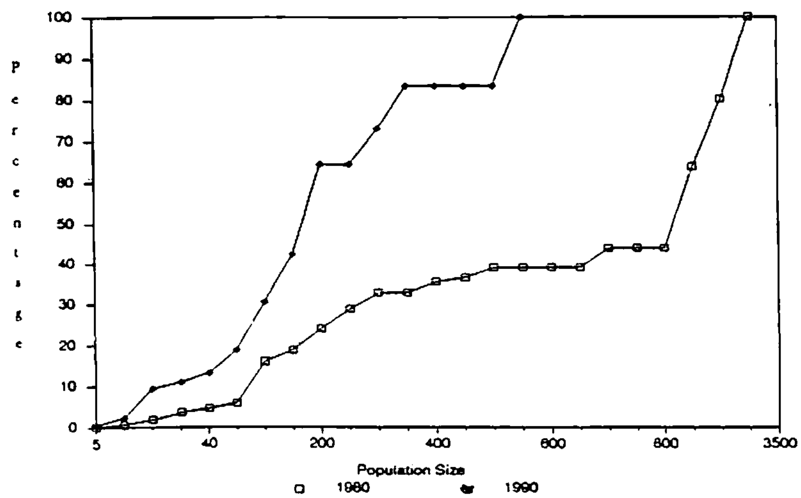

Figure 4. *Cummulative frequency curves of Black Rhino numbers in populations of various sizes, showing the change between 1980 and 1990*

the 15% of all rhinos living in populations of 100 individuals or less in 1980 has increased to 30% today. Similar figures for populations of 400 individuals are 32% and 80% respectively. A significant factor that has contributed to the shift of both ogives is the extinction of some populations which had under 10 individuals in 1980. Generally the survey reveals that the alarming decline of rhinos continues over most of the species range although at a lower rate. The exceptions are southern Africa and Kenya where rhino populations are stable or increasing, which is a reflection of the commitment and efficiency of wildlife authorities and, especially, the development and implementation of rhino management plans.

In countries which have experienced major civil unrest in the last decade rhino numbers are negligible; to all intents and purposes the rhino is extinct. The ready availability of automatic weapons, allocation of nearly all resources to war and the fact that poaching becomes a means of survival for people in remote areas during civil disturbance, are the main reasons for the demise of rhinos in these countries.

The cause of continuing pressure on rhinos is the intolerable trade in their horn which is used mainly for making traditional medicines in the Far East.[8,9,10,11] The limited supply has caused prices to rise to a level which encourages poachers to take great risks. What needs to be done has been repeated time and again: reinforce anti-poaching measures; improve regional co-operation of management and law enforcement authorities; find acceptable substitutes for rhino horn as medicine; enforce CITES regulations.

Half of all the world's black rhinos are in Zimbabwe and three other countries have more than 80% of the rest. South Africa holds nine of every ten white rhinos. Even to a layman the "all eggs in one basket" risk is obvious. For the conservationist questions of genetic depression, biased sex ratios and age structures and active management are the obvious challenges. Conservationists most often operate in areas of peace but the risk of future civil unrest in the countries with nearly all rhinos cannot be ruled out. Personally, I see a future challenge: endeavour to influence socio-political and economic systems so as to prevent those civil wars whose impact on rhinos and other wildlife is only too evident.

Nearly all rhinos are in parks or on private lands. Those outside protected areas and some in the larger parks are either scattered individuals or live in very small populations. Such conditions expose the animals to biological and environmental problems that accelerate their extinction and, because of limited resources, their protection is beyond the capability of wildlife authorities. Sanctuaries are often the rhinos' only chance of survival but require much forethought and careful planning.

Table. Present and Past Estimates of Black and White Rhino Populations in Africa

Country	Black Rhino 1980	1984	1987	1990	% of 1990 Total Pop.	White Rhino 1980	1984	1990	% of 1990 Total Pop.
Angola	300	90			0.0				0.0
Botswana	30	10	10	2	0.1	70	200	15	0.3
Cameroon	110	110	25	15	0.4				0.0
CAR	3,000	170	10		0.0	20	1	0	0.0
Chad	25	5	5	2	0.1				0.0
Ethiopia	20	10		6	0.2				0.0
Kenya	1,500	550	520	400	11.8	25	30	65	1.4
Malawi	40	20	25	5	0.1				0.0
Mozambique	250	130			0.0	30	20		0.0
Namibia	300	400	470	400	11.8	150	70	200	4.2
Rwanda	30	15	15	9	0.3				0.0
Somalia	300	90			0.0				0.0
South Africa	630	640	580	626	18.5	2,500	3,330	4,225	89.0
Sudan	300	100	3		0.0	400	10		0.0
Swaziland				2	0.1	60	60	8	0.2
Tanzania	3,795	3,130	270	185	5.5				0.0
Uganda	5			0	0.0	1	1	0	0.0
Zaire		.		0	0.0	400	15	26	0.5
Zambia	2,750	1,650	110	40	1.2	5	10	6	0.1
Zimbabwe	1,400	1,680	1,760	1,700	50.1	180	200	200	4.2
Totals	14,785	8,800	3,803	3,392		3,841	3,947	4,745	

The capture and translocation of solitary rhinos to small safe sanctuaries has proved the best strategy.[12,13] The success of the Kenyan experiment is evidence that normal population growth can be realized together with improved security from poaching. However, sanctuaries do pose management challenges in the establishment, development and operational stages.

Adopting sanctuaries without overall long-term management plans should be avoided. Plans and their development assist in evaluating costs, prospects and available alternatives, and are likely to gain the attention of international donor agencies. A preliminary survey for the establishment of a sanctuary should cover: the geographic location and history of the area in terms of past rhino numbers; the available food vegetation; security; the communication infrastructure, which is essential during translocation and future protection; and natural factors like predators and disease. Evaluation of other forms of land use and investigation of the lifestyles of surrounding human communities to establish potential support or hostility toward the sanctuary are also essential. Finally, there is need to assess the indirect benefits towards other wildlife species and habitats within the proposed sanctuary and neighbouring conservation areas.

Currently, information, knowledge and skills on rhino sanctuaries and other aspects of rhino conservation and management are almost totally confined to Kenya, South Africa and Zimbabwe. There is a need for more continental cooperation and exchange of knowledge and skills. AERSG has encouraged such interchange and will continue to do so in the future.

The survey reported here also requested information on problems and needs of rhino conservation. It would appear most difficulties are linked to poaching, inadequate communications, and un-coordinated management plans and strategies. The needs for repeated surveys, continuous monitoring and improved anti-poaching surveillance featured prominently. Lack of technical personnel and equipment including aircraft, vehicles and field gear are common to all rhino areas.

In summary, and as urged in the past, range states with rhinos should develop specific management plans both nationally and for conservation areas. Intensive anti-poaching surveillance together with active management and protection are essential. And, most importantly, if the African rhinos are to recover, there must be total elimination of trade in rhino horn products.

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Research findings on the rhinos in Garamba Park can usefully support investigations into reproductive efficiency of the captive population and *vice versa*. The detection of pregnancy, especially of the early stages of pregnancy, would have useful application to the Garamba Northern white rhinoceros.

Ex situ population

Recommended is the aggressive investigation of the estrus cycles and continuous monitoring of all captive females (except those less than 5 years of age). Monitoring of salivary and/or urinary 20α-DHP and estrogen conjugates is recommended.

Semen collection and freezing from all males should be undertaken.

A technical working group should be convened to discuss the options and protocols for the most appropriate action to be undertaken in order to increase the reproductive potential of the *ex situ* population.

The feasibility of induction and/or synchronization of estrus should be investigated using female Southern white rhinos.

All zoological parks maintaining Northern white rhinoceros should immediately construct and install manipulation chutes that allow for the safe handling of animals for reproductive examinations and other necessary veterinary investigations. Plans are available for these manipulation chutes.

The zoological parks that hold the Northern white rhinoceros have a critical responsibility for these animals and their potential contribution to the gene pool. The activities of these institutions should be monitored by the IUCN Captive Breeding Specialist Group. The individual rhinos removed from the wild provide a crucial source of gene pool resources that are of potential benefit to the future of the wild population.

No further transfers of Northern white rhinoceros from the Zoo Dvur Kralove is recommended at this time. The collection of a breeding nucleus of the Northern white rhinoceros and its husbandry at Dvur Kralove enable the option of utilizing an *ex situ* population in support of the population in the wild and the ecosystem in which it exists.

Coordination of efforts for *in situ* and *ex situ* conservation

More frequent and detailed communication of data and research conclusions is recommended. Detailed summaries of information relevant to reproduction and population management should be exchanged between all parties.

The opportunities for cooperation and linkage of aspects of the management of the gene pool resources is recognized by all parties and efforts to develop appropriate approaches to linking *in situ* and *ex situ* populations should be explored.

CURRENT RHINO POPULATIONS AND DISTRIBUTION

Introduction - The following represents the most current data available on rhinoceros populations and their distribution. It was collected by personal interview, conference presentations and related materials gathered at the International Symposium on Rhinoceros Biology and Conservation held May 9 through May 11 in San Diego, California, USA.

Northern White Rhinoceros - the Northern White rhinoceros *(Ceratotherium simum cottoni)* currently exists in the wild only in Garamba National Park, Zaire. The population there consists of 15 males and 13 females (K.H. Smith, 1991); six of these males and twelve of the females form the actively breeding portion of the population.

The captive population resides in two institutions: Vychodoceska Zoo in Dvur Kralove, Czechoslovakia and the Wild Animal Park in San Diego, USA. The Vychodoceska Zoo has two males and five females. One of the females is a Northern White/Southern White hybrid (P. Spala 1991). The Wild Animal Park has two males and two females in its herd.

Southern White Rhinoceros - the status of the Southern White rhinoceros *Ceratotherium simum simum* in the wild over the past decade is as follows (from C.G. Gakahu, 1991 and with revisions):

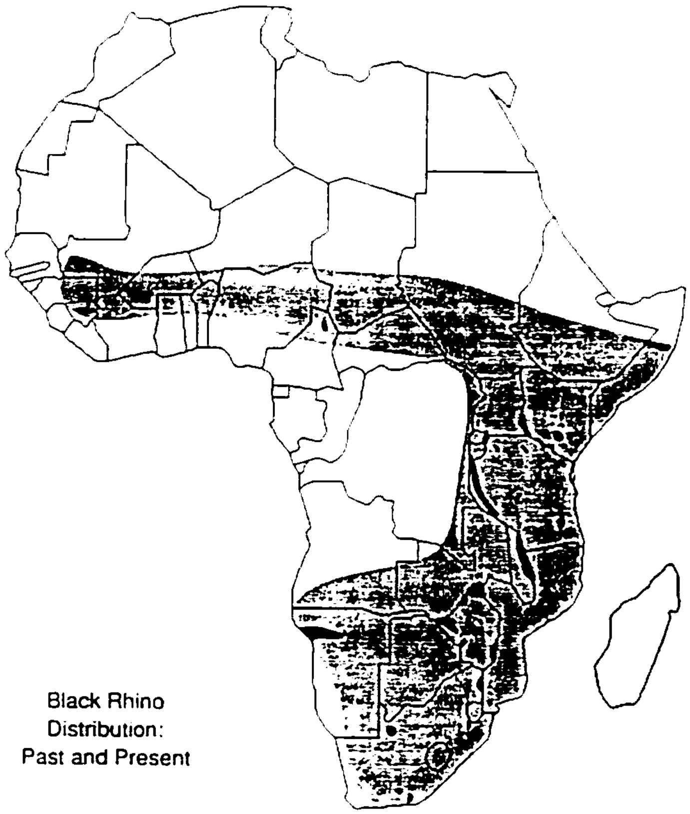
	1980	1984	1990
Botswana:	70	200	15
CAR:	20	1	0
Kenya:	25	30	65
Mozambique:	30	20	0
Namibia:	150	70	200
South Africa:	2500	3330	4225
Swaziland:	60	60	8
Zambia:	5	10	6
Zimbabwe:	180	200	200
	3841	3947	4745

The captive population consists of 698 individuals (342 males, 355 females one undetermined) in 245 institutions according to the 1991 African Rhino Studbook.

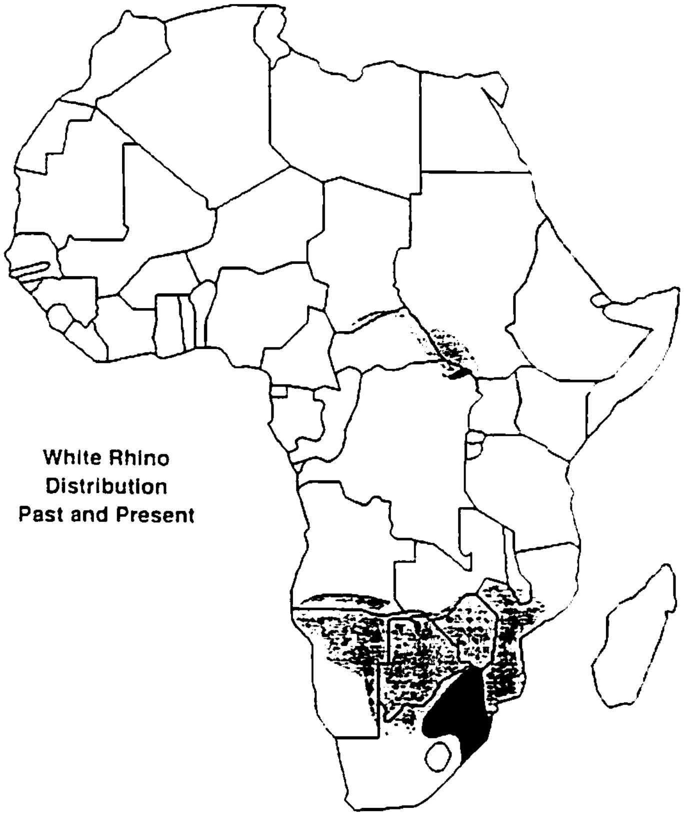
Black Rhinoceros - the status of the Black rhinoceros *(Diceros bicornis)* in the wild over the past decade is as follows (from C.G. Gakahu, 1991):

	1980	1984	1987	1990
Angola:	300	90	0	0
Botswana:	30	10	10	2
Cameroon:	110	110	25	15
CAR:	3000	170	10	0
Chad:	25	5	5	2
Ethiopia:	20	10	0	6
Kenya:	1500	550	520	400
Malawi:	40	20	25	5
Mozambique:	250	130	0	0
Namibia:	300	400	470	400
Rwanda:	30	15	15	9
Somalia:	300	90	0	0
South Africa:	630	640	580	626
Sudan:	300	100	3	0
Swaziland:	0	0	0	2
Tanzania:	3795	3130	270	185
Uganda:	5	0	0	0
Zambia:	2750	1650	110	40
Zimbabwe:	1400	1680	1760	1700
	14,785	8800	3803	3392

The captive population, according to the 1991 African Rhino Studbook, consists of 91 males and 113 females (204 total animals) in 72 institutions.

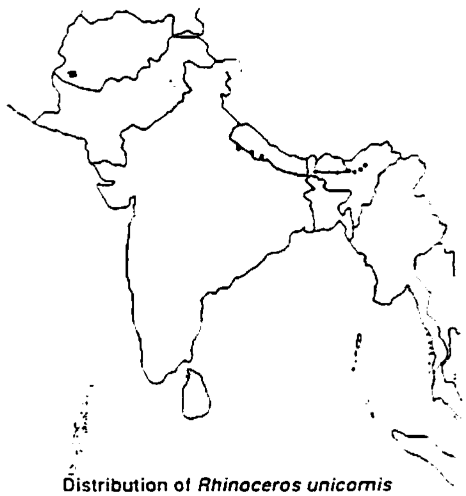


Black Rhino
Distribution:
Past and Present



White Rhino
Distribution
Past and Present

DISTRIBUTION OF SUMATRAN RHINOS
PAST AND PRESENT



Distribution of *Rhinoceros unicornis*
Past and Present

Selected papers

Proposed conservation plan for the black rhinoceros *Diceros bicornis* in South Africa, the TBVC[1] states and Namibia

P.M. BROOKS

Brooks, P.M. 1989. Proposed conservation plan for the black rhinoceros *Diceros bicornis* in South Africa, the TBVC states and Namibia. — *Koedoe* 32 (2): 1-30. Pretoria. ISSN 0075-6458

The conservation plan for the black rhinoceros presents specific aims and management guidelines for the conservation of the African black rhinoceros *Diceros bicornis* in the Republic of South Africa, the TBVC states and Namibia. The adoption of this plan, and the application of the strategies described therein (managing existing populations, establishing new populations and aspects of captive breeding) by the relevant conservation authorities should enhance the survival prospects of this species, both in the region and globally.

Key words: Black rhinoceros, *Diceros bicornis*, management, South Africa, Namibia, conservation plan, strategy.

P.M. Brooks, Natal Parks Board, P.O. Box 662, Pietermaritzburg, 3200 Republic of South Africa.

Introduction

The black rhinoceros *Diceros bicornis* (Linnaeus, 1758) is restricted to the African continent where it was widely distributed in the sub-Saharan region. Although early records lack detail, it is clear that the black rhinoceros has suffered a very severe decline in numbers and in the extent of its range since the turn of the century. It is currently listed as 'vulnerable' both globally and in South Africa (IUCN and South African Red Data Books).

The recent trend has been dramatic, with numbers dropping from an estimated 65 000 in 1970, to 15 000 in 1982, 9 500 in 1984 (distributed between 18 countries), down to 6 000 in 1985 and about 3 800 in 1987. This represents a decline of over 90 percent in the last 17 years. In 1970 the Selous National Park in Tanzania held more black rhinoceros than currently survive on the whole of the continent today. In recent years the black rhinoceros has either disappeared from, or is on the verge of extinction in 12 African countries (Cumming 1987). It is now only found in reasonable numbers (i.e. more than 100) in Zimbabwe, South Africa, Namibia, Tanzania, Kenya and Zambia.

[1] Republics of Transkei, Bophuthatswana, Venda, and Ciskei.

Poaching for horn is very largely responsible for this massive decline; and the southern sub-continent, where more than two thirds of the remaining black rhinoceros are conserved, is coming under increasing pressure with the first substantial poaching of rhinoceros taking place in the Zambezi Valley, Zimbabwe, in 1985.

The black rhinoceros was formerly widespread throughout most of South Africa, but by the 1930s it had been reduced to two relict populations comprising 100 to 150 rhinoceros of the southern-central subspecies *Diceros bicornis minor* (Drummond, 1876) in Hluhluwe-Umfolozi and Mkuzi game reserves in Zululand. Numbers increased under protection, so that by 1962 the Natal Parks Board was able to translocate animals to form new populations in reserves within their former range. By the end of 1987, a total of 150 black rhinoceros had been moved to reserves within Natal, as well as to re-establish the subspecies in the Pilanesberg and Kruger national parks (Hitchins 1984), and the Andries Vosloo Kudu Reserve in the Cape Province. A further seven have been supplied for captive breeding programmes in the United States of America. The re-establishment history of *Diceros bicornis minor* in the region is presented in detail in Appendix 1.

In Namibia a significant population of the arid zone *Diceros bicornis bicornis* (Linnaeus, 1758) survived in the Etosha National Park and relict populations elsewhere in Kaokoland/Damaraland. In 1985, the Directorate of Nature Conservation and Recreation Resorts in Namibia agreed to relocate 12 rhinoceros from Etosha to two reserves in the arid northwestern Cape region, namely the Augrabies Falls National Park and the Vaalbos National Park (Hall-Martin 1985, 1986).

There are currently about 990 black rhinoceros in the wild in South Africa, the TBVC states and Namibia (hereafter termed "the region"). These comprise just over 580 *Diceros bicornis minor* distributed between nine reserves, about 390 *Diceros bicornis bicornis* occurring in four reserves or areas, and a small but expanding population of *Diceros bicornis michaeli* Zukowsky, 1964 in the Addo Elephant National Park (see Table 1 for details).

In international terms, these populations are becoming increasingly important, not only because they represent more than 25 percent of the surviving world population, but also because they are the only ones to have expanded both in numbers and distribution in recent years.

Table 1
Current (1988) population sizes of black rhinoceros in the region
(Key: 1-6 denotes the controlling bodies which are given in the text)

Subspecies	Location	Population size
D. b. minor	[1] Hluhluwe-Umfolozi Game Reserve	220
	[2] Kruger National Park	160
	[1] Mkuzi Game Reserve	70
	[4] Ndumu Game Reserve	42
	[1] Itala Game Reserve	35
	[6] Pilanesberg National Park	27

	[1] Eastern Shores Nature Reserve	15
	Weenen Nature Reserve	7
	Andries Vosloo Kudu Reserve	4
	(Private land — Eastern Transvaal)	1
		Total. 581
D b bicornis	[3] Etosha National Park	300
	[3] Kaokoland/Damaraland	80
	Augrabies Falls National Park	6
	[2] Vaalbos National Park	6
		Total. 392
D b michaeli	[2] Addo Elephant National Park	18
		Total 18

In recent years it was generally accepted that the surviving rhinoceros in Africa represented four subspecies, namely *Diceros bicornis minor* (southern Africa), *Diceros bicornis bicornis* (Namibia), *Diceros bicornis michaeli* (East Africa) and *Diceros bicornis longipes* Zukowsky, 1949 (West Africa). This has recently been challenged and a taxonomic review is under way. However, it was agreed at the African Rhino Workshop (Cincinnati, October 1986) that, for practical management purposes, four basic ecological groupings should be recognised. These were the south-western (Namibia), southern-central (South Africa though Zimbabwe and Zambia to southern Tanzania), north-eastern (Kenya and northern Tanzania) and north-western (Cameroun, Central African Republic) groups, which accord closely with the subspecies breakdown given above. The workshop recommended that both *in situ* and captive management programmes should attempt to maintain the integrity of these ecotypes, i.e. they should not be allowed to interbreed, unless future genetic and other studies indicate that this separation is unjustified.

At its meeting in Zimbabwe in September 1985, the African Elephant and Rhino Specialist Group (AERSG) of the IUCN agreed that all countries should draft national conservation plans for the black rhinoceros. These would identify the key concerns requiring action, afford the countries concerned the opportunity critically to evaluate them and provide guidelines for future management action. The southern African representative for the AERSG, Dr. P.M. Brooks, was therefore tasked with developing the plan. This was undertaken with the assistance of other South African members of AERSG, namely Dr. J.L. Anderson (KaNgwane), Dr. A.J. Hall-Martin (National Parks Board) and Mr. P.M. Hitchins (KaNgwane), and other conservationists, in particular Dr. E. Joubert (Namibia), Mr. R.F. Collinson (Bophuthatswana), Mr. P.S. Goodman (Natal Parks Board) and the Hon. Richard Emslie (consultant ecologist).

The "Conservation plan for the black rhinoceros *Diceros bicornis* in South Africa, the TBVC states and Namibia" provides detailed information on the current rhinoceros populations and their management history, and presents clear conservation aims for each of the three subspecies represented. The adoption of common policy and management guidelines by the relevant conservation authorities, in conjunction with the specialist advice and co-ordination provided by the Rhino Management Group (RMG), should enhance the survival and growth prospects of these populations in the region. This is considered necessary, as the current rhinoceros populations are controlled by no fewer than six conservation bodies: the Natal Parks Board[1], the National Parks Board[2], the Department of Agriculture and Nature Conservation of Namibia[3], the KwaZulu Bureau of Natural Resources[4], the Cape Department of Nature and Environmental Conservation[5] and Bophuthatswana National Parks Board[6].

Participation in the black rhinoceros conservation programme (such as eligibility to receive surplus animals) by any conservation body would depend on its adoption of the conservation plan and observance of the CITES regulations pertaining to the trade in rhinoceros products.

While the conservation plan is restricted to South Africa, the TBVC states and Namibia, it is hoped that this co-operative approach will extend to the whole of the southern African region, including Botswana, Malawi, Mozambique, Zimbabwe and Swaziland. The adoption of national plans by these countries would form the basis for discussions on closer liaison regarding black rhinoceros conservation.

Aims

It is important that the conservation management programme for black rhinoceros in the region has clear aims which are accepted by all the relevant conservation bodies, and that it is undertaken co-operatively.

Internationally, it has been agreed that the medium-term aim is the maintenance of a large population of at least 2 000 rhinoceros of each of the four recognised ecological types, this being required to ensure long-term genetic viability. Smaller populations will lose genetic diversity in time, although this loss will be minimised if population growth is rapid.

Most of the rhinoceros in South Africa belong to the southern-central ecotype, currently recognised as *Diceros bicornis minor*, which also occurs in Zimbabwe, Zambia and southern Tanzania. Together they number just over 2 000 animals, of which about 580 occur in our region (see Table 1). However, there are two reasons why, while co-operating at all levels possible with our northern neighbours, we should take steps to ensure that a viable population is maintained within South Africa itself, and not depend on the populations to the north for long-term viability. The reasons are, firstly, that the Zambian and Tanzanian rhinoceros have already been depressed to critically low numbers and the large Zimbabwean population (*ca.* 1 600) has recently been experiencing heavy poaching pressure; and secondly, that political differences may prevent any interchange of animals across the Limpopo.

The south-western ecotype *Diceros bicornis bicornis* only occurs in Namibia and the south-western Cape, so clearly the responsibility for maintaining a viable population rests solely with the conservation bodies in the region.

The primary aims for the conservation of black rhinoceros in the region are:

- To develop, as rapidly as possible, and conserve in the long term a genetically-viable population of at least 2 000 black rhinoceros of the southern-central ecotype *Diceros bicornis minor* in its natural habitat in the region.
- To develop, as rapidly as possible, and conserve in the long term a genetically-viable population of at least 2 000 black rhinoceros of the south-western ecotype *Diceros bicornis bicornis* in its natural habitat in the region.
- To develop, as rapidly as possible, and conserve a population of at least 100 of the north-eastern ecotype of black rhinoceros *Diceros bicornis michaeli* in the wild in the region.
- To support captive breeding programmes for all three subspecies both within and outside the region and the African continent, providing they can play a significant and sustained role in maintaining or improving the conservation status of the species.

Role of the Rhino Management Group

The conservation management programme and other related programmes described in this conservation plan will be co-ordinated by the Rhino Management Group. The group, which will comprise one representative from each organisation actively involved in black rhinoceros conservation management (currently the six bodies with black rhinoceros populations specified in the Introduction) and selected rhinoceros specialists, will act in an advisory capacity for the various nature conservation authorities by:

— updating the conservation plan as new strategies and procedures are developed;

— evaluating the effectiveness of management programmes being applied and providing advice for their improvement;

— assessing the relative importance of potential new areas for black rhinoceros establishment;

— recommending rhinoceros offtakes and relocation areas in accordance with policy laid down in the conservation plan; and

— developing and co-ordinating an integrated research programme to meet the conservation needs of the species.

Each conservation body will be required to provide an annual report on the black rhinoceros populations under its control to the Rhino Management Group. This should be submitted by 1 March for the preceding calendar year, and will include information on the latest population estimates (including details of methods and dates), population structures, the marking of rhinoceros, personal history records, births, re-establishment exercises, mortalities, poaching and any cases of the illegal trade in rhinoceros products.

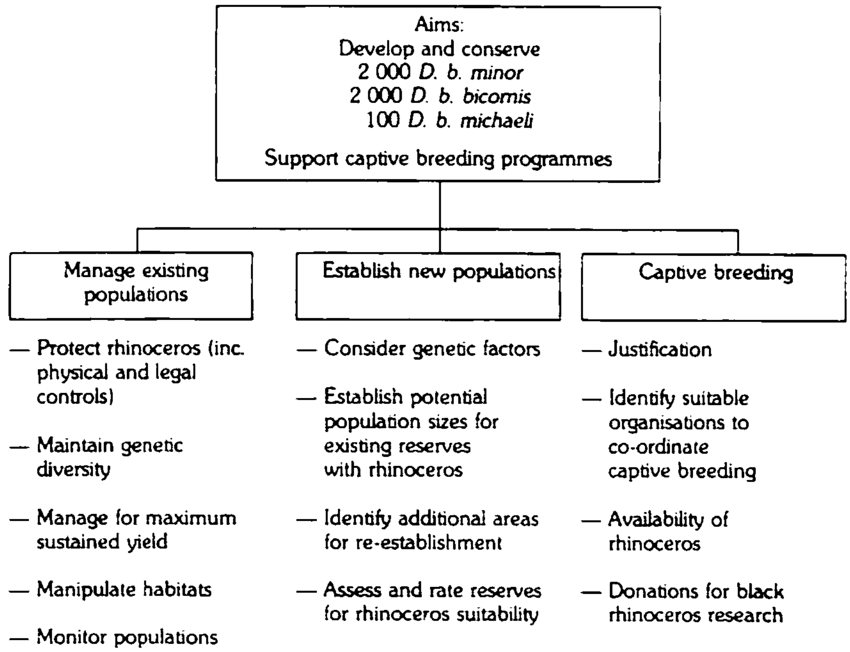
The group will meet at least once each year to discuss these annual reports and other priority issues, and recommendations will be forwarded to the relevant conservation bodies for their consideration.

Conservation Management Programme

The philosophy underlying the conservation aims for the black rhinoceros is based on the perceived need to prevent extinction due to man-induced changes and to maintain the evolutionary potential of the species.

The actions most essential for achieving these conservation aims are the management of existing populations, the re-establishment of new populations and the support of captive breeding programmes. The rhinoceros need to be protected, their habitats conserved and the species managed to maximise the rate of population increase and to maintain genetic diversity.

These, and other related actions and needs, are summarised below and are elaborated on later in this paper.



1. *Management of existing populations*

The survival of black rhinoceros in their natural habitats is the key aim of both this "Conservation Plan" and the "Continental Strategy for the Conservation of Black Rhino" (AERSG draft, July 1986).

The black rhinoceros populations and their habitats need to be managed to protect the current resources, to maximise recruitment and survival so as to provide animals for re-establishment elsewhere, and to maintain genetic diversity. At the very least, recruitment into the adult population from breeding must balance the animals lost.

(i) Protection of rhinoceros populations

The major threat to the rhinoceros populations in the region, as elsewhere in Africa, is illegal hunting for the horn. Their survival therefore depends largely on the ability of the relevant conservation bodies to control poaching through direct law enforcement supported by intelligence work and adequate legislation, and through national and international trade bans and propaganda campaigns.

(ii) Legal status

The legal status of the black rhinoceros and the penalties for illegally killing, or trading in rhinoceros products, varies throughout the region. The species is classified as Protected Game in the Transvaal, Specially Protected Game in Natal, Bophuthatswana, Namibia and KwaZulu, and as an Endangered Species in the Cape. The penalties for a first offence vary from maxima of R200 or 200 days imprisonment (KwaZulu) to R100 000 or 10 years (Bophuthatswana). Apart from Bophuthatswana, the next highest penalties are found in Natal (R2 000 or 2 years) and in the Transvaal (R3 000 or 1 year).

There is a clear need to standardise the legal status, and in particular to increase the penalties for illegal activities throughout most of the region. This is supported by the recommendation from the CITES meeting held in Canada, July 1987, namely that "... an increase in penalties for individuals/companies convicted of relevant (rhino) offences ... is one of the measures necessary to halt the catastrophic decline in numbers throughout Africa".

The Natal Parks Board has motivated for such an increase, to bring legislation in line with that operating currently in Zimbabwe (min. Z$15 000 or 5 years) and Bophuthatswana (maximum R100 000 or 10 years), and the National Parks Board is taking similar action. The other conservation bodies are urged to do likewise to ensure that the penalties operate as a significant deterrent.

(iii) Control of trade

While South Africa is the only signatory to the Convention on the International Trade in Endangered Species of Wild Fauna and Flora (CITES) in the region, the TBVC States and Namibia also abide by the CITES regulations. The black rhinoceros is listed under Appendix 1 of the agreement, which effectively means that any trade in rhinoceros products is banned. Hunting trophies may, however, be exported under a CITES permit issued by a relevant conservation body, although hunting of the black rhinoceros is currently not allowed in any country in Africa.

(iv) Anti-poaching

The poaching of rhinoceros for its horn is sporadic and of low intensity in the region, and is not associated with well-organised, armed gangs as in the rest of Africa. However, there are no grounds for complacency, and conservation authorities need to be constantly on the alert.

Efficient and intensive ground surveillance is clearly essential to detect illegal activities within reserves, but because the levels of poaching can be difficult to determine, this cannot work independently of intelligence work in the surrounding areas and information on the rhinoceros populations themselves.

Procedures are particularly required to ensure that the causes of death of rhinoceros in the field are adequately investigated and, once the horns have been collected, that the carcasses cannot be mistaken at a later date (see Rhinoceros mortalities). The security of the horns is also important, and the effectiveness of safes or strongrooms used for storage needs to be evaluated accordingly.

Close monitoring of rhinoceros numbers also provides invaluable information. Census techniques should be precise enough to detect clear trends, and any unusual declines investigated (see Monitoring black rhinoceros populations).

Intelligence work comprises obtaining inside information, investigating any possible illegal activities (including trade) and co-ordinating the activities of, or co-operating with, a variety of law enforcement and conservation agencies. The adequacy of such operations needs to be constantly re-evaluated.

(v) Maintenance of genetic diversity

It is important that the potential genetic concerns for the black rhinoceros be kept in perspective with the other factors affecting the conservation of the species, such as the need for physical protection. Genetic management should therefore be viewed as a long-term insurance policy should the protective and other conservation measures succeed. However, as genetic considerations give direction to, while not dictating, the management programmes described in this plan, a brief overview of these considerations is warranted.

The major genetic concern relates to the size of the black rhinoceros populations in the region, with only three of the 14 populations numbering more than 100 individuals (see Table 1). The loss of genetic variability in such small populations is a potential threat to their survival, and so, in the absence of specific information on the genetic characteristics of our black rhinoceros populations, an attempt has been made to draw up sound conservation management guidelines based on genetic principles. This was undertaken at a CSIR workshop entitled "Population genetics for conservation management", which was held in Pietermaritzburg on 7-9 July 1987. The following (abridged) guidelines for the genetic management of existing populations were forthcoming:

- The management goals of 2 000 *Diceros bicornis minor* and *Diceros bicornis bicornis* should be achieved as rapidly as possible, as this would provide the best insurance against significant loss of genetic diversity. Similarly the rapid expansion of the population of *Diceros bicornis michaeli*, albeit to a lower target level, would also minimise genetic losses.
- Until the population targets are reached for the various subspecies, each population should be managed at a level below ecological carrying capacity to maximise rates of increase.
- An alternative short-term (+ 200 years) strategy would be to interchange animals between sub-populations at the rate of one per generation, as this would maintain a large proportion of genetic diversity. However, this approach is not currently recommended as the same results can be achieved through the first option given above, with less disturbance and without the risks inherent in relocating animals into high density situations.
- An effective population size (Ne) of 50 represents a critical threshold. Below this, the rate of loss of genetic diversity exceeds 1 percent per generation, which is highly undesirable.
- Random gene flow is undesirable, and the exchange of individuals of different subspecies or ecotypes should not be undertaken under any circumstances, including the impending total collapse of any of the ecotypes.
- The selective removal of individuals is useful for maintaining heterozygosity in very small populations for which pedigrees are available. This requires personal history records to be kept for, and possibly nuclear DNA fingerprinting to be undertaken on all rhinoceros in small populations.

The genetic considerations applying to the establishment of new populations are presented separately (see below).

(vi) Managing populations for maximum sustained yield

Four reserves in the region, namely Hluhluwe-Umfolozi, Mkuzi, Ndumu (Hitchins 1984) and Etosha have provided black rhinoceros for re-establishment into other reserves. These removals have been conservative, with the only capital reduction taking place in Hluhluwe-Umfolozi in an attempt to drop the population below ecological carrying capacity and hence to stimulate breeding and survival (Brooks, Whateley & Anderson 1980). In Ndumu, which has a rate of population increase of 8-9 percent per annum (Conway & Goodman, *in review*), removals of 5 percent are implemented each year; while in Mkuzi, such removals average 3 percent each year, although in this case the addition of more land has enabled the population to expand in both size and range. Translocations from Etosha have, so far, been limited to the 12 animals supplied to the National Parks Board since 1985.

To achieve the primary conservation objectives for the species, it is essential to manage all the black rhinoceros populations for maximum sustained yield. Such management would ensure that both the rates of population increase and the numbers of rhinoceros available for relocation would be maximised. However, we currently lack the information on the response of black rhinoceros populations to different levels of harvesting under changing environmental conditions required to design such a programme.

The Rhino Management Group will consider the options available for maximising the production of rhinoceros for translocation, and will forward recommendations to the relevant conservation authorities for their consideration.

These options are:

(a) An adaptive management approach. Three or more levels of removal intensity are applied to different populations for at least two generations to determine equilibrium offtake. This would test the partial compensation model that Caughley (1985) suspects will be appropriate for most large herbivores in fairly stable environments. Such experimentation should ultimately provide the best basis for sound management.

(b) Fixed stocking rate strategy. This could be applied to the rhinoceros population in each reserve at a level below the ecological carrying capacity, i.e. below the threshold equilibrium level at which negative feedback from the food resources, social interactions and other environmental factors significantly reduces the rate of population increase, but at a sufficient density to ensure that all available females are mated. The optimum stocking rate could be fixed at about 75 percent of the estimated ecological carrying capacity, with numbers being permitted to build up by 5-10 animals, depending on overall population size, before removals take place. These periodic removals which, for the smaller populations, would take place at 3-4 year intervals (assuming a 4 percent annual rate of increase), would optimise the efficiency and cost-effectiveness of the removal programmes, would minimise the disturbance to the animals and would allow time for annually-repeated surveys to provide reliable population estimates or trends. Such management would have to be based on accurate population estimates, particularly where the black rhinoceros populations are small (see Monitoring black rhinoceros populations). The implementation of this strategy would, assuming a 4 percent rate of increase, provide about 150 black rhinoceros for translocation in the first ten years from Hluhluwe-Umfolozi, Mkuzi, Ndumu and Itala Game Reserves (see Appendix 2).

(c) Recruitment rate. Age structure is a good performance indicator, both within and between populations (see Monitoring black rhinoceros populations). Such information can assist decision-making either by itself, as in Brooks *et al.* (1980), or in conjunction with other strategies, such as (a) and (b) above. For example, removals or increased removals might be indicated should certain threshold levels of calves or immatures not be reached over a period of years.

(vii) Habitat manipulation

The aim of habitat manipulation would mainly be to counter any adverse effects that vegetation change within a reserve might have on its ability to support black rhinoceros. Any persistent deterioration would not only threaten the survival of the rhinoceros in the reserve, but would also adversely affect the regional programme through a reduced rate of increase and fewer becoming available for translocation.

Management must be able to detect any significant declines in ecological carrying capacity for black rhinoceros and, if this is considered to threaten the achievement of the conservation goal for the species, it must be prepared to take appropriate action. This might comprise an immediate capital reduction to stimulate breeding and increase survival rates, possibly followed by habitat manipulation. The possibility of setting aside special rhinoceros reserves and managing the habitat specifically for the species could also be considered. Clear guidelines on how to improve habitat suitability for black rhinoceros are not currently available, but a study being undertaken in Zululand (Emslie 1987) should provide direction.

(viii) Monitoring black rhinoceros populations

To achieve the stated aims for the black rhinoceros, as presented in Aims (see above), information is required on the size and dynamics of each population, the causes, and extent, of mortality and long-term genetic fitness.

The details of each programme will vary according to the characteristics of the area, its rhinoceros populations and financial or manpower constraints, but certain minimum requirements need to be met, namely:

(a) An absolute estimate of population size, or a precise index of abundance, with performance indicators at least every 3 years, but preferably annually.
(b) Detailed rhinoceros-death records indicating numbers, location and causes of death.

All monitoring programmes need to be strictly controlled, and appropriate techniques applied, if they are to be effective in supplying the information required by management. Monitoring guidelines are given below along with recommended procedures developed specifically for the black rhinoceros programme.

(ix) Population estimates

The accuracy, or precision, of estimates and their frequency will determine their use to management. The requirement is for accurate estimates (or at least precise indices of abundance) that allow the sizes, or trends, of the rhinoceros populations to be assessed at intervals of 1-3 years, but preferably annually.

Various census techniques are suitable for counting black rhinoceros, their selection depending mainly on the number and density of animals present.

(a) Known animals: highly suitable for small populations (less than 100) where every individual is recognisable through ear notching (see Marking rhinoceros for individual identification) or natural characteristics, e.g. sex, age, horn, scars, sores, ear tears or damaged tails. Estimate is accurate, and allows precise management through personal history records kept on all individuals (see Personal history records).
(b) Mark-recapture: estimates based on pattern of resightings of individually-recognisable rhinoceros seen on successive surveys. Most *suitable for* small to medium-sized populations (50-150) at moderate densities. Estimate has confidence limits, with accuracy depending on sampling design.
(c) Line transect sampling (Burnham, Anderson & Laake 1980). Suitable for large populations (100 +) that are evenly distributed. Estimate is precise (potentially biased) with confidence limits, thereby giving reliable trends.

Aerial techniques, except when used in (a) or (b) above, are not sufficiently accurate or repeatable (precise) for use on black rhinoceros populations in heavily-wooded areas (Knott & Brooks 1986).

(x) Recruitment rate

A variety of limiting factors may operate to reduce the rate of population increase in growing populations and to determine the level at which ecological carrying capacity is reached. These factors do not necessarily need to be identified nor the rate of increase determined because, providing adult mortality is not abnormally high (e.g. significant poaching), the rate at which young rhinoceros are recruited into the population can provide a good measure of the population's performance. This is because population regulation normally operates through reduced breeding and increased mortality amongst calves and immatures.

The age structure of each population should be monitored annually, either by ground or aerial sampling, or through the maintenance of personal history records.

The field criteria for ageing immature black rhinoceros are described by Hitchins (1970), and are presented in pictorial form on the reverse side of the form presented in Appendix 6. These should be strictly followed when undertaking surveys. The minimum requirement is to differentiate three age classes, namely 0-1 year (size classes A and B), 1-2 y (C) and 2 y +

(D, E and fully grown); while specific studies should attempt to identify all five calf and immature classes (A — E) and fully-grown adults (F).

Information collected at either level allows not only the performance trend of a population to be followed as rhinoceros densities and habitat conditions change, but also provides comparative information between populations on which management decisions can be based.

(xi) Personal history records

Detailed records of individual rhinoceros can provide a wealth of information useful to management. The regular sighting of known individuals provides data on reproduction (age of first parturition, calving intervals, mating, lineage), movements (home range size, dispersion), territorial behaviour (indicating reproductive dominance), numbers, density (high and low density zones to guide removals and re-establishments respectively), body condition (after Keep 1971), and survival and mortality (vulnerable ages, problem regions which can give early warning of poaching, and seasonal or cyclical peaks).

For such personal history records to be effective, individual rhinoceros must be clearly identifiable to a number of observers. The best way to achieve this is to mark the animals, and the recommended method is ear-notching (see below).

Once an individual becomes recognisable, a personal history record sheet is drawn up (see Appendix 3). This records the characteristics of the animal, its origin, each resighting and a variety of behavioural observations. These records may then be entered into the Natal Parks Board mainframe computer in Pietermaritzburg, and analysed on an annual basis.

(xii) Marking rhinoceros for individual identification

(a) External characteristics

It is recommended that all rhinoceros immobilised for research purposes, treatment or translocation be individually ear-notched according to the system described below. Ear-notching of additional animals specifically for monitoring purposes is also highly desirable. The presence of marked animals not only facilitates censusing, but also allows individual records to be kept of the individual's behaviour, reproductive performance and lineage which can assist management.

The marking system utilises V notches (2,0 cm — 2,5 cm deep) and occasional "triangular" notches cut from the perimeter of the ears, and also single holes (diameter 1,0 — 1,5 cm) through one or both ears. Treating males and females separately, this system allows for the individual marking of 764 rhinoceros of each sex (1 528 rhinoceros in all) without duplication. A detailed description of the marking system is given in Appendix 4.

Numbers are allocated to each reserve with a black rhinoceros population to avoid duplication either within or between reserves as shown in Appendix 5. A previously unmarked rhinoceros being relocated to another reserve would be marked using a number allocated to the donor reserve.

(b) Cryptic labelling

Techniques are being investigated for the cryptic labelling of both black rhinoceros horns (on live animals) and the rhinoceros itself, as follows:

(aa) Chemical labelling of horn by impregnation, or metabolic deposition, to render the horns permanently identifiable (either on an individual reserve, or combined reserves, basis) to conservation authorities, but not to illegal traders lacking the required sophisticated equipment or technology. This concept, the details of which should remain confidential for obvious reasons, would involve immobilising the rhinoceros and giving the required treatment, so that should the horn subsequently enter the illegal trade and be seized, the origin of the horn could be determined. This would hold obvious benefits for securing convictions.

(bb) Electronic labelling of the body of the rhinoceros, and possibly also of the horn, using a strategically placed transponder, pre-programmed with a unique and unalterable code. This would allow one to establish the identity of a carcass even if the ears and other identifying external features had been mutilated.

(xiii) Rhinoceros mortalities

The detection, examination and disposal of rhinoceros carcasses, as well as the maintenance of meticulous records, is a critical part of the black rhinoceros conservation programme. If handled correctly, this operation will provide management with early warning of a variety of potentially serious problems, such as nutritional deficiency, disease and, in the current climate, especially poaching; mismanaged, it will provide a cover, and even provide additional opportunities, for rhinoceros poaching that will result in an increased availability of rhinoceros products on the black market.

Serious considerations should be given to the routine implantation of transmitters which are only activated on death of the individual rhinoceros. This could enhance the timeous location of carcasses and the early detection of poaching.

The programme has a number of important components:

(a) Initial inspection on discovery
  - Presence/collection of horns
  - Distinguishing natural characteristics/ear notches
  - External examination for cause of death.

(b) Post-mortem
  - Veterinary surgeon
  - Geiger counter
  - Activation of transponder.

(c) Collection or destruction of skull/carcass.

(d) Marking, measuring and weighing horns, and handling to maintain security.

(e) Marking and storage of skulls, for later ageing and taking of morphometric measurements.

(f) Completion and distribution of a standard rhinoceros mortality form (see Appendix 6), including date, location, age, sex, horn measurements and disposal, skull details, cause of death (copy of post-mortem report to be attached), names of individuals finding the carcass and completing the form.

(g) Checking of game death forms for completeness and accuracy, analysis for trend in numbers, distribution throughout reserve, and detection rates by different grades of personnel.

2. *Establishment of new populations*

The translocation of black rhinoceros from well established populations, either to create new populations or to bolster small, existing populations, is a major component of this conservation plan.

Decisions on which reserves should receive rhinoceros preferentially have to be based on a wide variety of considerations. Strategically, a large number of small populations, possibly in small reserves, provide protection against disease outbreak and localised, extreme climatic changes, and are arguably easier to police than larger areas. Conversely, large areas provide increased possibilities for natural population expansion and, in the long-term, will maintain higher levels of genetic diversity without management intervention. A balance needs to be struck between these strategic and genetic considerations, in conjunction with biological suitability, and decisions taken according to perceptions at the time.

(i) Genetic considerations

Some genetic considerations (in addition to those mentioned earlier under Maintenance of genetic diversity) of direct relevance to the re-establishment programme were identified at the Pietermaritzburg workshop, and these should be borne in mind when making decisions. These are:

- Preference should be given to the rapid achievement of the minimum founder number in any given area, rather than dispersing effort between areas.
- Priority should go to areas with the highest potential population sizes.
- There are no compelling genetic reasons for adding more founders to Kruger National Park, as the 70 re-established are adequate in numbers and diversity of origin (Hluhluwe-Umfolozi, Mkuzi and Zambezi Valley).
- The ideal situation would be at least one large population and several others over 200.
- The primary reservoir of genetic diversity should be the largest population. When filled to capacity, it should become the primary source for the repopulation of new areas.

(ii) Potential sizes of existing black rhinoceros populations

The estimated ecological carrying capacities of these reserves for black rhinoceros are presented in Table 2. These are, however, often based on fairly superficial information, and more accurate assessments are required, particularly for the smaller reserves. This is necessary if the reserves are to be effectively screened for suitability and rated for genetic potential (see Rating procedure for reserves).

Table 2
Potential sizes of existing black rhinoceros populations in the region

Subspecies	Location	
D. b. minor	Kruger National Park	3 500
	Hluhluwe-Umfolozi Game Reserve	300
	Pilanesberg National Park	120
	Eastern Shores Nature Reserve — Sodwana State Forest	100

	Mkuzi Game Reserve	70
	Itala Game Reserve	60
	Andries Vosloo Kudu Reserve	50
	Ndumu Game Reserve	40
	Weenen Nature Reserve	10
		Total: 4 250
D. b. bicornis	Etosha National Park	500
	Kaokoland/Damaraland	120
	Vaalbos National Park	40
	Augrabies Falls National Park	30
		Total: 690
D. b. michaeli	Addo Elephant National Park	30
		Total: 30

Detailed information on these populations, such as numbers, trends and population structures, as well as brief descriptions of the habitats, will be included in the conservation plan in the forseeable future.

The size of the *Diceros bicornis minor* population in the region is not currently limited by lack of available conserved habitat. The reserves holding this ecotype amount to about 2,2 million hectares, and have an estimated ecological carrying capacity of over 4 000 animals (see Table 2), or about double the target figure of 2 000. Kruger National Park could hold by far the largest population of about 3 500, followed by Hluhluwe-Umfolozi (300), and Pilanesberg (120) and the Eastern Shores-Sodwana Complex (100); the remainder all having carrying capacities of less than 100. It would, nevertheless, from a strategic viewpoint, be preferable to have the population more widely spread.

In the cases of *Diceros bicornis bicornis* and *Diceros bicornis michaeli*, there is currently insufficient space in reserves for either to achieve their minimum target figures of 2 000 and 100 respectively, although there are up to about 4 million hectares of rhinoceros habitat suitable for *Diceros bicornis bicornis* in Kaokoland/Damaraland. Additional reserves, or significant extensions to current reserves, will definitely be required.

(iii) Additional areas for re-establishment

A number of reserves have been proposed as being possibly suitable for black rhinoceros, and these will be assessed by the Rhino Management Group in due course. A standard procedure will be adopted, which may necessitate a new assessment being done for reserves evaluated in the past so as to get a good indication of relative suitability.

Some potential new areas are listed below:

D. b. minor	Pongola Nature Reserve	}
	Loskop Dam Nature Reserve	}
	Langjan Nature Reserve	} Transvaal
	Messina Nature Reserve	}

	Timbavati Private Nature Reserve	
	Hans Merensky Nature Reserve	
	Borakalalo National Park	Bophuthatswana
	Songimvelo Game Reserve	KaNgwane
D. b. bicornis	Karoo Nature Reserve Karoo National Park Richtersveld National Park (Proposed)	Cape Province
D. b. michaeli	Zuurberg National Park	Cape Province

(iv) Assessing the suitability of reserves

The success of the re-establishment programme, measured in terms of the achievement of the stated conservation goals (see Conservation aims), depends largely on the identification of those areas most suitable for rhinoceros population growth and survival.

The selection of areas will be based on a field assessment of all areas potentially suitable for black rhinoceros. This assessment will provide the information required for an initial screening of reserves and the subsequent rating of suitable reserves for their biological, genetic and security potential. This exercise will be undertaken by the Rhino Management Group, and recommendations forwarded to the appropriate conservation authorities for consideration.

(v) Initial screening of reserves

The initial sorting of reserves and areas into those potentially suitable and those unsuitable for the re-establishment of black rhinoceros is based on a set of minimum standards. If any of these standards, which are given below, are not met, then the area is disqualified from further consideration.

- The habitat must be suitable.
- Areas of less than 10 000 ha must have physical boundaries preventing dispersion.
- Poaching threat should not be severe, or if it is, effective control must be demonstrated.
- No threat of deproclamation must be apparent.
- Current or proposed land-use must be compatible with conserving the species.
- Potential rate of increase of rhinoceros population in recipient area must be greater than in donor areas.
- Potential effective founder population must be at least 10 rhinoceros.
- Number of founders must not exceed 50 percent of ecological carrying capacity.
- Current population size must not exceed 60 percent of ecological carrying capacity.
- Ecological carrying capacity must be at least 20 rhinoceros.
- If previous re-establishment was unsuccessful, causes must have been rectified.
- Re-establishment must not adversely affect another Red Data Book species with a more critical conservation status.
- Veterinary clearance must be granted.

Those reserves that meet the minimum standards are then rated for relative suitability according to the ecotype or subspecies *(D.b. minor, D.b. bicornis* or *D.b. michaeli)* allocated to them.

(vi) Rating procedure for reserves

The rating system, which identifies three major areas of concern (biological, genetic and security), provides for flexibility as the decision-making climate changes. Improved biological or genetic knowledge can be integrated and changes in the security situation can be taken into account without a complete re-assessment being necessary.

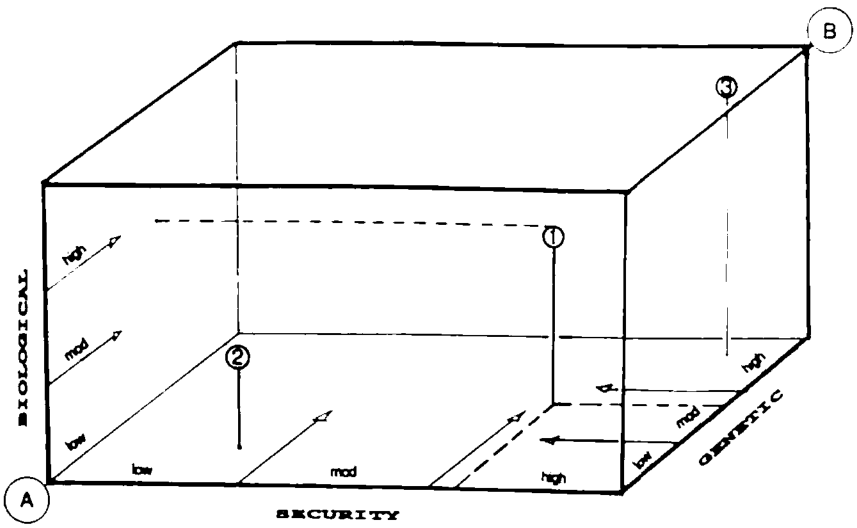


Fig. 1. Scores for biological, genetic and security concerns presented three-dimensionally for rating procedure for each reserve.

A variety of factors falling under the three areas of concern are scored for each reserve as shown below.

(a) Biological concerns

Habitat suitability: 1 — 10

This is based on a wide variety of observations, such as base level of soils, availability of palatable browse, condition and performance of browsers. Ideal habitat scores 10.

Predation threat : 1 — 3

Assuming that large predators, e.g. lions, spotted hyaenas, inflict some mortality, scoring varies from a high density of such predators (1) to there being no significant predators (3).

Disease threat: 1 — 3

This may vary from a known risk affecting the rate of increase of the re-established or resident population (1) to no known risk (3).

(b) Genetic concerns

Potential population size: 1 — 10

Long-term genetic viability increases and the need for interchange management decreases with increasing population size. Scoring:

(1) 20 — 29 rhinoceros	(6) 100 — 149
(2) 30 — 39	(7) 150 — 249
(3) 40 — 49	(8) 250 — 349
(4) 50 — 74	(9) 350 — 499
(5) 75 — 99	(10) 500+

Number of founders present: 1 — 3

The genetic risk decreases as the number of founders increases. The allocation of additional animals where founder numbers are low is therefore encouraged.

Scoring : (1) 50 + founders
(2) 20 — 49 founders
(3) 10 — 19 founders

(c) Security concerns
Poaching threat: 1 — 10
Aspects considered include distance to political (national) boundary, extent of organised crime, security status of region, previous incidents of poaching. Scores increase as the threat decreases.
Management control: 1 — 10
This is a measure of the intensity and effectiveness of law enforcement in the reserve and in surrounding areas, the effectiveness of the boundary fence (especially in smaller reserves) and the security of land tenure. Excellent control rates 10.

The scores for the biological, genetic and security concerns are then presented three-dimensionally for each reserve as shown below. The three reserves shown have the following characteristics:

Reserve	Biological suitability	Genetic viability	Security status
(1)	High	Moderate	High
(2)	Moderate	Low	Low
(3)	High	High	High

This presentation results in reserves with similar characteristics being clumped together, with the least suitable tending towards (A) and the most suitable towards (B). Also those that rate highly for any particular concern can be easily identified (Fig. 1).

3. *Captive breeding*
While accepting that *in situ* protection and conservation of black rhinoceros populations in Africa is the highest priority, it is recognised that these efforts may be unsuccessful for one or more of the four recognised ecotypes. The alternative is captive propagation.

The African Rhino Workshop (Cincinnati, October 1986) strongly recommended that viable foundation populations should be established immediately for those ecotypes not presently well represented in zoological gardens. Genetic analysis suggest that a viable captive population should be based on at least 20 founder individuals that will reproduce. Of the four ecotypes, only the East African *Diceros bicornis michaeli* is well represented in captivity.

Captive breeding can serve two purposes, namely:

(i) to produce surplus rhinoceros for the on-going exercise of re-establishment in reserves; however such a breeding programme, which could be based in Africa, can only be justified if rhinoceros husbandry is developed to the stage where the population growth rate in captivity exceeds that in natural habitats; or

(ii) to insure against the worst-case scenario, that of economic or political collapse within the region resulting in the loss of all rhinoceros; in which case the breeding programme must be based outside Africa and lower population growth rates would be acceptable. The purpose would be to maintain genetically diverse populations for re-establishment in natural habitats within Africa should conditions return to normal. The implication is that this is a very long-term programme, with no return expected in less than 10-50 years.

(a) The American Association of Zoological Parks and Aquaria Programme

Captive breeding programmes are extremely expensive, and require sophisticated management to be effective. The only organisation considered capable of supporting and co-ordinating such an exercise at present is the American Association of Zoological Parks and Aquaria (AAZPA) under the auspices of the Species Survival Programme (SSP) of the IUCN. This breeding programme falls into the strategic planning scenario (ii) above. New founder animals becoming available from the wild would be assured, through AAZPA, of placement in facilities with proven records in black rhinoceros reproduction and survival.

The two black rhinoceros ecotypes native to the region, the southern-central *Diceros bicornis minor* and south-western *Diceros bicornis bicornis*, are very poorly represented in captivity in North America and Europe, with only 4 founders from the southern-central type currently available.

(b) Availability of rhinoceros

Limited numbers of *Diceros bicornis minor* are currently available each year for relocation from Natal's reserves, and consideration needs to be given as to whether some might be made available for the AAZPA SSP programme. There also exists the possibility of supplying some *Diceros bicornis bicornis* from Namibia to form a breeding nucleus.

Rhinoceros do occasionally become available that are not suitable for translocation into the wild. These would include orphaned calves that need to be hand-reared or which are not old enough to risk introducing into occupied areas in the wild, or adults that have recovered (in captivity) from injury but which are to some extent handicapped and which would therefore be disadvantaged in the wild. Provided these animals are potentially suitable for captive breeding, they should be offered to the AAZPA SSP programme.

(c) Donations for black rhinoceros research

It is recommended that black rhinoceros should not be sold at the full market rate to captive breeding institutions, as this might (a) upset the economic viability of the breeding programme, which is anyway planned mainly for Africa's benefit, and (b) result in the highest bidder, possibly not offering the best conservation breeding programme, gaining the rhinoceros.

Instead, it is suggested that a voluntary donation be solicited to support research and monitoring programmes for black rhinoceros. It is envisaged that this could be in the region of 10-50 percent of the current export value, but that it should not in any way prejudice the selection of the breeding institution.

Acknowledgements

This plan was drawn up with the collaboration of J.L. Anderson, R.F. Collinson, R.H. Emslie, P.S. Goodman, A.J. Hall-Martin, P.M. Hitchins and E. Joubert. Their comments and enthusiastic support is much appreciated.

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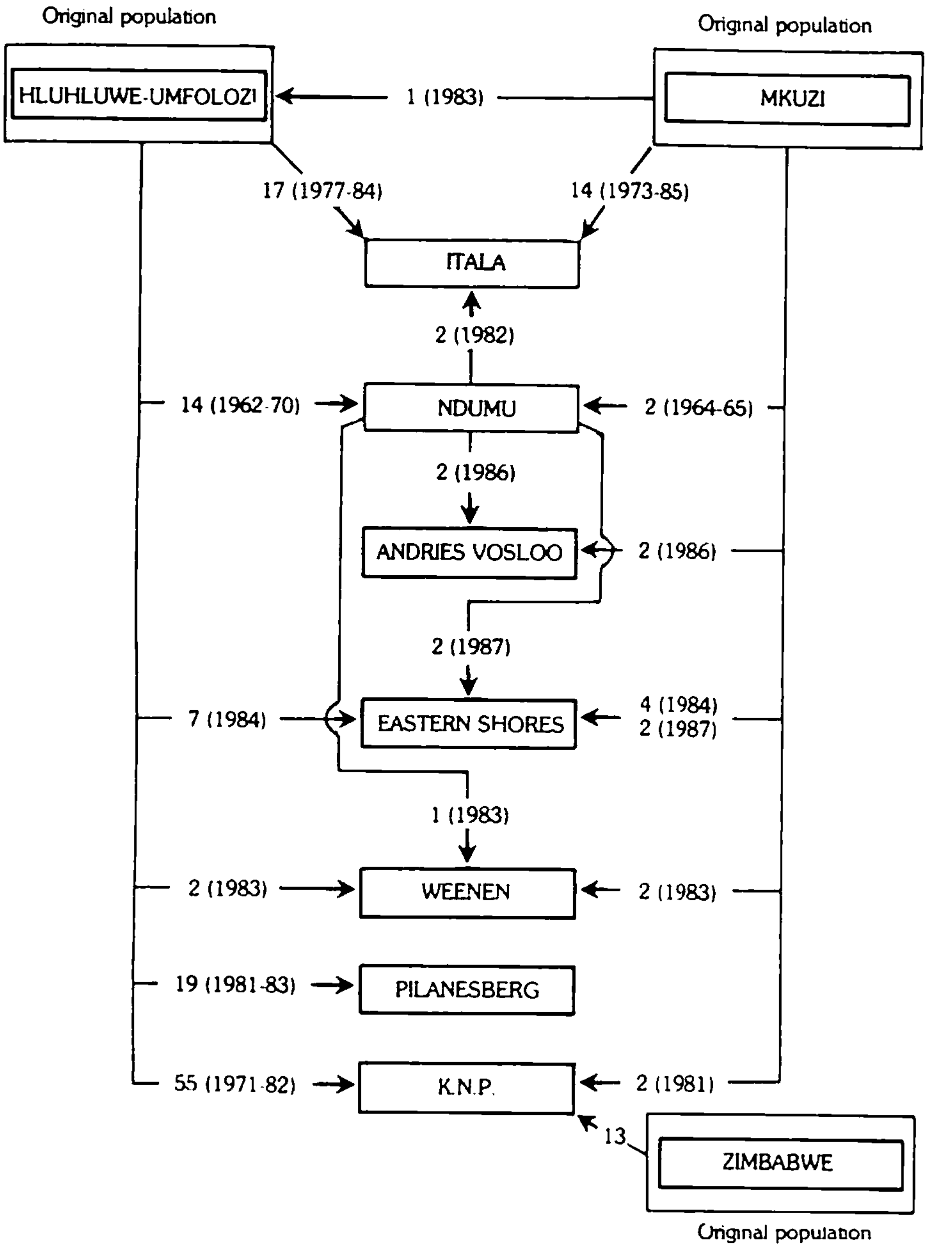
Appendix 1

Re-establishment history of *D. b. minor* in the region (September 1962 — December 1987)



Appendix 2

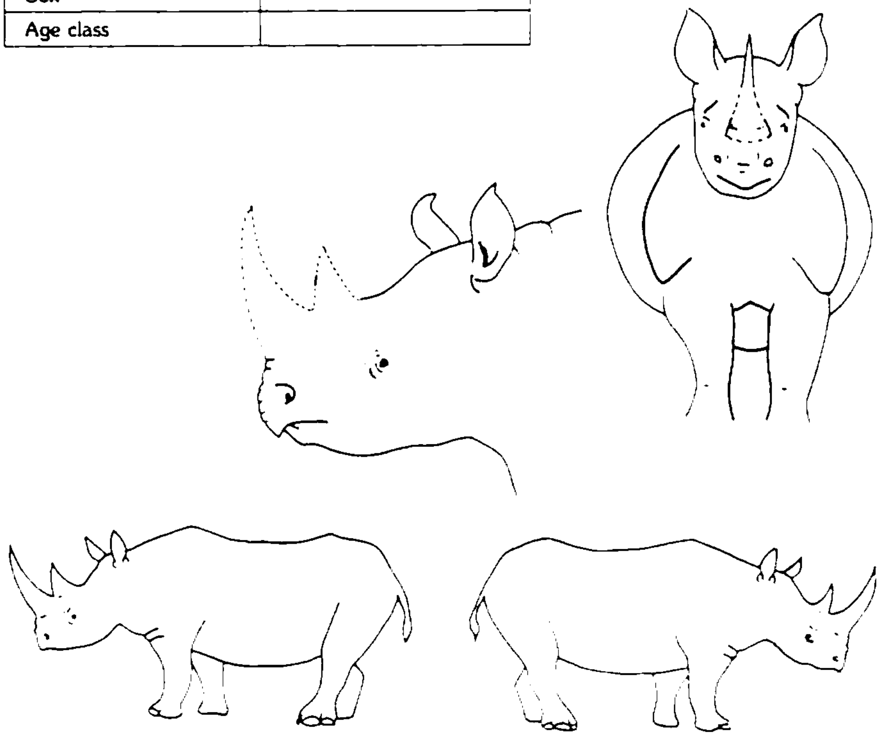
Availability of black rhinoceros for translocation over a 10 year period if populations managed at 75% of ecological carrying capacity.

Reserve	Current population size	75% ECC	Removals									
			Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr 9	Yr 10
HGR-UGR	220	225	—	13	9	9	9	9	9	9	9	9
Mkuzi	70	53	17	—	—	7	—	—	7	—	—	7
Ndumu	42	32	10	—	—	—	5	—	—	—	5	—
Itala	35	45	—	—	—	—	—	—	—	—	5	—
		TOTALS	27	13	9	16	14	9	16	9	19	16

Appendix 3

Black rhinoceros personal history record

Reserve	
Rhino code no	
Ear-notch no	
Date identified	
Sex	
Age class	



Identification	Ears			
	Horn			
	Sores/scar			
	Tail			
	Other			
Origin	Mother		Date	
	Donor reserve			
Death or Removal	Date			
	Cause/reason			
	Skull no			
	Housed			

(**Appendix 3** *Continued*)

SIGHTINGS

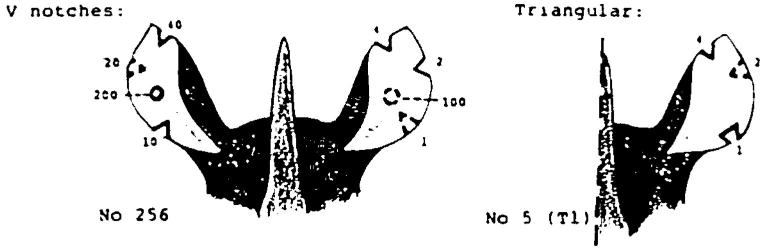
Sighting no.	Grid ref	Date	Body condition	Observations (e.g. with calf (age, sex), mating, fighting, spray urinating, immobilisation, treatment, etc.)

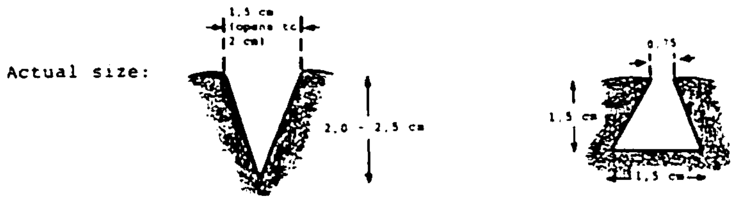
Calves	Date born	Sex	Rhino code no	Ear-notch no.	Remarks (inc. death(date), translocation, destination, etc.)

Appendix 4

Ear-notch marking system for black rhinoceros *Diceros bicornis* in the region.

The ear-notching system is based on V and inverted triangular (T) notches cut from the perimeter of the ears and holes punched through the ear pinnae as shown below.





Each black rhinoceros will receive an individual number code, derived from the number of notches or holes cut in the ears, and whether or not a triangular notch is present. The types of marking are:

(i) V notches only. This allows 63 individuals (1 — 7, 10 — 17, etc). of each sex to be marked without duplication.

(ii) One triangular notch (at positions 1, 4, 10 or 40) plus V notches. Gives 128 combinations for each sex, with numbers allocated to individual rhinoceros being post-fixed by T1, T4, T10 or T40 depending on the triangular notch used to avoid confusion with (i) above. Errors due to failure to detect the triangular shape of the notches are avoided due to similar codes, e.g. 15, 15(T1), 15(T4) and 15 (T10) being allocated to different reserves.

(iii) Holes in one or both ears, i.e. 100, 200 or 300. Used in combination with the V notch and triangular notch systems, the holes add 189 and 384 combinations respectively for each sex.

Use of the above system allows for the individual marking of 764 rhinoceros of each sex. Each reserve is allocated certain numbers as shown in Appendix 5, these having been carefully selected to avoid recording errors.

When marking animals, numbers in the table in Appendix 5 should be preferentially selected from left to right. This is because

— If marking is restricted to numbers appearing in columns 1-10 (i.e. restricted to simple V and triangular notch systems) then individuals can be identified without sexing or, in fact, distinguishing between V and triangular notches.

— When marking is extended to columns 11-16 (i.e. V notch and holes) the same conditions apply as above. However, if there is difficulty in detecting the holes (denoting hundreds), then animals must be sexed to avoid confusion with those marked earlier. For example, if No 150 (male) is read as 50, reference to the table in Appendix 5 reveals the error, as No 50 is a female.

— When marking is extended beyond column 16, the need to detect triangular notches and holes and to record sexes increases if errors are to be avoided.

Appendix 5

Allocation of ear-notch numbers to black rhinoceros *D. b. minor* in the region.
(Excludes rhinoceros marked before 1 January 1988. *combinations of ⏢ (T) notch and V notches and hole(s) not shown or allocated)

Reserve	V notches only		⏢ (T) notch plus V notches			
			T1 notch		T4 notch	
	Male	Female	Male	Female	Male	Female
Hluhluwe-Umfolozi GR	7.20-27	6.47.50-57	61.63.65.67	11.13.15.17	74.75.76.77	34.35.36.37
Mkuzi GR	44.46.47.50-57	45	21.23.25.27	31.33.35.37	14.15.16.17	—
Itala GR	30-37	—	51.53.55.57	1.3.5.7	24.25.26.27	14.15.16.17
Weenen NR	—	1	11.13.15.17	—	64.65.66.67	44.45.46.47
Eastern Shores NR	10-17	60-67	71.73.75.77	21.23.25.27	34.35.36.37	—
Ndumu GR	3	20-27	31.33.35.37	71.73.75.77	44.45.46.47	4.5.6.7
Kruger NP	60-67	—	—	51.53.55.57	4.5.6.7	74.75.76.77
Pilanesberg NP	70-77	10-17	1.3.5.7	41.43.45.47	54.55.56.57	64.65.66.67
Andries Vosloo NR	—	30-37.70-77	—	—	—	24.25.26.27
New reserves 1	—	—	—	—	—	—
2	—	—	41.43.45.47	—	—	54.55.56.57
3	—	—	—	61.63.65.67	—	—
Remainder	—	—	—	—	—	—

 ISSN 0075-6458

				V notches plus hole(s)							Number of ear-notch combinations allocated	
T10		T40		Hole 100		Hole 200		Hole 300				
[illegible]ale	Female	Male	Female	Male	Female	Male	Female	Male	Female	*	Male	Female
—	—	—	—	150-157	120-127	210-217	260-267	330-337	370-377		41	42
—	70-77	60-67	—	130-137	150-157	270-277	220-227	—	310-317		43	37
—	—	70-77	60-67	101-107	140-147	260-267	230-237	310-317	320-327		47	40
—	—	50-57	70-77	No more allocated							16	13
	—	—	50-57	160-167	130-137	220-227	201-207	—	—		32	35
[illegible]	50-57	—	—	120-127	110-117	—	240-247	No more allocated			25	40
[illegible]	10-17	—	40-47	140-147	101-107	250-257	—	320-327	330-337		44	39
	30-37	—	—	110-117	170-177	230-237	250-257	No more allocated			32	40
[illegible]	—	40-47	—	—	160-167	201-207	—	—	—		23	28
	70-77	—	—	—	—	—	—	340-347	350-357		16	8
	—	—	—	170-177	—	—	210-217	301-307	—		19	12
	—	—	—	—	—	240-247	270-277	350-357	301-307		16	19
	—	—	—	—	—	—	—	360-367	340-347		16	16
								370-377	360-367			
										TOTAL	370	369

Appendix 6

Black rhinoceros mortality record

Reserve ____________________

Month: ____________________ Year: ____________

Code Numbers		Date	Location		Age Class (A-F)	Sex (M,F)
Rhino death	"Known" death		Area	Grid ref		

Horns

Present	Collected	Marked	Measurements (nearest mm or g)						Disposal	
			Front			Rear			Destination	Date
			Length	Circum	Mass	Length	Circum	Mass		

Skull

Collected	Destroyed	Marked	Aged	Measurements				

Post-mortem

Undertaken	Vet's Name	Report Attached	Cause of death		If predation, then	
			Code		Predator	
			Details		Evidence (A-E)	
					Details	

Individual reporting death ____________________

Officer completing form ____________________

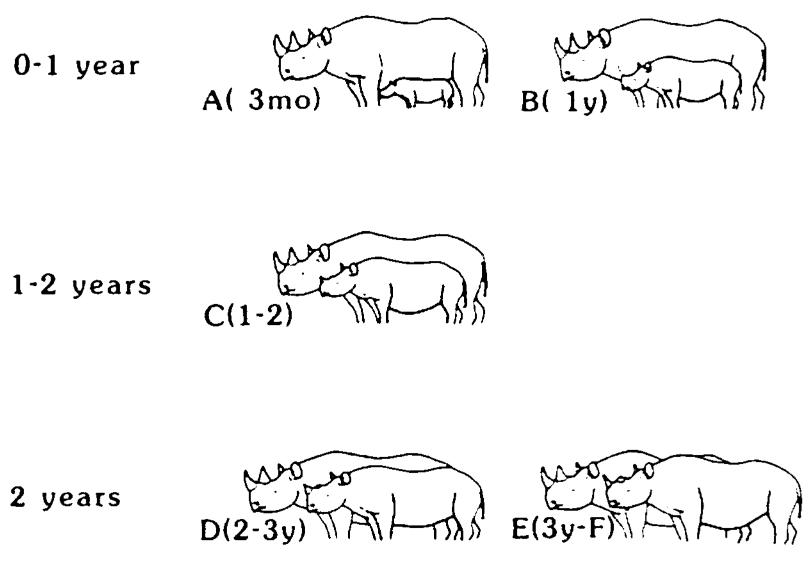
(Appendix 6 *Continued***)**

All horns and skulls to be marked immediately with the game death code number, initially using permanent marker pen and later permanent labels

Age classes

Size Class Description	A	B	C	D	E
Size in relation to adult	Level with inguinal region of adult female	Top of shoulder level with ventral part of vulva	Shoulder level with base of tail	Shoulder height at a level between base of tail and sacral region	Slightly smaller than adult
Skin lesions	Absent	Absent	Start appearing on chest. Absent on sides.	Present on chest. Absent on sides.	Present on chest, start developing on sides, but generally not in the usual position of behind the shoulder
Horns	Absent	Anterior horn small and 'knob' like (approx. 3 inches in length). Posterior horn not noticeable	Anterior horn approx. 6 inches in length Posterior horn noticebale	Anterior horn approx. 6-12 inches in length. Posterior horn approx. 2-4 inches.	Anterior horn approx. 10-12 inches in length. Posterior horn approx. 2-4 inches

Black rhino age classes



(Appendix 6 *Continued*)

Horn measurement:

These are taken in accordance with Rowland Ward and Safari Club International specifications.

Length:	Measure length of the horns on the front surface along the curve from the lowest point in front to the tip.
Circumference:	Measure along the edge of the base as close to the head as possible. This does not have to be at right angles to the axis of the horn.

Cause of death codes:	P — poacher	B — capture
	C — carnivore	D — destroyed
	F — fighting injury	U — unknown
	I — other injury	
Evidence of predation:	A — observed killing	D — spoor at carcass
	B — heard killing	E — signs of struggle
	C — seen at carcass	

Monitor

The Black Rhino Conservation Potential in Tanzania

During the first quarter of this year I visited those National Parks in Tanzania which have been ear-marked for the establishment of black rhino sanctuaries. The purpose of the visit was to carry out preliminary surveys on the rhino status, gather baseline information on the areas and rank them according to habitat suitability. The potential sanctuaries in Tanzania are the Arusha, Lake Manyara, Tarangire and Rubondo Island National Parks; and the Ngorongoro Crater. The latter, although not a National Park, is the only place in Tanzania where one can easily see a rhino.

Using the criteria adopted during the IUCN African Elephant and Rhino Specialist Group (AERSG) meeting of September 1989 held in Nairobi, the potential rhino sanctuaries were ranked according to their habitat suitability. The results were:-

National Park	Proposed sanctuary	Rank	Present rhino no
Arusha:	Ngurdoto Crater	1	0
Lake Manyara:	whole area	2	0
Tarangire:	Sirale area	3	5*
Rubondo Island:	whole area	4	6*

*Number unreliable.

The Ngurdoto Crater in Arusha National Park ranked highest due to its natural barrier/security, small size, former high rhino density and diversity of rhino browse plants. This Crater should be used as a breeding ground for rhinos. Lake Manyara National Park can be considered as an ideal area for re-introduction once rhinos are available. A small area in the Sirale region of Tarangire Park can be developed into a sanctuary like Ngulia Rhino Sanctuary in Tsavo West National Park in Kenya.

Rubondo Island National Park was ruled out as a potential rhino sanctuary because:-

a. The Park never had rhinos prior to 1965.

b. To date, the rhinos introduced in 1965 have not successfully bred and the causes for this failure have not been established.

c. There is lack of security due to the closeness of the Park to inhabited areas and easy access for poachers from all sides by boat.

d. The vegetation type and terrain makes proper monitoring of the introduced rhinos impossible and maintenance of security very difficult.

Ten rhinos were observed on the floor of the Ngorongoro Crater. However, the total population for the whole of the Ngorongoro Conservation Area is estimated as being 10 to 30. No rhinos were sighted during the visits to potential sanctuaries although on Rubondo Island rhino dung piles and foot prints were seen. The Warden of Tarangire National Park said that five rhinos were sighted in Sirale region late last year. The ear-marked Parks have no rhinos which can be used for re-introduction and the Tanzania Government will have to acquire animals to establish a breeding stock from wherever they can.

Fred Waweru

An employee of a traditional medicine shop in Johannesburg holds up two rhino horns: Zulu men sometimes put rhino horn ash on their eyebrows to allure women. *Copyright Esmond Bradley Martin*

Further Notes on Pygmy and Forest Elephants

I would like to add some short notes that may be of interest complementary to the article by David Western, "The Pygmy Elephant: A Myth and a Mystery", *Pachyderm*, No 7, December 1986.

The elephant population of Garamba National Park appears to be an inter-grade between the savanna (*Loxodonta africana africana*) and the forest (*L. a. cyclotis*) types. Some groups show the predominately forest type characteristics of small size, small round ears and narrow straight tusks, while others are of the savanna type, larger, with thicker curved tusks, bigger ears and different body shape. The *cyclotis* type predominates although the Park is mainly long grass, open savanna in the guinea savanna belt, and the surrounding woodland is not forest but small mixed deciduous trees dominated by *Combretum* species.

Since 1927 the Elephant Domestication Centre of the previous Belgian Congo has been based here and the Belgians recognized the two types of elephants as separate sub-species: *L. a. cyclotis* and *L. a. oxyotis*. The *cyclotis* type was reputed to be much more tractable and favoured for domestication.

Offerman (1951) also talks of the small form of elephant which the Azande people called 'Abele' meaning 'those of the forest'. During extensive capture operations, Offerman observed that the small type was almost always found in dense stands of *Raphia* or swamp of difficult access. They captured a small male at Ango in 1925. He was then 1.30 m in height with tusks 0.65 m long. Thirteen years later, when estimated to be 25 years old, he was still only 1.60 metres tall with tusks of 1 m length. Normal *cyclotis* males of this age averaged 2.35 metres in height. A female captured in 1912 had also remained much smaller than her peers throughout life. The small type of 'pygmy' elephant may therefore not be exclusively juveniles of

Afr. J. Ecol. 1988, Volume 26, pages 181–187

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

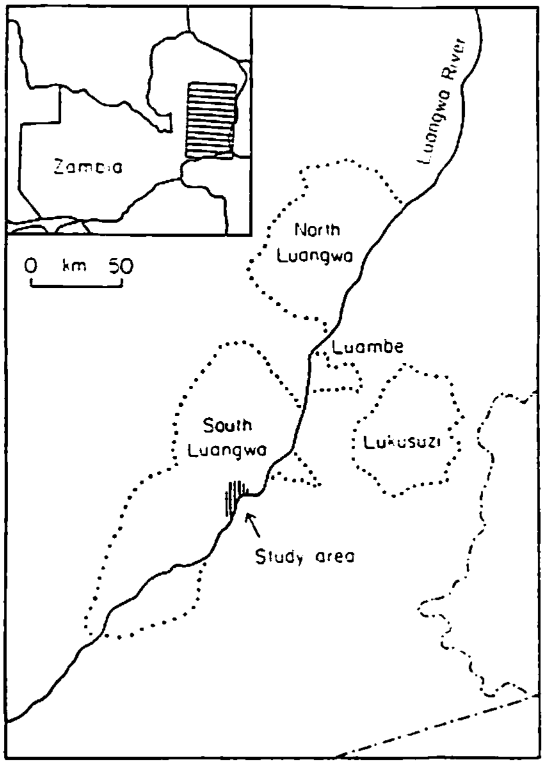

Fig. 1. Map of Luangwa Valley, showing the location of the national parks and of the study area near Mfuwe.

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

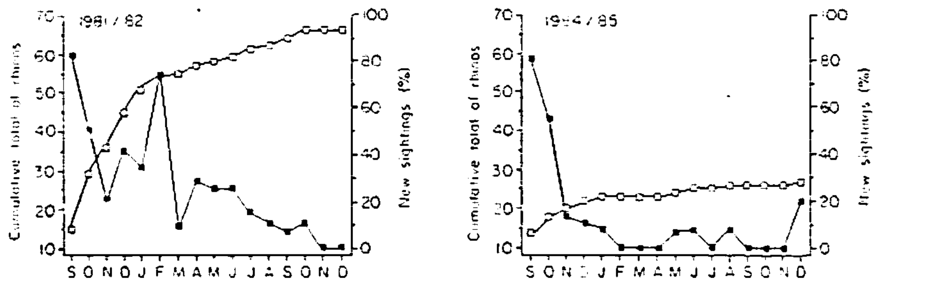

Fig. 2. Cumulative total of new rhinos (open squares) and percentage of new rhinos amongst total resightings (solid squares) observed in the Mfuwe study area during 1981/82 and 1984/85 (data for 1981/82 from Leader-Williams, 1985).

(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

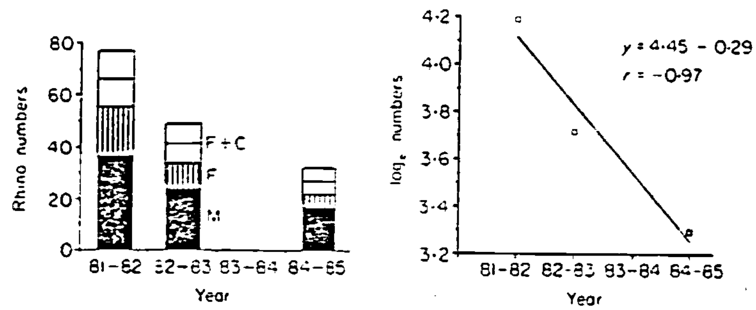

Fig. 3. Total numbers and sex- and age-class (M = subadult and adult males; F = unaccompanied subadult and adult females; F + C = accompanied females and calves) of rhinos living in the Mfuwe study area between 1981 and 1985 and the instantaneous rate of decrease of the study population calculated from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

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

Locality	Intact (N)	Axed	
		(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. $= 4$, $P > 0{\cdot}10$

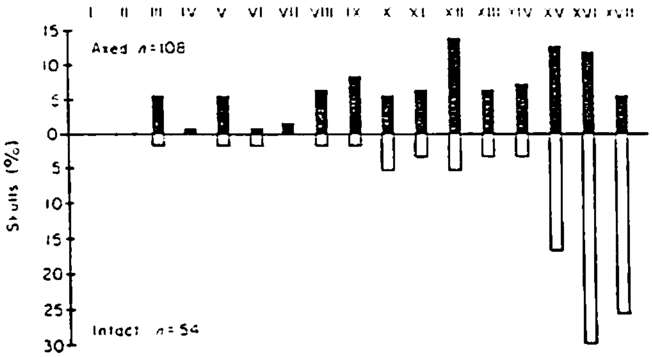

Fig. 4. Age classes (after Hitchins, 1978) of axed and intact rhino skulls collected throughout Luangwa Valley during 1979 to 1985.

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 $0{\cdot}29\ \mathrm{yr}^{-1}$ far exceeds the recruitment rate of $0{\cdot}07$–$0{\cdot}11\ \mathrm{yr}^{-1}$ 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).

Acknowledgments

Fieldwork was undertaken with permission from National Parks and Wildlife Services of Zambia with the support of G. B. Kaweche and G. Mubanga. Financial support was provided largely by the People's Trust for Endangered Species, with additional grants from the Fauna and Flora Preservation Society and the New York Zoological Society. Sponsorship of project logistics and costs in Zambia was organized by Rover Zambia, Dunlop Zambia and Zambia Oxygen through Save the Rhino Trust. P. S. M. Berry, C. L. P. Mwale and M. J. Faddy kindly arranged for the scouts of Save the Rhino Trust to collect skulls whilst on anti-poaching patrols. Wildlife Scouts C. R. Phiri, J. Tembo, B. Nkata and F. Chansa of NPWS provided assistance and companionship in the field. Drs S. D. Albon, T. H. Clutton-Brock and W. A. Laurie made helpful comments on the manuscript.

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(*Manuscript accepted 13 November 1987*)

Luangwa rhinos: "Big is best, small is feasible"

N. Leader-Williams

The conservation of large and therefore genetically viable populations of black rhinos within large protected areas poses a problem that has been discussed previously in *Pachyderm*: "big is best, small is feasible" (Western 1984). Tsavo's population of black rhinos and elephants was depleted during the 1970s and by the early 1980s only small numbers of rhinos remained in Kenya. At that time international attention became focused on the plight of both black rhinos and elephants and very high conservation priorities were given to Selous and Luangwa because these areas contained Africa's largest populations of each species (Cumming and Jackson 1984). No reader of *Pachyderm* needs to be told that the conservation effort has like Humpty Dumpty 'had a great fall' and it is now a matter of trying to better the performance of 'all the king's horses and all the king's men' and put back together a realistic policy (Western 1984). Probably less than a hundred scattered rhinos currently survive in either Selous or Luangwa, where in the early 1980s there were a few thousand.

The seriousness of the situation in the Selous took some while to be appreciated because no full-time researcher was based there in the 1980s (Western and Vigne 1984 with Douglas-Hamilton 1984). However, I for one had the sorry task of witnessing the decline of Luangwa's rhinos and elephants during 1980-85. Over that period data were collected from both an intensive study site and over more extensive areas using law enforcement patrols (Bell 1986), both to make recommendations for improved conservation in Luangwa and to document any lessons that could be learnt for future conservation initiatives.

Big is Rarely Big Enough

When I arrived in Zambia there was a mood of optimism in conservation circles. 'Save the Rhino Trust' (SRT) had recently been established with what was then WWF's largest ever single grant of US$ 0.5 million over three years and believed it was succeeding in its aims because patrols were capturing large numbers of offenders (Anon. 1980-85). This represented a great improvement on the 1970s when the National Park and Wildlife Service had lacked the resources to undertake any patrolling. But was it enough? To answer this question it was obviously necessary to monitor trends in rhino and elephant numbers rather than to count captured offenders and by 1982 it had become clear that SRT was not succeeding (Leader-Williams 1985). Individually recognized rhinos were being killed in the study area, around 70% skulls found throughout Luangwa valley were axed and scouts were seeing fewer rhinos on their patrols (Leader-Williams 1988; Leader-Williams and Albon 1988).

On the one hand SRT had received a very large grant and needed to appear worthy of support if it was to raise further funds after WWF's grant ran out in December 1982. On the other, the funds allocated to SRT had only permitted it to field an anti-poaching unit of 22 men in Luangwa, too few to cover the 16,660 sq km of national parks let alone the 34,910 sq km of game management areas. As a solution to the problem I recommended in early 1983 that SRT should retrench to cover the areas of a few hundred sq km where rhinos still survived in higher densities (Leader-Williams 1985), utilizing the rule-of-thumb that scouts need to be at an effective density of one man per 50 to 20 sq km (Cumming, Martin and Taylor 1984; Bell and Clarke 1986). In the event SRT responded with only a partial reorganisation. This was effected initially by some redeployment and assigning one or two permanent patrols to one small area, and latterly by an increase in manpower following NORAD's funding of SRT in 1984.

By 1985 it was clear these changes had been fruitless. Rhinos had declined at rates varying from 99% to 24% per year since 1979, the lower rates being for the more heavily patrolled smaller areas where rhinos were still sighted relatively regularly; elephants too had recognized such areas of comparative safety by moving into them. However the point was that rhinos and elephants still continued to be shot in all areas, the effort was spread too thinly to prevent the decrease of rhinos in any sector. In a formal analysis of the data from Luangwa, it was shown that rates of change in rhino and elephant sightings by patrols were directly related to patrol effort, corrected for size of area and initial sighting rate (Leader-Williams and Albon 1988). Extrapolation of the relationship to a 0% change in rhino numbers does indeed suggest that SRT should have concentrated all its available manpower in one small area of 400 sq km. We return, therefore, to the fact that the quandary that "big is best,but small is feasible" was not faced squarely in the 1980s.

Why Big was Really Small

One apparent anomaly remains to be explained, that of the apparently large grant awarded to Zambia by WWF in the expectation that SRT would be effective at curtailing illegal exploitation of rhinos and elephants over the large area of the Luangwa valley. Zambia is amongst that group of countries which spends relatively little (in Zambia's case US$ 11 per sq km per year in 1980) on their conservation areas. However it appeared that no one set the size of the WWF grant against another rule of thumb current in the early 1980s, namely that around US$ 200 per sq km needed to be spent annually to maintain the integrity of conservation areas (Cumming, Martin and Taylor 1984; Bell and Clarke 1986). This was later confirmed by the direct relationship which resulted from comparing the spending on their conservation areas by different countries and their success at protecting rhinos and elephants (Leader-Williams and Albon 1988). Thus the supposedly large WWF grant to Zambia was really only sufficient to protect around 700 sq km over three years, a conclusion not too different from that reached by considering the distribution of patrol effort within Luangwa. The grant was large in only one context, comparison with other grants made, or perhaps affordable, by conservation organisations. In the more pertinent context, that of what it realistically could have been expected to achieve, the grant was in fact small.

What is a Realistic Value

The annual sum of US$ 200 per sq km that it was necessary to spend in 1980 to maintain the integrity of conservation areas and talk of grants of US$ 0.5 million being small may make subscribers to conservation despair at its apparent high costs. However, it is important to be aware that in situ conservation is much more economical than ex situ conservation. At the normal density of 0.4 rhinos per sq km, effective protection of each animal would have cost US$ 500 per year in 1980 if all conservation costs were charged to rhinos as the main indicator species. Moreover, 1 sq km of Africa normally contains a lot more than 0.4 rhinos, in the case of Luangwa around 2.2 elephants, a few hundred impala, many thousands of trees and much else besides. Even if the sum for effective protection of African conservation areas has risen to US$ 400 per sq km today, it is still safe to say that in situ conservation represents excellent value for money. This can be amply demonstrated by comparing in situ costs with London Zoo's animal adoption scheme which is based on what it costs to look after and feed one animal for a year (Anon. 1988). Adoption of a rhino costs £2,000 and of an elephant £ 6,000. Thus the pachyderm equivalent of 1 sq km of Africa kept in a zoo can be estimated conservatively to cost £ 14,000 (0.4 x 2,000 + 2.2 x 6,000) or US$ 22,000.

A Little can do a Lot

The lessons here for those who fund conservation are fairly obvious. Adequate resources must be invested to achieve given objectives in conservation. Funds invested or utilized at "dilute" levels merely delay the inevitable and are ultimately wasted. Hence, the relatively small sums that international conservation agencies and NGO's have available to spend on valuable species in developing countries are most likely to achieve results in one of two contrasting situations. First, in low-spending countries only if they are concentrated at appropriate levels over small areas, in the case of rhinos within formal fenced sanctuaries or high-priority core areas. Second, over large areas only if funds are allocated to a relatively high-spending country like Zimbabwe which now needs extra resources to prevent Zambians killing rhinos in the Zambezi valley.

Can the concept "big is best and feasible" ever become a reality for large conservation areas in low-spending countries? Clearly not without more funds than can be invested by conservation organisations or, more importantly, without rectification of the socio-economic problems attendant upon people living within or around conservation areas (e.g. Marks 1984; Dalal-Clayton and Lewis 1984; Bell 1987). Sorting out the latter, and maintaining and/or rebuilding large populations of valuable species, most probably requires the funding of conservation and rural development projects by international aid organisations. The Luangwa Integrated Resources Development Project, funded by NORAD, is now under way and it can only be hoped that appropriately directed schemes which allow local residents to participate in plans for their conservation areas, coupled with enhanced investment in infrastructure and policing, will permit the recovery of elephants and rhinos to the point where they can contribute more directly to the rural economy of the Luangwa valley. After witnessing this particular Humpty Dumpty falling off the wall, I do hope that he can be put back together again.

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How Much Rhino Horn has come onto International Markets since 1970?

Esmond Bradley Martin and T.C.I. Ryan

To deal with the international trade in rhinoceros horn it is essential that all major markets are known. If the number of rhinos dying during a certain period is estimated and the equivalent horn weight compared with total identified sales over the same time, then some indication of whether a so-far unidentified market exists should be evident. Undoubtedly there is a large difference between the weight of horn from dead rhinos and that vended, and this apparent discrepancy has led Western to postulate that some large market remains undiscovered. We argue against this and show that supply and demand agree within reasonable limits of error.

Asian rhinos supply a small but very valuable part of the total weight of rhino horn. The amount of Javan rhino horn put onto the market since 1970 has been negligible because so few have died. In 1969 the Schenkels, who were working in the Ujong Kulon Reserve in Western Java where probably the only viable Javan rhino population exists, estimated that there were 25 animals.[1] This population expanded to just under 60 by 1979 but declined to 54 in 1984,[2] largely due to disease which killed at least five animals in 1981 and 1982, and it has remained at about 55 since then. From 1967 to 1986 there was very little poaching of Javan rhinos,[3] but some died from natural causes. Perhaps no more than three horns on average (Javan rhinos have only one horn) could have been supplied to middlemen each year, so probably less than two kg of Javan horn have been sold annually.

It is not known how many Sumatran rhinos existed in 1970; conservationists were grossly underestimating their numbers long before then. In 1958 Bernhard Grzimek wrote that the world population of this species was no more than ten.[4] In 1968 Werner T. Schaurte, in an IUCN publication, estimated between 150 and 170;[5] and a year later Rudolf Schenkel, then Chairman of the IUCN Asian Rhino Specialist Group, and E.M. Lang estimated that there were between 50 and 100 Sumatran rhinos left.[6] The most recent range, supplied by Nico van Strien, is the most realistic: between 539 and 991.[7] This conforms to what wildlife traders believe, and also it makes sense when we consider what is known about the supply of Sumatran rhino horn, hide, nails and other products found on markets since 1970. This species has been under dire threat from poachers and has also lost much of its natural habitat; during the past ten years we have found a reasonably large quantity of Sumatran horn for sale in the traditional medicine shops of eastern Asia. It seems likely that there must have been a minimum of 2,000 Sumatran rhinos in 1970. Bearing in mind the annual recruitment rate, this population could have sustained 3,000 deaths during the 18-year-period to date. Since the mature Sumatran rhino carries horns totalling about 269 gm in weight,[8] the carcasses could have yielded at most an average 45 kg of horn per year. But of the 3,000 a number would have died from natural causes in the depths of the tropical rain forest which is their home; the horn on these animals would be lost. Thus a figure of 25 kg annually would be a more probable figure for the amount of horn coming to the trade.

For Indian rhinos the statistics are fairly accurate because censuses have been carried out over the past quarter-century in both India and Nepal by wildlife departments' personnel[9] and independent scientists such as G. Caughley,[10] A. Laurie,[11] J. Spillett[12] and E. Dinerstein.[13]. Also there is information available on Indian rhino horn entering the market as some has been sold officially, unlike the case of Sumatran rhino horn.

From 1969/1970 to 1978/1979 the Assam Forest Department sold 210.39 kg of Indian rhino horn.[14] Some 39.50 kg offered for tender in 1979/1980 were not sold due to criticism against marketing a product from an endangered species and since then no rhino horn has been sold officially by any Indian authority. All horn collected from dead rhinos is being stockpiled. In addition to that sold officially poached horn was, and still is, available to traders. Twenty-seven Indian rhinos were illicitly killed between 1970 and 1978 in Kaziranga National Park, Assam,[15] where 75% of Indian rhinos live. From 1979, figures for the whole of Assam, which contains 95% of the total Indian rhino population (1,295 in 1986), show that a minimum of 400 animals were poached in the nine years up to December, 1987.[16]

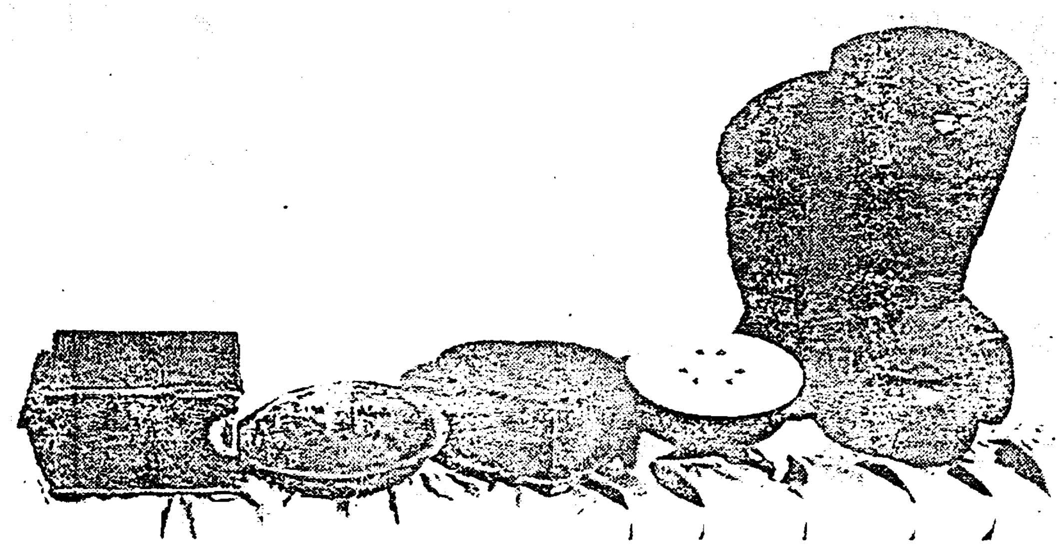
Given an average weight of 722 gm per horn[17], the poached animals yielded some 310 kg of horn which together with official sales make a minimum total of some 520 kg put onto the market from Assam between 1970 and 1987. Furthermore, during this period some rhinos were poached in the state of West Bengal[18] and Nepal's Royal Chitwan National Park; these supplied perhaps another 40 kg to traders. Horn recovered from rhinos found dead of natural causes in Chitwan after 1975 has not been sold nor put onto the international market.[19] It would, therefore, seem that the total amount of horn from the greater one-horned rhinoceros over the past 18 years is at least 560 kg, an average of 31 kg per year.

Table
Estimates of Asian Rhino Horn coming onto the Market

Species	Average kg per year	@	Av. horn wt. per animal (gm)	=	Approximate no. of rhinos
Javan	2		676		3
Sumatran	25		269		93
Indian	31		722		43
	—				
Total	58 kg				

(NB: When compared with the more than 50 times as much African rhino horn on the market this total weight is very small but its value is astounding. At some US$ 10,000 a kg the wholesale value per annum is US$ 580,000 whereas 3,000 kg of African horn would fetch US$ 2,000,000.)

While African rhinos have provided the market with over 50 times as much weight of rhino horn as have the Asian animals quantifying the amount exported to Asia, using sources within Africa, has proved to be impossible because of the lack of reliable data. Most African countries have no statistics at all and of those that have published annual customs reports on rhino horn exports, such as Kenya and Tanzania, the amounts shown are roughly only half of what actually went out.[20] Of the 19 African countries still possessing wild rhino populations none now has legal trade in rhino products and practically all horns that leave the continent are smuggled: it is also now illegal for most Asian consumer countries to import rhino products. Even in the early and mid-1970s, when trade in rhino horn was mostly legitimate, some major user countries, such as China and Hong Kong, kept no records of imports while the official statistics from Taiwan, Japan and South Korea were inaccurate as import levies encouraged both smuggling and the falsification of invoices.[21] In North Yemen, which was the single largest rhino horn importing country from 1972 until the early 1980s, the official statistics for the 1970s are erratic and for the 1980s non-existent.



All the objects here were made from various parts of a greater one-horned rhino for General Kiran Shumsher Rana whose father was a prime minister in Nepal.

Once trade becomes illegal, dealers are naturally reluctant to disclose the amount of horn they are bringing into their countries. Nevertheless, it is possible to develop a rapport with certain traders who will then discuss their business practices and, with the advantage of having started research on the international trade in rhino products before many restrictions were imposed, Esmond Bradley Martin has been able to discover much about supply and demand. In some instances, on condition of anonymity, major traders have divulged certain facts which over the years we have been able to cross-check and confirm. These and other information confirms that the estimate EBM published for the average annual amount of rhino horn which left Africa between 1970 and 1979, a minimum of eight tonnes, is still valid. From 1980 to 1987, EBM has estimated that exports of horn fell to three tonnes a year.[22] The essence of our argument is that these estimates are consistent with the death rates of rhinos over the years: that the error between the possible supply of horn and the known use or demand is negligible in terms of the uncertainty in the parameters used.

Let us look first at the estimates for black and white rhino populations. David Western and EBM calculated that there were 65,000 black rhinos in 1970, using data from John Goddard for East Africa, counts for southern Africa and by applying studies of rhino population densities to central and west Africa. This figure has been generally accepted as a reasonable approximation. From the combined efforts of over 30 scientists, including Kes Hillman, David Cumming, Anthony Hall-Martin and Martin Brooks, all members of the IUCN African Elephant and Rhino Specialist Group, David Western and Lucy Vigne obtained estimates for 1980 of 14,785[23] and 8,800 for 1984[24]. In 1987, the Nyeri meeting of the IUCN African Elephant and Rhino Specialist Group determined a figure of 3,832.[25] However, as anyone who has attempted to conduct a rhino count will readily agree, it is extremely difficult to locate these animals in the thick bush where they live and most estimates, including those above, are likely to be below the true figure.[26]

For white rhinos it is assumed that there were about 3,900 (2,000 northern and 1,900 southern) in 1970, 3,840 in 1980,[27] 3,948 in 1984[28] and 4,600 (50 northern and 4,550 southern) in 1987.[29] In determining the number of white rhino deaths and hence the amount of horn, it would be illogical to apply a common recruitment rate to both the northern and southern populations. The northern population has been severely reduced by poaching from some 2,000 animals in 1970[30] to less than 50 today and will have only a small recruitment rate. Conversely, with the exception of those animals in Mozambique[31] where some have been poached, the southern population is youthful and will have a low natural death rate and high recruitment rate. Using a 3% mortality rate for the southern group[32] and a small recruitment rate for the northern then perhaps 4,350 white rhinos have died since 1970. If 80% of these were adults carrying an average of four kg of horn apiece[33] and assuming half of the horn was not found, then some 7,000 kg of white rhino horn came onto the market from 1970 to 1987.

It is worthy of note that although the figures as to the status of the white rhino appear very encouraging we should remember that in 1970 there were about 2,000 spread among Zaire, the Central African Republic, Sudan and Uganda and that practically all these are now dead. It is the strides in conservation management made by South Africa that have made the numbers look comparatively healthy: the population in South Africa has more than doubled in the past 18 years.

Black rhinos have been the source of the greatest weight of horn reaching the market. Our arguments on this source of horn are therefore somewhat more detailed.

During the mid-1960s the first reasonably accurate census of rhinos in Tsavo East Park, based on stratified random samples, was made by John Goddard.[34] He stated that the population was stable, estimated the number of rhinos in Tsavo East to be 4,200±25%, and calculated that the annual recruitment rate was 10.9%. Goddard's finding of a 10.9% recruitment rate on a stable population implies a death rate also of 10.9%.[35] The observed population was not under particular duress, so we may conclude that 10.9% is the natural death rate.

Western argues that when a population comes under heavy poaching pressure the recruitment rate is between 7% and 10.9%[36] and Rob Brett considers that a 7% recuitment rate is more likely than 10.9%.[37] The lower figure would seem more plausible for a variety of reasons, ranging from the wider dispersion of individuals to the increased killing of fertile females.

It is possible to calculate the death rate which would reduce the number of animals estimated for 1970 to the estimate for 1980, and similarly for the periods 1980 to 1984 and 1984 to 1987, taking into account the annual increment for recruitment. If the initial population is P_S, the final population P_F, the death rate d%, the recuitment rate b% and the period of years is n then $P_F = P_S.R^{nb}.R^{nd}$ where $R^d = 1 + d/100$ and $R^b = 1 + b/100$.

The figures given in the Appendix were obtained by adding the births to each year-start number and then subtracting the deaths. Then summing the deaths each year gives the approximate number of dead rhinos since 1970.[38] (If deaths are subtracted from the year-start figure before births are added then the total number of rhinos dying over the period would reduce by more than 15%. We will take the higher figure in conformity with our policy of maximizing supply and minimizing demand estimates.)

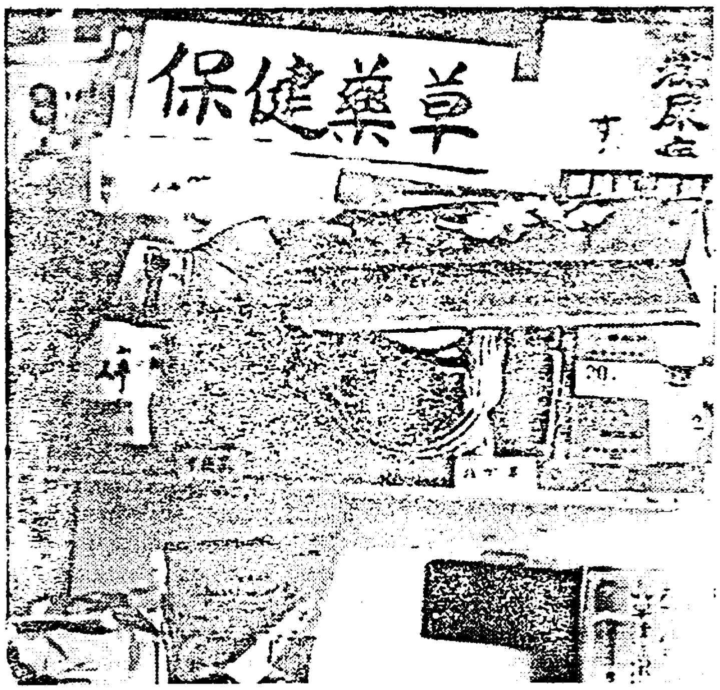
The calculations yield a total of some 93,800 dead rhinos at the 7.5% recruitment rate. Of these, 20% would be juveniles carrying little or no horn, and the remaining 75,100 would have horns weighing on average 2.88 kg.[39] The maximum amount of black rhino horn which could have been produced would thus be some 216,100 kg.

A lot of this horn never would have reached the international market. It is made of keratin fibres which rapidly deteriorate under wet conditions and also is destroyed quickly by insects. In areas of high rainfall such as Zambia, the Central African Republic, southern Tanzania and parts of Kenya, it is unlikely that rhino horn on a carcass would last more than a few weeks during the rainy season. Thus a considerable quantity of horn from rhinos dying of natural causes would never be recovered. Partially damaged horn is difficult to sell and only in South Korea is there a demand for that which has been riddled by insects. During the 1970s the main market for African rhino horn was North Yemen; it was the easiest and closest market to supply, but buyers there would accept only good quality horn; they could not use damaged horn to carve dagger handles. Consequently, even when poor quality horn was found, it would not usually be collected. Moreover, few people lived in the places where large numbers of rhinos existed in the 1970s, such as the vast wildlife sanctuaries of Luangwa Valley, Zambezi Valley and the Selous, and so chance discovery of horn was uncommon.

A recovery rate is the percentage of a total product that is found by chance and/or search. Regrettably, no investigation has been made of such rates for rhino horn in Africa. However, Ian Parker in his major report, "The Ivory Trade", reviewed the recovery rates for elephant ivory over the period 1950 to 1978.[40] The tusks picked up by the authorities in various parks included those from wounded animals which escaped illicit hunters as well as those from animals dying naturally. According to Parker, official recovery rates for ivory varied from 84% of the mortality in a small, well-patrolled park such as Manyara to 8% in Tsavo which is vast and under-staffed. Given the predisposition of rhinos to live in thick vegetation which reduces the visibility of both live and dead animals, and the fact that their horns perish quicker than ivory, it is doubtful that the recovery rate for rhino horn could ever be as high as that for ivory. According to Ian Parker, within the large parks and game reserves where the majority of Africa's rhinos lived in the 1970s the recovery rate would have been lower than the 8% figure estimated for ivory in Tsavo.[41]

The records kept by the authorities in Tsavo East Park show that the recovery of rhino horn by the park's staff and other officials has always been extremely low, even when Tsavo was well-managed in the 1960s. From 1962 until 1967 between 42 and 75 rhino horns were officially collected each year, the annual average being 62, representing 31 dead rhinos.[42] On the basis of Goddard's findings, each year of the mid-1960s an average 458 rhinos (10.9% of 4,200) should have died, but the authorities picked up horns from only 31 rhinos or 7% of the estimated number of dead animals. We do not know how many horns were collected by poachers nor, more importantly, do we know what percentage of the horn was never found or was in such poor condition it was simply left in the bush.

In 1976, 56 horns were officially collected from the many hundreds of rhinos remaining in Tsavo East but then poaching escalated and the standard of management declined and in 1977 only 16 horns were found. From 1978 to 1987 not a single one was handed into Park headquarters![43] The story was practically the same for Kenya's other parks: Tsavo West's park staff collected a total of only 14 horns between 1978 and 1985,[44] and in Aberdare Park from 1977 until 1986 only 22 horns were officially recovered,[45] although that park's rhino population was estimated to be 600 in 1978.[46] What happened in Kenya's parks



During the 1970s Japan was one of the world's largest importers of rhino horn; shown on a book here are small pieces of sliced rhino horn which were later sold as medicine to lower fever, cure measles, stop nosebleeds and alleviate blood poisoning.

An official of Nepal's Royal Chitwan National Park displays some rhino horns, hooves and a piece of hide collected from dead rhinos, which were later sent to the King's Palace in Kathmandu. Copyright Esmond Bradley Martin

from 1976 onwards was that illicit hunters took more horns and some officials misappropriated those that were found.

The low official recovery rate of 7% for rhino horn in Tsavo East in the mid-1960s is not typical of all parks. In Meru National Park from 1969 to 1974 there were an estimated 200 black rhinos[47], and heavy poaching had not yet begun. Taking the usual 10.9% mortality rate, 22 rhinos would be expected to die per year in Meru. Over the six-year period 55 horns were officially found[48], representing an average annual recovery rate of 21%. For Nairobi National Park, a small reserve which has had little rhino poaching since the major translocation of rhinos into it between 1966 and 1968,[49] the official recovery rate is probably the highest of all East Africa's parks. Using Goddard's mortality rate on a population of 30 to 35 during the 1970s and the 14 horns known to have been handed to the authorities between 1979 and 1981[50], the recovery rate is in excess of 75%.

We will assume that Tsavo East's and Meru's recovery rates are closer to reality for most areas containing large rhino populations than that for Nairobi Park because in the 1960s and 1970s most black rhinos in Africa lived in reserves similar to Tsavo East and Meru. We therefore estimate 14% at most (i.e. the un-weighted average of the recovery rates for Tsavo East and Meru) as the recovery rate of horn from animals dying a natural death. We also assume that poachers would generally be successful in collecting the horn from their victims.

Sport hunting for rhinos accounts for a small but quantifiable amount of horn. Until the mid-1970s, and until 1979 in Zambia,[51] most countries with rhino populations allowed licensed hunting. Mozambique, Tanzania, Zambia, Kenya, the Central African Republic and Sudan attracted many foreigners from Europe, North and South America by offering them the opportunity to shoot one of the "Big Five". It was expensive to hunt a rhino for sport because licences had to be purchased from the government and the safari firms which organized the hunts charged high fees. The horns from a minimum of 600 rhinos shot on licence between 1970 and 1979 were usually exported by the visiting sportsmen who would normally retain them as trophies and so the horn did not enter the market.

Other African rhino horn unavailable to the market would be that from animals exported live to safari parks and zoos throughout the world. Over 1,500 rhinos have left Africa since 1970 to go to new homes, most of these animals being white rhinos from southern Africa.

Since the mid-1970s and early 1980s, when most of the official bans on export of rhino horn were established in African countries, various government departments have stockpiled horn confiscated from traders and poachers and that recovered from the bush. Several of these stockpiles are now substantial amounts. The largest is held by the Natal Parks Board which in April, 1987, had 1,692 kg.[52] Zimbabwe officially has over 750 kg, Kenya 247 kg (as of October, 1986),[53] Namibia 173 kg (as of May, 1987),[54] and the South African National Parks had 100 kg in their strongrooms in 1987.[55] The Zambian government has a small quantity (55 kg in January, 1985)[56] and so does Tanzania (31 kg in September, 1987).[57] A few other African countries have some as well. Therefore, by the end of 1987 there was a minimum of 3,100 kg (in southern Africa mostly from white rhino) which had not been exported. Aside from that held officially, some traders and collectors in Africa retain rhino horn which must amount to at least half a tonne in total.

Some rhino horn kept in government storehouses has deteriorated. In 1987, when EBM last visited the Ivory Room in Mombasa where the Kenya Wildlife Conservation and Management Department traditionally keeps game trophies, the majority of the horns he saw were in appalling condition, and some even fell apart in his hands. Insects and high humidity are responsible for the damage and these have taken toll also of government-owned stocks held in Dar es Salaam.

At the first meeting of the African Rhino Specialist Group, in Kenya during 1980, a programme to try to end trade in rhino horn was initiated and one of the recommendations made was that governments should destroy the stocks of rhino horn they held to prevent them from ever going onto markets. As far as we know, only Pilanesburg Game Reserve in Bophuthatswana did this: officials burned 35 kg in early 1981.[58]

One more reduction in the weight of horn available to the market should be made due to the perishable nature of the commodity and consideration of the fact that it is smuggled between countries. There is no way of telling what this amount would be, but perhaps a couple of percent of the horn destined for Asia from Africa is lost or damaged *en route*.

Lastly, some would be found and given neither to the authorities nor the trade. The rhino horns displayed for tourists in lodges and hotels are examples. Additionally a number of African peoples have their own uses for rhino horn. For example Zulu men burn rhino horn when they find it and daub the ash on their eyebrows to attract beautiful women.[59] Zimbabweans in the 1970s purchased rhino horn from traditional doctors in Harare's Pedzanhamo market for use as a talisman to give them strength and power and to protect their homes from evil spirits[60] and Sudanese in Khartoum made boxes out of rhino horn until quite recently.[61]

As was earlier remarked, those who have studied the black rhino populations have come up with accepted numbers for four years: 1970,1980, 1984 and 1987. These numbers were computed in various ways and do not relate to any particular time of the year. Since we need base numbers to make our calculations of rhino disappearance and not wishing to imply a greater accuracy than, perhaps, the data warrant, we have chosen to round the numbers to the nearest hundred and assume that they relate to the beginning of the year of observation i.e. 65,000(1970), 14,800(1980), 8,800(1984) and 3,800(1987). These are the numbers used in the computations in the Appendix where a variety of recruitment rates(7.5%, 5%, 4%, 3%) have been applied to calculate the implicit death rates necessary to achieve these population changes.

The death rates vary in the three time periods and show the expected very large increase in 1984 - 1986 (inclusive) during which time poaching was thought to have increased in response to the very large rise in the price of rhino horn.

The annual sales to identified markets have been presented. These, of necessity, are annual averages over spans of years: 8,000 kg per annum between 1970 and 1979 and 3,000 kg per annum from 1980 to 1986, all data inclusive. Since the average black rhino produces 2.88 kg of horn, these figures account for 2,780 rhinos annually over the decade of the 1970s, giving 27,800 rhinos; and 1,040 rhinos annually up to 1987, giving 7,280 rhinos. These compare with the dead rhinos of the 1970s -- using a 7.5% recruitment rate -- of 77,572 and 16,230 in the recorded years of the 1980s. That there is no major discrepancy between these figures is shown in the following analysis which considers a variety of corrections which must be made to both the supply and demand figures.

There has always been a demand for rhino horn within Africa, ranging from Sudanese box-making to talismans; this is estimated at some 15 rhinos per year throughout the period. Until sport hunting was comprehensively banned in 1979, a minimum of 63 rhinos were killed annually on licence. On average, about 29 black rhinos per year have been exported live to zoos and safari parks. Legal stockpiles have grown to about 3,600 kg since 1978 and this figure would have been say 20% greater if the horn was stored efficiently. Stockpiles of 4,200 kg would represent 170 rhinos annually. These four items would increase the demand figures by approximately 1,240 in the 1970s and 1,500 in the 1980s to totals of 29,040 and 8,780 respectively.

Considering the supply figures, if we accept Western's 20% of deaths as juveniles which do not contribute horn, the numbers to be accounted for in the market are significantly reduced to 62,057 in the 1970s and 12,984 in the 1980s and of these animals approximately half died natural deaths. Taking the Goddard death rate of 10.9% of the population, natural deaths would account for 42,764 in the 1970s and 8,947 in the 1980s or, ignoring juveniles, 34,211 and 7,157 respectively. Earlier in this paper we have argued that the empirical evidence indicates a low recovery rate of 14% of horn from rhinos which die naturally. Of the 42,764 natural deaths this would mean some 5,987 found and for the 1980s figure of 7,157 natural deaths 1,002.

The supply of horn would then be obtained from total adult deaths less natural deaths plus the 14% of natural deaths recovered. This represents a total of 62,057-34,211+5,987 = 33,833 for the 1970s and 12,984 -7,157+1,002 = 6,829 in the 1980s.

Comparison of the 33,833 supply for the 1970s with the known demand of 29,040 implies that poachers were successful in getting the horn from 85% (29,040/33,833) of the animals killed or that some 1,380kg of horn are unaccounted for annually. For the 1980s, the demand appears to exceed the supply.

In view of these calculations and their conclusions, it seems that little rhino horn is unaccounted for. Finer analysis of the demand side might clarify whether there were occasional bumps which would explain the disappearance of the surpluses in the 1970s and mid-1980s if poacher recovery truly was about 100%. Nevertheless a fairly small decrease in the population estimate for 1970 would remove completely the unaccounted surplus.

Appendix

Numbers of dead black rhinos from 1970 - 1987 using recruitment rates of 7.5%, 5%, 4% and 3%, and base black rhino populations for 1970(65,000), 1980(14,800), 1984(8,800) and 1987(3,800)

Year	7·5%	5·0%	4·0%	3·0%
1970	13,816	12,191	11,541	10,891
1971	11,915	10,514	9,953	9,393
1972	10,276	9,068	8,584	8,101
1973	8,863	7,820	7,403	6,986
1974	7,644	6,745	6,385	6,025
1975	6,592	5,817	5,507	5,197
1976	5,686	5,017	4,749	4,482
1977	4,904	4,327	4,096	3,865
1978	4,229	3,732	3,533	3,334
1979	3,647	3,218	3,047	2,875
(70s totals	77,572	68,449	64,798	61,149)
1980	2,914	2,544	2,396	2,248
1981	2,559	2,234	2,104	1,974
1982	2,247	1,962	1,847	1,733
1983	1,973	1,722	1,622	1,522
(80s subtotals	9,693	8,462	7,969	7,477)
1984	2,809	2,589	2,501	2,413
1985	2,123	1,957	1,890	1,824
1986	1,605	1,479	1,429	1,378
(80s subtotals	6,537	6,025	5,820	5,615)
Total dead rhinos	93,800	82,934	78,587	74,240

(All numbers rounded to the nearest whole integer)

Deaths per 1,000 rhinos per year given various recruitment rates

Period	Recruitment rates 7.5%	5%	4%	3%
1970 - 1979	198	179	171	163
1980 - 1983	183	164	156	147
1984 - 1987	297	280	273	266

(All numbers rounded to the nearest whole integer)

Acknowledgement

The authors would like to thank WWF International for their financial support.

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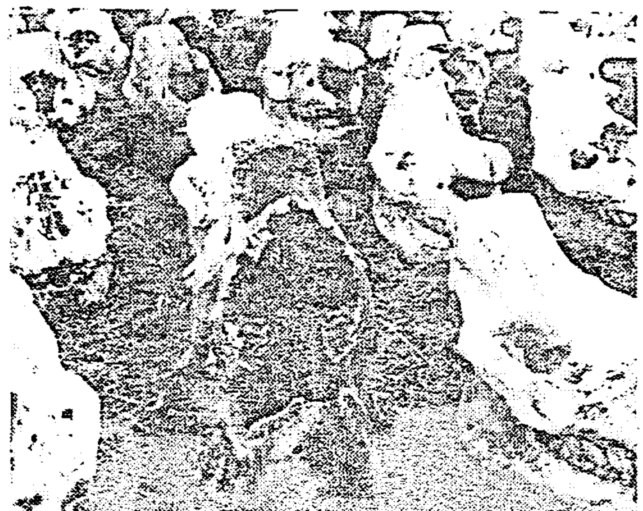

These black rhino skulls were photographed in South Luangwa National Park, Zambia, in 1983. During the 1970s and 1980s thousands of rhinos succumbed to poachers in the Luangwa Valley, and today probably less than 200 rhinos survive in Zambia. Copyright Esmond Bradley Martin

KENYA BLACK RHINOCEROS

METAPOPULATION WORKSHOP

BRIEFING BOOK

SECTION 7
CAPTIVE POPULATIONS

GLOBAL AND REGIONAL CURRENT AND TARGET POPULATIONS FOR RHINO IN CAPTIVITY

	WORLD			AFRICA		ASIA		AUSTRLSIA		EUROPE		N. AMERICA		S. AMERICA	
TAXON	WILD POP	CPTV POP	CPTV TRGT	CPTV POP	TRGT POP	CPTV POP	TRGT POP	CPTV POP	TRGT POP	CPTV POP	TRGT POP	CPTV POP	TRGT POP	CPTV POP	TRGT POP
N. Black Rhino	600	160		?		35		2		52		70		1	
S. Black Rhino	2,300	22		0		0		0		2		20		0	
S.W. Black Rhino	400	0		0		0		0		0		0		0	
N. White Rhino	28	10		0		0		0		6		4		0	
S. White Rhino	4,700	550		16		152		14		206		122		40	
Indian/Nepali Rhino	1,700	114		0		46		0		32		35		1	
Javan Rhino	< 100	0		0		0		0		0		0		0	
W. Sumatran Rhino	700	21		0		13		0		2		6		0	
E. Sumatran Rhino	100	3		0		3		0		0		0		0	
All Rhino Taxa	**10,628**	**880**		**16**		**249**		**16**		**300**		**257**		**42**	

T.J. Foose
15 September 1991

STRATEGIC SUPPORT OF *IN SITU* PROTECTED AREAS FOR RHINO BY THE GLOBAL AND REGIONAL CAPTIVE COMMUNITIES

TAXON	NUMBER OF SIGNIFICANT *IN SITU* SANCTUARIES	SUPPORTED BY ZOOS FROM					
		AFRICA	ASIA	AUSTRALASIA	EUROPE	N. AMERICA	S. AMERICA
N. Black Rhino	7				3	2+ ?	
S. Black Rhino	7			1		1 ?	
S.W. Black Rhino	2						
N. White Rhino	1						
S. White Rhino	5						
Indian/Nepali Rhino	6					1	
Javan Rhino	6					1	
W. Sumatran Rhino	5						
E. Sumatran Rhino	4						
All Rhino Taxa	40						

T.J. Foose
15 September 1991

4. Objectives of conservation of rhinos can only be achieved through the implementation of co-ordinated management programs involving management of existing populations, establishment of new populations and support for captive breeding programs.

5. The main factors likely to affect the future of African rhinos ranked in order of importance are poaching, civil unrest from within and outside national boundaries, habitat changes, genetics, and inbreeding in relation to the demographic data.

6. When discussing, developing strategies and conservation plans, the socio-economic and political factors must never be underestimated. The basic survival needs of people who shoulder the cost of supporting wildlife should be catered for by the conservation programmes. Their active participation through education, understanding of benefits from wildlife (rhino included), extension and community based conservation is vital for sustained management of the natural resource base which rhinos are part of. This is both a short and long term strategy and it should not be above the most urgent and, hopefully, short term security enhancement for rhinos in sanctuaries, private lands, and government conservation areas.

Plenary IV - Summary
Captive and Other Managed Populations

P. Spala, chair: *Breeding experience with northern white rhinos*
J. Anderson: *Management of translocated white rhino in Southern Africa*
C. Furley: *The management of black and Sumatran rhinos at Port Lympne Zoopark, U.K.*
R. Reece: *Captive breeding of rhinoceroses in North America*
R. Rieches: *Rhinoceros breeding at the San Diego Wild Animal Park*

Some aspects of captive breeding of black, white, Indian and Sumatran rhino populations were discussed with the following results:

1) None of the captive rhino programs have so far reached the sustaining level.

2) The southern white rhino groups have not proved to be growing at expected rate. The other SSP's for rhinos are progressing satisfactorily.

3) Fulfillment of required population size objectives will require a doubling of available space.

4) Disease factors appear more prominent in browsing species (i.e., black rhino) than in grazing ones.

5) More research in reproduction, genetics, behavior, nutrition, etc., is necessary to achieve self-sustaining populations.

6) Managed populations of the translocated white rhinos in Southern Africa are doing well and are currently producing surplus at the rate of 10% per year.

Plenary V - Summary
Endocrinology and Reproduction

J.K. Hodges, chair: *Studies in rhinoceros reproductive endocrinology*
N. Czekala: *Salivary hormone analysis for black rhino pregnancy detection*
R. Godfrey: Progress in reproductive physiology researcy in rhinoceros
J. Hindle: *Recent advances in reproductive monitoring of rhinos in captivity and in the wild*
N. Schaffer: *Reproductive ultrasound and semen collection in chute-restrained cognizant rhinoceroses*

The aim of the session was to provide a brief account of current status in the field of reproductive physiology and to examine priorities for future studies in relation to management/conservation needs. Keith Hodges provided some background on the importance of monitoring methods, different approaches and potential applications. Jo Hindle highlighted the species differences hormone metabolism and their implication for methods of urinary hormone analysis. She presented data describing the pattern of excretion of 20α-dihydroprogesterone (20α-HP) and conjugated estrogens, allowing for the first time the monitoring of follicular development and corpus luteum function in African rhinos. An alternative method of monitoring based on hormone analysis of saliva was described by Nancy Czekala. The measurement of 20α-HP and estrogens in saliva should be useful in pregnancy diagnosis and prediction of parturition in the black rhino. Data on circulating levels of estradiol and progesterone during the ovarian cycle in a black rhino were presented by Bob Godfrey, showing that animals may be trained to use a squeeze chute for non-stressful blood sampling. He also reported that ovarian follicles, a corpus luteum and an early embryo had been visualized in using ultrasound. Nan Schaffer summarized her work on ultrasound and reproductive tract gross anatomy. The finding of a convoluted cervix may cause difficulties when attempting intra-uterine insemination. She also reported that viable semen had been collected from epididymes and by electrical and manual stimulation from Indian and African rhinos.

The value of assisted reproductive technologies (A.I., embryo transfer) to rhino management was discussed. Potential was clearly seen for captive animals. However, much more work was needed and any real impact on rhino conservation is unlikely within the next five years.

Priorities for the future.

1. Confirm endocrine data for ovarian cycle in African rhinos. More cycles from more animals are needed (especially white).

2. Correlate urinary data with blood samples and ultrasound. Focus on timing of ovulation and assessment of luteal function.

3. Greater precision is required for hormonal profiles during (early) pregnancy. The range of normal values for urinary and salivary hormones needs to be established.

4. Alternative methods of early pregnancy diagnosis need to be sought.

5. Method of pregnancy diagnosis from 1 or 2 samples needs to be developed to facilitate use on free-ranging animals.

6. Use of faecal hormone analysis for pregnancy detection should be pursued (due to potential for use with wild animals).

7. Wherever possible squeeze chute (crush) facilities should be installed and animals conditioned to regular handling.

8. Methods for ovarian stimulation and synchronization of ovulation need to be established. Different approaches, doses, treatment protocols and responses all need to be worked out.

9. Success rate for semen collection needs to be improved. Further work is needed to establish optimal semen freezing and storage methods. Procedures and instumentation for A.I. need to be developed.

10. Placental material (particularly early pregnancy) should be collected and stored for structural, histological and endocrine evaluation.

BIRTHS & DEATHS - 1981 TO 1991
IN NORTH AMERICAN CAPTIVE POPULATIONS OF
Diceros bicornis michaeli

ENTIRE POPULATION

YEAR	BIRTHS	DEATHS	BIRTHS/FEMALES>AGE 7
1981	4 (2.2)	2 (1.1)	4/31
1982	6 (2.4)	6 (3.3)	6/30
1983	3 (2.1)	2 (1.1)	3/30
1984	0 (0.0)	0 (0.1)	0/29
1985	7 (2.5)	4 (3.1)	7/28
1986	7 (4.3)	8 (4.4)*	7/27
1987	2 (2.0)	4 (3.1)	2/24
1988	5 (2.3)	2 (1.1)	5/26
1989	4 (2.2)	5 (1.4)	4/29
1990	5 (2.3)	2 (0.2)	5/27
1991	1 (0.1)	1 (0.1)	1/27
	43 (20.23)	37 (18.19)	4/28 (14%)

* 5 (4.1) are estimated dates of death for animals in St. Felicien, Oklahoma, and Granby.

BIRTH INTERVAL DATA:
Number of intervals: 24 — Number of females: 13
Range: 494 - 1633 days — Median: 808 days — Mean: 909 days

CORE POPULATION *

YEAR	BIRTHS	DEATHS	BIRTHS/FEMALES>AGE 7
1981	3 (2.1)	2 (1.1)	3/20
1982	3 (0.3)	1 (0.1)	3/20
1983	2 (2.0)	0 (0.0)	2/21
1984	0 (0.0)	1 (0.1)	0/21
1985	5 (1.4)	1 (0.1)	5/20
1986	5 (2.1)	1 (0.1)	5/19
1987	2 (2.0)	1 (1.0)	2/19
1988	5 (2.3)	1 (1.0)	5/20
1989	2 (1.1)	4 (0.4)	2/23
1990	5 (2.3)	1 (0.1)	5/21
1991	1 (0.1)	1 (0.1)	1/21
	33 (14.17)	14 (3.11)	3/20 (15%)

BIRTH INTERVAL DATA:
Number of intervals: 20 — Number of females: 11
Range: 494 - 1633 days — Median: 753 days — Mean: 878 days

* CORE: Chicago Brookfield, Cincinnati, Denver, Los Angeles, Metrozoo Miami, San Antonio, San Francisco, St. Louis, San Diego Wild Animal Park, San Diego Zoo

SUMMARY OF LAMBDAS IN NORTH AMERICAN CAPTIVE POPULATIONS OF RHINO

Eastern Black Rhino
Diceros bicornis michaeli

ENTIRE POPULATION

1971-1991: 1.005
1981-1991: 1.020

CORE POPULATION

1971-1991: 1.035
1981-1991: 1.040

CORE POP.: Chicago Brookfield, Cincinnati, Denver, Los Angeles, Metrozoo Miami, San Antonio, San Francisco, St. Louis, San Diego Wild Animal Park, San Diego Zoo

Greater One-Horned Asian Rhino
Rhinoceros unicornis

ENTIRE POPULATION

1981-1991: 1.044

T.J. Foose
Robert Reece
Karen Wachs
15 September 1991

Fecundity & Mortality Report
Restricted to: EASTERN BLACK RHINO Studbook
Dates: During 01/01/1971 <= date

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Taxon Name: DICEROS BICORNIS MICHAELI

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	Fecundity [Mx]...				Mortality [Qx]...			
Age Class	Male	N	Female	N	Male	N	Female	N
0- 1	0.00	29.4	0.00	33.0	0.12	34.3	0.08	37.0
1- 2	0.00	29.3	0.00	32.9	0.04	28.2	0.03	32.8
2- 3	0.00	26.3	0.00	30.8	0.00	26.3	0.06	31.3
3- 4	0.00	25.2	0.00	32.2	0.00	24.6	0.03	30.8
4- 5	0.00	23.3	0.03	32.4	0.00	23.3	0.03	32.0
5- 6	0.03	19.2	0.00	31.8	0.00	19.2	0.00	31.8
6- 7	0.08	19.0	0.03	29.9	0.00	18.2	0.00	29.9
7- 8	0.07	21.0	0.02	30.0	0.00	20.3	0.00	30.0
8- 9	0.08	20.0	0.07	30.2	0.05	20.0	0.03	29.6
9-10	0.10	20.1	0.02	28.3	0.05	19.9	0.00	28.3
10-11	0.17	18.5	0.08	29.8	0.00	18.5	0.00	29.0
11-12	0.15	16.4	0.06	27.2	0.00	16.4	0.07	27.0
12-13	0.16	15.9	0.07	28.0	0.00	15.9	0.00	28.0
13-14	0.04	13.1	0.11	28.0	0.08	13.0	0.00	28.0
14-15	0.00	13.4	0.06	26.6	0.00	13.4	0.12	25.0
15-16	0.11	14.0	0.09	23.3	0.00	14.0	0.04	22.5
16-17	0.15	14.0	0.07	22.2	0.00	14.0	0.10	21.0
17-18	0.10	14.7	0.10	20.7	0.00	14.7	0.00	20.7
18-19	0.07	15.0	0.10	20.0	0.00	15.0	0.00	20.0
19-20	0.03	15.7	0.05	18.3	0.00	15.7	0.00	18.3
20-21	0.03	15.0	0.06	17.1	0.07	15.0	0.00	17.1
21-22	0.04	13.9	0.07	14.5	0.00	13.4	0.07	14.0
22-23	0.00	12.3	0.00	11.4	0.08	12.0	0.00	11.4
23-24	0.09	11.7	0.05	9.7	0.00	11.0	0.00	9.7
24-25	0.06	8.7	0.11	9.0	0.37	8.0	0.00	9.0
25-26	0.06	8.0	0.00	9.0	0.00	7.5	0.00	9.0
26-27	0.07	7.1	0.00	9.0	0.14	7.0	0.00	9.0
27-28	0.08	6.7	0.06	8.7	0.00	6.7	0.00	8.2
28-29	0.00	5.5	0.00	7.5	0.20	5.0	0.15	6.7
29-30	0.20	5.0	0.00	5.7	0.00	5.0	0.00	5.7
30-31	0.00	5.0	0.00	3.8	0.00	5.0	0.00	3.8
31-32	0.10	5.0	0.00	3.0	0.00	5.0	0.00	3.0
32-33	0.00	5.0	0.00	2.7	0.00	4.0	0.00	2.7
33-34	0.00	3.4	0.00	2.0	0.50	4.0	0.00	2.0
34-35	0.17	3.0	0.00	2.0	0.00	3.0	0.00	2.0
35-36	0.00	3.0	0.00	1.1	0.00	3.0	1.00	1.0
36-37	0.17	3.0	0.00	0.7	0.00	3.0	0.00	0.7
37-38	0.00	2.7	0.00	0.0	0.00	2.7	0.00	0.0
38-39	0.00	2.0	0.00	0.0	0.00	2.0	0.00	0.0
39-40	0.00	1.7	0.00	0.0	0.00	1.7	0.00	0.0
40-41	0.00	0.7	0.00	0.0	0.00	0.7	0.00	0.0
41-42	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
42-43	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0

Male	Female	
T = 15.315	T = 14.957	30 day mortality: 10%
Ro = 1.326	Ro = 0.808	(6 out of 63)
lambda=1.02	lambda=0.99	
r = 0.018	r = -0.014	

56 birth events to known age parents tabulated for Mx...plus...

1 births to UNK or MULT sires...

37 death events of known age tabulated for Qx...

WARNING: Values with small sample sizes (N) warrant less confidence...

Fecundity & Mortality Report

Restricted to: EASTERN BLACK RHINO Studbook

Locations: CHICAGOBR/CINCINNAT/DENVER /LOSANGELE/METROZOO /SAN ANTON/ST LOUIS SAN FRAN /SD-WAP /SANDIEGOZ/

Dates: During 01/01/1971 <= date

Taxon Name: DICEROS BICORNIS MICHAELI

Age Class	Fecundity [Mx]... Male	N	Female	N	Mortality [Qx]... Male	N	Female	N
0- 1	0.00	19.7	0.00	19.4	0.05	20.7	0.13	23.1
1- 2	0.00	14.2	0.00	14.3	0.00	13.4	0.00	14.3
2- 3	0.00	10.7	0.00	10.0	0.00	10.7	0.10	9.6
3- 4	0.00	10.7	0.00	10.8	0.00	10.7	0.00	10.8
4- 5	0.00	11.0	0.04	12.1	0.00	11.0	0.00	12.1
5- 6	0.00	10.8	0.00	13.2	0.00	10.8	0.00	13.2
6- 7	0.14	10.4	0.00	11.9	0.00	10.4	0.00	11.9
7- 8	0.09	11.0	0.04	11.9	0.00	11.0	0.00	11.9
8- 9	0.14	10.4	0.12	12.8	0.10	10.4	0.00	12.8
9-10	0.10	10.0	0.00	12.9	0.00	10.0	0.00	12.9
10-11	0.25	10.0	0.14	14.2	0.00	10.0	0.00	14.2
11-12	0.17	8.9	0.11	14.1	0.00	8.9	0.07	14.0
12-13	0.28	8.9	0.13	15.0	0.00	8.9	0.00	15.0
13-14	0.07	7.0	0.10	15.0	0.00	7.0	0.00	15.0
14-15	0.00	6.7	0.10	15.6	0.00	6.7	0.07	14.9
15-16	0.14	7.0	0.10	14.5	0.00	7.0	0.00	14.5
16-17	0.21	7.0	0.11	13.8	0.00	7.0	0.07	13.6
17-18	0.13	7.7	0.15	13.3	0.00	7.7	0.00	13.3
18-19	0.07	7.0	0.12	13.0	0.00	7.0	0.00	13.0
19-20	0.00	6.7	0.09	11.6	0.00	6.7	0.00	11.6
20-21	0.08	6.0	0.05	11.1	0.00	6.0	0.00	11.1
21-22	0.00	5.4	0.12	8.5	0.00	5.4	0.13	8.0
22-23	0.00	5.0	0.00	5.8	0.00	5.0	0.00	5.8
23-24	0.10	5.0	0.11	4.7	0.00	5.0	0.00	4.7
24-25	0.13	3.7	0.13	4.0	0.33	3.0	0.00	4.0
25-26	0.20	2.5	0.00	3.5	0.00	2.0	0.00	3.5
26-27	0.25	2.0	0.00	3.0	0.00	2.0	0.00	3.0
27-28	0.25	2.0	0.00	3.5	0.00	2.0	0.00	3.5
28-29	0.00	2.0	0.00	3.5	0.00	2.0	0.37	2.7
29-30	0.50	2.0	0.00	2.0	0.00	2.0	0.00	2.0
30-31	0.00	2.0	0.00	1.7	0.00	2.0	0.00	1.7
31-32	0.25	2.0	0.00	1.0	0.00	2.0	0.00	1.0
32-33	0.00	2.0	0.00	1.0	0.00	2.0	0.00	1.0
33-34	0.00	1.1	0.00	1.0	0.00	1.0	0.00	1.0
34-35	0.50	1.0	0.00	1.0	0.00	1.0	0.00	1.0
35-36	0.00	1.0	0.00	0.1	0.00	1.0	0.00	0.0
36-37	0.50	1.0	0.00	0.0	0.00	1.0	0.00	0.0
37-38	0.00	0.7	0.00	0.0	0.00	0.7	0.00	0.0
38-39	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
39-40	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0

Male	Female	
T = 20.891	T = 14.803	30 day mortality: 7%
Ro = 3.185	Ro = 1.174	(3 out of 43)
lambda=1.06	lambda=1.01	
r = 0.055	r = 0.011	

42 birth events to known age parents tabulated for Mx...

13 death events of known age tabulated for Qx...

WARNING: Values with small sample sizes (N) warrant less confidence...

Fecundity & Mortality Report
Restricted to: EASTERN BLACK RHINO Studbook
Dates: During 01/01/1981 <= date

Taxon Name: DICEROS BICORNIS MICHAELI

	Fecundity [Mx]...				Mortality [Qx]...			
Age Class	Male	N	Female	N	Male	N	Female	N
0- 1	0.00	20.6	0.00	21.7	0.16	25.5	0.12	24.8
1- 2	0.00	21.2	0.00	18.3	0.05	20.7	0.05	18.2
2- 3	0.00	18.9	0.00	14.8	0.00	18.9	0.13	15.3
3- 4	0.00	17.8	0.00	10.4	0.00	17.8	0.10	10.2
4- 5	0.00	17.1	0.09	10.9	0.00	17.1	0.10	10.5
5- 6	0.04	13.2	0.00	11.0	0.00	13.2	0.00	11.0
6- 7	0.14	11.0	0.10	9.7	0.00	11.0	0.00	9.7
7- 8	0.13	12.0	0.05	11.0	0.00	12.0	0.00	11.0
8- 9	0.14	10.7	0.17	11.6	0.09	10.7	0.08	12.2
9-10	0.20	10.1	0.05	11.1	0.10	9.9	0.00	11.1
10-11	0.34	9.0	0.19	13.4	0.00	9.0	0.00	12.5
11-12	0.27	9.4	0.11	14.1	0.00	9.4	0.14	13.9
12-13	0.32	7.9	0.13	16.0	0.00	7.9	0.00	16.0
13-14	0.09	5.7	0.14	20.7	0.18	5.7	0.00	20.7
14-15	0.00	5.4	0.08	19.6	0.00	5.4	0.17	18.0
15-16	0.31	5.0	0.12	16.3	0.00	5.0	0.06	15.5
16-17	0.29	7.0	0.11	14.2	0.00	7.0	0.15	13.0
17-18	0.18	8.7	0.15	13.7	0.00	8.7	0.00	13.7
18-19	0.12	8.3	0.14	14.0	0.00	8.3	0.00	14.0
19-20	0.05	9.7	0.07	13.9	0.00	9.7	0.00	13.9
20-21	0.06	8.0	0.07	15.1	0.13	8.0	0.00	15.1
21-22	0.07	6.9	0.09	11.5	0.00	6.4	0.09	11.0
22-23	0.00	6.3	0.00	9.4	0.17	6.0	0.00	9.4
23-24	0.18	5.7	0.06	7.7	0.00	5.0	0.00	7.7
24-25	0.14	3.7	0.14	7.0	1.00	3.0	0.00	7.0
25-26	0.13	4.0	0.00	7.0	0.00	3.5	0.00	7.0
26-27	0.16	3.1	0.00	8.0	0.33	3.0	0.00	8.0
27-28	0.14	3.7	0.06	7.7	0.00	3.7	0.00	7.2
28-29	0.00	3.5	0.00	6.5	0.33	3.0	0.18	5.7
29-30	0.25	4.0	0.00	4.7	0.00	4.0	0.00	4.7
30-31	0.00	5.0	0.00	2.8	0.00	5.0	0.00	2.8
31-32	0.10	5.0	0.00	3.0	0.00	5.0	0.00	3.0
32-33	0.00	5.0	0.00	2.7	0.00	4.0	0.00	2.7
33-34	0.00	3.4	0.00	2.0	0.50	4.0	0.00	2.0
34-35	0.17	3.0	0.00	2.0	0.00	3.0	0.00	2.0
35-36	0.00	3.0	0.00	1.1	0.00	3.0	1.00	1.0
36-37	0.17	3.0	0.00	0.7	0.00	3.0	0.00	0.7
37-38	0.00	2.7	0.00	0.0	0.00	2.7	0.00	0.0
38-39	0.00	2.0	0.00	0.0	0.00	2.0	0.00	0.0
39-40	0.00	1.7	0.00	0.0	0.00	1.7	0.00	0.0
40-41	0.00	0.7	0.00	0.0	0.00	0.7	0.00	0.0
41-42	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
42-43	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0

Male	Female	
T = 12.381	T = 12.815	30 day mortality: 13%
Ro = 1.775	Ro = 0.881	(6 out of 46)
lambda=1.05	lambda=0.99	
r = 0.046	r = -0.010	

56 birth events to known age parents tabulated for Mx...plus...

1 births to UNK or MULT sires...

37 death events of known age tabulated for Qx...

WARNING: Values with small sample sizes (N) warrant less confidence...

Fecundity & Mortality Report

Restricted to: EASTERN BLACK RHINO Studbook

Locations: CHICAGOBR/CINCINNAT/DENVER /LOSANGELE/METROZOO /SAN ANTON/ST LOUIS SAN FRAN /SD-WAP /SANDIEGOZ/

Dates: During 01/01/1981 <= date

Taxon Name: DICEROS BICORNIS MICHAELI

	Fecundity [Mx]...				Mortality [Qx]...			
Age Class	Male	N	Female	N	Male	N	Female	N
0- 1	0.00	16.2	0.00	16.0	0.06	17.2	0.16	18.8
1- 2	0.00	12.0	0.00	9.3	0.00	11.2	0.00	9.3
2- 3	0.00	8.0	0.00	4.5	0.00	8.0	0.25	4.0
3- 4	0.00	7.0	0.00	4.0	0.00	7.0	0.00	4.0
4- 5	0.00	7.0	0.09	5.5	0.00	7.0	0.00	5.5
5- 6	0.00	6.8	0.00	5.7	0.00	6.8	0.00	5.7
6- 7	0.23	6.4	0.00	3.9	0.00	6.4	0.00	3.9
7- 8	0.13	8.0	0.17	3.0	0.00	8.0	0.00	3.0
8- 9	0.22	6.7	0.35	2.8	0.15	6.7	0.00	2.8
9-10	0.14	7.0	0.00	3.9	0.00	7.0	0.00	3.9
10-11	0.33	7.5	0.20	7.4	0.00	7.5	0.00	7.4
11-12	0.19	7.9	0.15	10.0	0.00	7.9	0.10	9.9
12-13	0.36	6.9	0.18	11.0	0.00	6.9	0.00	11.0
13-14	0.09	5.7	0.13	12.0	0.00	5.7	0.00	12.0
14-15	0.00	5.4	0.12	12.6	0.00	5.4	0.08	11.9
15-16	0.20	5.0	0.13	11.5	0.00	5.0	0.00	11.5
16-17	0.30	5.0	0.14	10.8	0.00	5.0	0.09	10.6
17-18	0.11	4.7	0.19	10.3	0.00	4.7	0.00	10.3
18-19	0.13	4.0	0.14	11.0	0.00	4.0	0.00	11.0
19-20	0.00	3.7	0.10	9.6	0.00	3.7	0.00	9.6
20-21	0.00	3.0	0.05	10.1	0.00	3.0	0.00	10.1
21-22	0.00	2.4	0.15	6.5	0.00	2.4	0.17	6.0
22-23	0.00	3.0	0.00	4.8	0.00	3.0	0.00	4.8
23-24	0.17	3.0	0.14	3.7	0.00	3.0	0.00	3.7
24-25	0.26	2.0	0.17	3.0	0.78	1.3	0.00	3.0
25-26	0.33	1.5	0.00	2.5	0.00	1.0	0.00	2.5
26-27	0.50	1.0	0.00	2.0	0.00	1.0	0.00	2.0
27-28	0.25	2.0	0.00	2.5	0.00	2.0	0.00	2.5
28-29	0.00	2.0	0.00	2.5	0.00	2.0	0.59	1.7
29-30	0.50	2.0	0.00	1.0	0.00	2.0	0.00	1.0
30-31	0.00	2.0	0.00	0.7	0.00	2.0	0.00	0.7
31-32	0.25	2.0	0.00	1.0	0.00	2.0	0.00	1.0
32-33	0.00	2.0	0.00	1.0	0.00	2.0	0.00	1.0
33-34	0.00	1.1	0.00	1.0	0.00	1.0	0.00	1.0
34-35	0.50	1.0	0.00	1.0	0.00	1.0	0.00	1.0
35-36	0.00	1.0	0.00	0.1	0.00	1.0	0.00	0.0
36-37	0.50	1.0	0.00	0.0	0.00	1.0	0.00	0.0
37-38	0.00	0.7	0.00	0.0	0.00	0.7	0.00	0.0
38-39	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
39-40	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0

Male	Female	
T = 15.746	T = 13.289	30 day mortality: 9%
Ro = 2.672	Ro = 1.377	(3 out of 35)
lambda=1.06	lambda=1.02	
r = 0.062	r = 0.024	

40 birth events to known age parents tabulated for Mx...

13 death events of known age tabulated for Qx...

WARNING: Values with small sample sizes (N) warrant less confidence...

Stud #	Sex	Birth Date	Sire	Dam	Location	Date	Local ID	Birth-Origin	Country	Death-Date
34	M	~ 1965	WILD	WILD	AFRICAN	~ 1965	UNK	Wild Born	AFRICAN	
					ITALY	5 Jul 1966	UNK		ITALY	
					ATLANTA	26 Sep 1972	UNK		U.S.A.	
						23 Apr 1987 (died)				23 Apr 1987
38	F	~ 1961	WILD	WILD	AFRICAN	~ 1961	UNK	Wild Born	AFRICAN	
					ITALY	26 Oct 1962	UNK		ITALY	
					ATLANTA	23 Nov 1968	UNK		U.S.A.	
					METROZOO	1 Jul 1988	M00966		U.S.A.	
						28 Oct 1989 (died)				28 Oct 1989
52	M	~ 1964	WILD	WILD	AFRICAN	~ 1964	UNK	Wild Born	AFRICAN	
					DETROIT	19 Jun 1967	UNK		U.S.A.	
					METROZOO	16 Jul 1985	M00442		U.S.A.	
						1 Sep 1988 (died)				1 Sep 1988
53	F	~ 1962	WILD	WILD	KENYA	1 Jun 1965	UNK	Wild Born	KENYA	
					FERNDALE	5 Sep 1965	UNK		U.S.A.	
					DETROIT	30 Sep 1965	UNK		U.S.A.	
					(OKLAHOMA)	5 Jun 1985	UNK		U.S.A.	
					(SEDGWICK)	2 Aug 1988	3327			
54	M	19 Apr 1962	T2020	T2023	DETROIT	19 Apr 1962	UNK	Captive Born	U.S.A.	
					OKLAHOMA	28 Jun 1963	024701		U.S.A.	
						~ 1986 (died)				~ 1986
55	F	27 Jul 1961	56	57	CINCINNAT	27 Jul 1961	UNK	Captive Born	U.S.A.	
					ZEEHANDLR	19 Jun 1962	UNK		U.S.A.	
					SHEPHERD	~ 1963	UNK		U.S.A.	
					CHICAGOLP	~ 1963	UNK		U.S.A.	
					OKLAHOMA	28 Jun 1963	UNK		U.S.A.	
					(DETROIT)	5 Jun 1985	1442		U.S.A.	
56	M	1 Apr 1956	WILD	WILD	W.GERMANY	1 Apr 1956	UNK	Captive Born	W.GERMANY	
					MIAMI	~ 1957	UNK			
					CINCINNAT	14 May 1957	M14004		U.S.A.	
					OKLAHOMA	20 Apr 1989	490219		U.S.A.	
						18 Aug 1989 (died)				18 Aug 1989
63	F	~ 1972	WILD	WILD	KENYA	1 Jan 1963	UNK	Wild Born	KENYA	
					KANSASCTY	26 Apr 1963	UNK		U.S.A.	
					WICHITA	24 May 1972	UNK		U.S.A.	
					OKLAHOMA	15 Jan 1974	UNK		U.S.A.	
						12 May 1981 (died)				12 May 1981
66	M	~ 1953	WILD	WILD	AFRICAN	~ 1953	UNK	Wild Born	AFRICAN	
					DALLAS	1 Oct 1959	001043		U.S.A.	
						~ 1986 (died)				~ 1986
67	F	~ 1955	WILD	WILD	KENYA	~ 1956	UNK	Wild Born	KENYA	
					ZEEHANDLR	~ 1956	UNK		U.S.A.	
					DALLAS	1 Sep 1956	001029		U.S.A.	

Stud #	Sex	Birth Date	Sire	Dam	Location	Date	Local ID	Birth-Origin	Country	Death-Date
68	M	~ 1951	WILD	WILD	KENYA	1 Jun 1950	UNK	Wild Born	KENYA	
					BASEL	~ 1951	UNK		SWITZRLND	
					COLUMBUS	1 Jan 1954	542001		U.S.A.	
71	M	~ 1956	WILD	WILD	KENYA	1 Jan 1957	UNK	Wild Born	KENYA	
					COLO SPRG	21 May 1957	UNK		U.S.A.	
						5 Nov 1982	(died)			5 Nov 1982
72	F	~ 1967	WILD	WILD	KENYA	1 Jan 1967	UNK	Wild Born	KENYA	
					COLO SPRG	26 Jun 1967	UNK		U.S.A.	
						13 Jan 1983	(died)			13 Jan 1983
74	M	~ 1954	WILD	WILD	AFRICAN	~ 1956	UNK	Wild Born	AFRICAN	
					SAN FRAN	22 Nov 1956	1564		U.S.A.	
76	F	~ 1963	WILD	WILD	KENYA	~ 1966	UNK	Wild Born	KENYA	
					FERNDALE	~ 1966	UNK		U.S.A.	
					LOSANGELE	3 Oct 1966	02774		U.S.A.	
78	F	~ 1950	WILD	WILD	SANDIEGOZ	30 Aug 1952	152002	Wild Born	U.S.A.	
						7 Feb 1985	(died)			7 Feb 1985
79	M	~ 1962	WILD	WILD	AFRICAN	~ 1962	UNK	Wild Born	AFRICAN	
					GRANBY	11 May 1966	238638		CANADA	
						~ 1986	(died)			~ 1986
104	F	3 Jan 1968	7	8	HANNOVER	3 Jan 1968	UNK	Captive Born	W.GERMANY	
					BUDAPEST	20 Jun 1969	UNK		HUNGARY	
					SD-WAP	25 Jun 1983	UNK		U.S.A.	
						21 Mar 1984	(died)			21 Mar 1984
110	M	31 Aug 1967	46	47	NZP-WASH	31 Aug 1967	UNK	Captive Born	U.S.A.	
					SD-WAP	18 Apr 1970	100285		U.S.A.	
					SANDIEGOZ	11 Jan 1983	100285		U.S.A.	
121	F	~ 1961	WILD	WILD	KENYA	~ 1965	UNK	Wild Born	KENYA	
					ST LOUIS	16 Jun 1965	065411		U.S.A.	
124	M	~ 1959	WILD	WILD	KENYA	~ 1960	UNK	Wild Born	KENYA	
					DENVER	~ 1960	UNK		U.S.A.	
					GARDENCTY	14 Jul 1984	00456		U.S.A.	
						11 Jul 1987	(died)			11 Jul 1987
125	F	~ 1959	WILD	WILD	KENYA	~ 1959	UNK	Wild Born	KENYA	
					DENVER	~ 1959	UNK		U.S.A.	
					(GARDENCTY)	14 Jul 1984	0002		U.S.A.	
155	M	~ 1965	WILD	WILD	E. AFRICA	~ 1965	UNK	Wild Born	AFRICAN	
					BUSCH TAM	22 May 1969	15317		U.S.A.	
						5 Jan 1985	(died)			5 Jan 1985

Stud #	Sex	Birth Date	Sire	Dam	Location	Date	Local ID	Birth-Origin	Country	Death-Date
161	M	1 Jan 1972	74	75	SAN FRAN	1 Jan 1972	UNK	Captive Born	U.S.A.	
					DENVER	4 Sep 1973	00457		U.S.A.	
163	F	6 Jan 1971	124	125	DENVER	6 Jan 1971	00459	Captive Born	U.S.A.	
169	M	~ 1970	WILD	WILD	KENYA	~ 1970	UNK	Wild Born	KENYA	
					DVURKRALV	~ 1972	UNK		CZECHOSLO	
					SAN ANTON	22 Apr 1978	781454		U.S.A.	
176	F	~ 1968	WILD	WILD	AFRICAN	~ 1968	UNK	Wild Born	AFRICAN	
					JACKSONVL	????	167		U.S.A.	
					(COLUMBUS)	14 May 1978	782005		U.S.A.	
						17 Apr 1982	(died)			17 Apr 1982
179	F	30 Apr 1971	120	121	ST LOUIS	30 Apr 1971	UNK	Captive Born	U.S.A.	
					MEMPHIS	8 Jun 1971	UNK		U.S.A.	
					SD-WAP	18 Feb 1982	UNK		U.S.A.	
						28 May 1982	(died)			28 May 1982
180	F	21 Mar 1970	56	57	CINCINNAT	21 Mar 1970	M14005	Captive Born	U.S.A.	
					(COLUMBUS)	10 Apr 1989	UNK		U.S.A.	
					CINCINNAT	10 Jan 1990	M14005		U.S.A.	
187	F	3 May 1972	71	72	COLO SPRG	3 May 1972	100435	Captive Born	U.S.A.	
						13 Dec 1986	(died)			13 Dec 1986
188	F	~ 1972	WILD	WILD	KENYA	~ 1972	UNK	Wild Born	KENYA	
					FERNDALE	~ 1972	UNK		U.S.A.	
					SD-WAP	30 Nov 1972	100287		U.S.A.	
					SANDIEGOZ	19 May 1982	100287		U.S.A.	
					(COLUMBUS)	2 May 1989	892041		U.S.A.	
190	F	26 Nov 1969	16	17	LONDON RP	26 Nov 1969	UNK	Captive Born	ENGLAND	
					SAN ANTON	28 Dec 1976	761258		U.S.A.	
192	F	2 May 1972	54	55	OKLAHOMA	2 May 1972	UNK	Captive Born	U.S.A.	
					SEDGWICK	5 Nov 1973	UNK			
					(SANDIEGOZ)	5 Oct 1988	588371		U.S.A.	
202	F	~ 1971	WILD	WILD	KENYA	~ 1973	UNK	Wild Born	KENYA	
					FERNDALE	~ 1973	UNK		U.S.A.	
					METROZOO	13 Jun 1973	110		U.S.A.	
207	F	~ 1968	WILD	WILD	AFRICAN	~ 1968	UNK	Wild Born	AFRICAN	
					CINCINNAT	12 Jul 1973	M14007		U.S.A.	
						28 Jun 1989	(died)			28 Jun 1989
212	F	9 Sep 1975	52	53	DETROIT	9 Sep 1975	313	Captive Born	U.S.A.	
					(ST LOUIS)	30 Oct 1984	084437		U.S.A.	

Stud #	Sex	Birth Date	Sire	Dam	Location	Date	Local ID	Birth-Origin	Country	Death-Date
213	F	~ 1971	WILD	WILD	KENYA	~ 1974	UNK	Wild Born	KENYA	
					FERNDALE	~ 1974	UNK		U.S.A.	
					SAN FRAN	16 Apr 1974	17415		U.S.A.	
225	F	~ 1968	WILD	WILD	KENYA	~ 1971	UNK	Wild Born	KENYA	
					BUSCH TAM	24 Jul 1971	15318		U.S.A.	
					(CINCINNAT)	16 Aug 1990	190189		U.S.A.	
226	F	11 Nov 1974	155	225	BUSCH TAM	11 Nov 1974	UNK	Captive Born	U.S.A.	
					ST FELICI	19 Jul 1978	UNK		CANADA	
						~1986 +/-1yr (died)				~1986 +/-1yr
233	F	~ 1969	WILD	WILD	KENYA	~ 1973	UNK	Wild Born	KENYA	
					CHICAGOBR	23 Nov 1973	UNK		U.S.A.	
					(SD-WAP)	1 Nov 1986	037690		U.S.A.	
235	F	~ 1970	WILD	WILD	KENYA	~ 1973	UNK	Wild Born	KENYA	
					CHICAGOBR	11 Dec 1973	22624		U.S.A.	
239	F	15 Oct 1976	110	188	SD-WAP	15 Oct 1976	101929	Captive Born	U.S.A.	
						12 Jun 1991 (died)				12 Jun 1991
243	M	31 Oct 1976	155	225	BUSCH TAM	31 Oct 1976	UNK	Captive Born	U.S.A.	
					ST FELICI	19 Jul 1978	UNK		CANADA	
						~1986 +/-1yr (died)				~1986 +/-1yr
247	M	29 Jun 1970	WILD	WILD	W.GERMANY	29 Jun 1970	UNK	Captive Born	W.GERMANY	
					CINCINNAT	19 Jul 1972	M14006		U.S.A.	
251	M	~ 1974	WILD	WILD	KENYA	~ 1976	UNK	Wild Born	KENYA	
					FERNDALE	~ 1976	UNK		U.S.A.	
					ST LOUIS	12 Sep 1976	076444		U.S.A.	
254	M	1 Jan 1970	WILD	WILD	NAMIBIA	1 Jan 1970	UNK	Wild Born	NAMIBIA	
					FRANKLINP	9 Jul 1973	UNK		U.S.A.	
					BUFFALO	8 Nov 1976	UNK		U.S.A.	
						18 Jan 1983 (died)				18 Jan 1983
255	F	~ 1969	WILD	WILD	KENYA	~ 1973	UNK	Wild Born	KENYA	
					FERNDALE	~ 1973	UNK		U.S.A.	
					FRANKLINP	~ 1973	UNK		U.S.A.	
					METROZOO	21 Jan 1983	M00092		U.S.A.	
259	M	10 Apr 1977	182	181	ASA ZOO	10 Apr 1977	UNK	Captive Born	JAPAN	
					METROZOO	10 Nov 1983	M00208		U.S.A.	
267	F	16 Sep 1976	56	207	CINCINNAT	16 Sep 1976	M14008	Captive Born	U.S.A.	
					LOSANGELE	27 Oct 1979	09851		U.S.A.	
271	M	18 Sep 1978	241	150	ZURICH	18 Sep 1978	UNK	Captive Born	SWITZRLND	
					CHICAGOBR	5 Aug 1980	24401		U.S.A.	

Stud #	Sex	Birth Date	Sire	Dam	Location	Date	Local ID	Birth-Origin	Country	Death-Date
281	M	8 Dec 1979	74	213	SAN FRAN	8 Dec 1979	505	Captive Born	U.S.A.	
						17 Dec 1987	(died)			17 Dec 1987
285	M	7 Nov 1978	199	126	MEMPHIS	7 Nov 1978	UNK	Captive Born	U.S.A.	
					LOSANGELE	27 Aug 1979	09850		U.S.A.	
292	M	11 Dec 1979	79	293	GRANBY	11 Dec 1979	UNK	Captive Born	CANADA	
					SANDIEGOZ	25 May 1983	181039		U.S.A.	
					SD-WAP	11 Apr 1985	181039		U.S.A.	
293	F	~ 1970	WILD	WILD	AFRICAN	~ 1970	UNK	Wild Born	AFRICAN	
					GRANBY	6 Jun 1973	238637		CANADA	
						16 Dec 1986	(died)			16 Dec 1986
294	F	21 May 1981	169	190	SAN ANTON	21 May 1981	UNK	Captive Born	U.S.A.	
					CHICAGOLP	21 Jul 1982	6798		U.S.A.	
296	M	~ 1964	WILD	WILD	AFRICAN	~ 1971	UNK	Wild Born	AFRICAN	
					MEXICOCTY	~ 1971	UNK		MEXICO	
297	F	~ 1964	WILD	WILD	AFRICAN	~ 1971	UNK	Wild Born	AFRICAN	
					MEXICOCTY	~ 1971	UNK		MEXICO	
301	M	25 Feb 1980	56	207	CINCINNAT	25 Feb 1980	M14016	Captive Born	U.S.A.	
					SEDGWICK	23 Jun 1981	779			
302	M	7 Aug 1980	247	180	CINCINNAT	7 Aug 1980	M14019	Captive Born	U.S.A.	
					(SD-WAP)	28 Sep 1981	681515		U.S.A.	
304	M	9 Jul 1981	155	225	DENVER	9 Jul 1981	UNK	Captive Born	U.S.A.	
						9 Jul 1981	(died)			9 Jul 1981
305	M	31 Mar 1981	182	181	ASA ZOO	31 Mar 1981	UNK	Captive Born	JAPAN	
					COLO SPRG	10 Nov 1983	101541		U.S.A.	
308	M	18 Oct 1981	74	213	SAN FRAN	18 Oct 1981	UNK	Captive Born	U.S.A.	
					(CHICAGOLP)	17 Jun 1982	6780		U.S.A.	
309	F	30 Jun 1981	155	225	BUSCH TAM	30 Jun 1981	UNK	Captive Born	U.S.A.	
						19 Aug 1982	(died)			19 Aug 1982
311	F	~ 1974	WILD	WILD	KENYA	~ 1974	UNK	Wild Born	KENYA	
					FERNDALE	~ 1974	UNK		U.S.A.	
					R SCHMITT	24 Oct 1974	UNK		U.S.A.	
					COLUMBUS	6 Oct 1984	842122		U.S.A.	
					BUSCH TAM	24 Oct 1986	UNK		U.S.A.	
					DALLAS	13 Dec 1986	864857		U.S.A.	
317	F	29 Sep 1982	56	207	CINCINNAT	29 Sep 1982	M14028	Captive Born	U.S.A.	
					(CHICAGOLP)	12 Jun 1984	7421		U.S.A.	

Stud #	Sex	Birth Date	Sire	Dam	Location	Date	Local ID	Birth-Origin	Country	Death-Date
319	M	27 Mar 1982	54	55	OKLAHOMA	27 Mar 1982	UNK	Captive Born	U.S.A.	
						14 Apr 1982	(died)			14 Apr 1982
328	F	15 Nov 1982	161	163	DENVER	15 Nov 1982	06258	Captive Born	U.S.A.	
330	F	28 Dec 1981	261	262	NEW DELHI	28 Dec 1981	UNK	Captive Born	INDIA	
					FERNDALE	~ 1989	UNK		U.S.A.	
					OKLAHOMA	2 Feb 1989	484717		U.S.A.	
331	F	11 Dec 1982	169	190	SAN ANTON	11 Dec 1982	UNK	Captive Born	U.S.A.	
					SAN FRAN	~ 1984	UNK		U.S.A.	
					(KANSASCTY)	15 Jul 1984	UNK		U.S.A.	
					(COLO SPRG)	14 Jan 1987	870004		U.S.A.	
332	M	11 Jan 1983	247	180	CINCINNAT	11 Jan 1983	UNK	Captive Born	U.S.A.	
					(DENVER)	13 Jul 1984	07986		U.S.A.	
337	M	3 Oct 1983	74	213	SAN FRAN	3 Oct 1983	UNK	Captive Born	U.S.A.	
					KANSASCTY	19 Nov 1984	UNK		U.S.A.	
						12 Jul 1985	(died)			12 Jul 1985
343	F	4 Apr 1983	155	225	BUSCH TAM	4 Apr 1983	18237	Captive Born	U.S.A.	
						10 Sep 1987	(died)			10 Sep 1987
348	M	3 May 1982	UNK	255	BUFFALO	3 May 1982	UNK	Captive Born	U.S.A.	
						3 May 1982	(died)			3 May 1982
351	F	24 Jun 1985	74	213	SAN FRAN	24 Jun 1985	UNK	Captive Born	U.S.A.	
					(METROZOO)	15 Mar 1987	M00744		U.S.A.	
353	F	31 Oct 1985	251	121	ST LOUIS	31 Oct 1985	085437	Captive Born	U.S.A.	
						27 Apr 1986	(died)			27 Apr 1986
356	M	9 Feb 1986	155	225	BUSCH TAM	9 Feb 1986	18539	Captive Born	U.S.A.	
359	F	1 Feb 1986	169	190	SAN ANTON	1 Feb 1986	860200	Captive Born	U.S.A.	
					CINCINNAT	16 Jul 1987	M14058		U.S.A.	
					(CALDWELL)	17 Jul 1987	001111		U.S.A.	
360	F	25 Aug 1985	285	267	LOSANGELE	25 Aug 1985	UNK	Captive Born	U.S.A.	
					KANSASCTY	17 Jan 1988	002218		U.S.A.	
						27 Jan 1988	(died)			27 Jan 1988
361	M	3 Oct 1985	54	55	DETROIT	3 Oct 1985	1652	Captive Born	U.S.A.	
					OKLAHOMA	3 Oct 1985	UNK		U.S.A.	
					DETROIT	12 Oct 1985	(died)		U.S.A.	12 Oct 1985
362	M	11 Mar 1986	259	202	METROZOO	11 Mar 1986	UNK	Captive Born	U.S.A.	
					CALDWELL	15 Sep 1988	001315		U.S.A.	

Stud #	Sex	Birth Date	Sire	Dam	Location	Date	Local ID	Birth-Origin	Country	Death-Date
363	M	14 Dec 1985	247	180	CINCINNAT	14 Dec 1985	M14046	Captive Born	U.S.A.	
					(CHICAGOBR)	23 Mar 1987	870051		U.S.A.	
364	F	27 Dec 1985	56	207	CINCINNAT	27 Dec 1985	M14047	Captive Born	U.S.A.	
					SAN ANTON	19 Jul 1987	870793		U.S.A.	
365	F	18 Jan 1985	271	235	CHICAGOBR	18 Jan 1985	850006	Captive Born	U.S.A.	
367	F	6 Nov 1986	251	212	ST LOUIS	6 Nov 1986	UNK	Captive Born	U.S.A.	
					DETROIT	6 Nov 1986	UNK		U.S.A.	
					(CALDWELL)	9 Jul 1987	086435		U.S.A.	
						31 Jan 1990	(died)			31 Jan 1990
372	M	11 Dec 1986	271	235	CHICAGOBR	11 Dec 1986	UNK	Captive Born	U.S.A.	
					(CALDWELL)	22 Oct 1988	001425		U.S.A.	
376	M	7 May 1987	161	163	DENVER	7 May 1987	10522	Captive Born	U.S.A.	
					PORTLAND	25 Jun 1988	88036		U.S.A.	
377	M	12 Jul 1987	302	239	SD-WAP	12 Jul 1987	687485	Captive Born	U.S.A.	
					SANDIEGOZ	5 Jan 1990	687485		U.S.A.	
					(LANSING)	30 Jun 1990	1304		U.S.A.	
381	M	10 Jun 1986	285	76	LOSANGELE	10 Jun 1986	UNK	Captive Born	U.S.A.	
					(OKLAHOMA)	9 Jun 1988	460416		U.S.A.	
					(MILWAUKEE)	27 Jun 1989	3359		U.S.A.	
382	F	31 Dec 1986	259	255	METROZOO	31 Dec 1986	M00711	Captive Born	U.S.A.	
						3 Feb 1989	(died)			3 Feb 1989
383	F	2 Jul 1988	74	213	SAN FRAN	2 Jul 1988	188050	Captive Born	U.S.A.	
					(MILWAUKEE)	19 Dec 1989	3408		U.S.A.	
388	M	26 Aug 1986	268	282	DVURKRALV	26 Aug 1986	UNK	Captive Born	CZECHOSLO	
					ATLANTA	18 Oct 1989	891043		U.S.A.	
389	M	12 Sep 1988	292	233	SD-WAP	12 Sep 1988	688551	Captive Born	U.S.A.	
					CHICAGOBR	12 Sep 1988	880335		U.S.A.	
					(COLUMBUS)	9 Oct 1989	892117		U.S.A.	
395	M	18 Mar 1988	52	202	METROZOO	18 Mar 1988	M00924	Captive Born	U.S.A.	
396	F	4 Nov 1988	271	235	CHICAGOBR	4 Nov 1988	880388	Captive Born	U.S.A.	
					(PORTLAND)	15 Mar 1990	90023		U.S.A.	
397	F	19 Oct 1988	247	180	CINCINNAT	19 Oct 1988	M14066	Captive Born	U.S.A.	
					(COLUMBUS)	10 Apr 1989	892021		U.S.A.	
398	F	28 Jan 1989	259	255	METROZOO	28 Jan 1989	M01055	Captive Born	U.S.A.	
						8 Feb 1989	(died)			8 Feb 1989

Stud #	Sex	Birth Date	Sire	Dam	Location	Date	Local ID	Birth-Origin	Country	Death-Date
409	M	~ 1952	WILD	WILD	AFRICAN	~ 1954	UNK	Wild Born	AFRICAN	
					PRSPCT PK	12 Jul 1954	UNK		U.S.A.	
					DETROIT	1 Aug 1988	2492		U.S.A.	
418	F	23 Mar 1989	281	55	DETROIT	23 Mar 1989	UNK	Captive Born	U.S.A.	
					OKLAHOMA	24 Mar 1989	UNK		U.S.A.	
					(DETROIT)	24 Mar 1989	2797		U.S.A.	
					(BUSCH TAM)	10 Aug 1990	UNK		U.S.A.	
419	M	21 May 1989	308	317	CHICAGOLP	21 May 1989	8910	Captive Born	U.S.A.	
					CINCINNAT	22 May 1989	UNK		U.S.A.	
					(GARDENCTY)	31 Jul 1990	UNK		U.S.A.	
423	F	5 Jan 1990	251	212	ST LOUIS	5 Jan 1990	090001	Captive Born	U.S.A.	
						12 Jan 1990	(died)			12 Jan 1990
426	F	6 Jan 1990	74	213	SAN FRAN	6 Jan 1990	190003	Captive Born	U.S.A.	
					(ATLANTA)	23 Nov 1990	901030		U.S.A.	
427	M	25 Feb 1990	292	239	SD-WAP	25 Feb 1990	UNK	Captive Born	U.S.A.	
432	M	30 Oct 1989	161	163	DENVER	30 Oct 1989	11902	Captive Born	U.S.A.	
435	M	29 Nov 1990	292	233	SD-WAP	29 Nov 1990	690706	Captive Born	U.S.A.	
64	F	4 Oct 1990	332	328	DENVER	4 Oct 1990	UNK	Captive Born	U.S.A.	
T2065	F	7 Mar 1991	271	235	CHICAGOBR	7 Mar 1991	910037	Captive Born	U.S.A.	

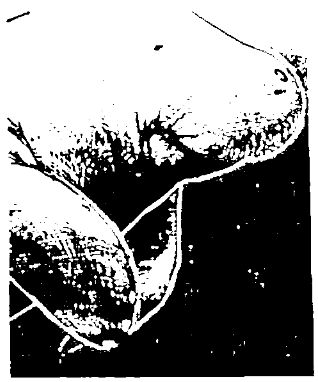
TOTALS: 49.57.0 (106)











AMERICAN ASSOCIATION OF ZOOLOGICAL PARKS AND AQUARIUMS
A·A·Z·P·A 1924

AAZPA ANNUAL REPORT
on conservation and science

RHINOCEROS ADVISORY GROUP

Chair:
Robert W. Reece, Wild Animal Habitat, Kings Island

Primary Goals

The AAZPA Rhinoceros Advisory Group was officially recognized in January 1991 by the AAZPA's Wildlife Conservation and Management Committee (WCMC). While still in the formative stages, the group has the following long-term objectives: (1) to establish a regional management plan for rhinos which focuses on the efficient use of existing resources, the development of new resources, and the encouragement of effective relationships with other regional breeding programs (e.g., EEP, ASMP, etc.); (2) to develop strategies for the support of *in situ* conservation efforts through increased communication and interaction between SSP institutions, range country managers, NGO's and field scientists; (3) to identify research priorities and assist in the development and implementation of an aggressive research program with specific objectives in those areas of greatest concern; (4) to maintain current information on the status of all captive and wild rhino populations; and (5) to assess the implementation of all rhino SSP Master Plans and provide assistance wherever possible.

Data Table

	Current year
# of meetings	0
# of studbooks under umbrella	4
# of SSPs under umbrella	4
# of new studbook petitions submitted	0
# of new studbooks approved	0
# of new SSP petitions submitted	0
# of new SSPs approved	0

Special Concerns

It has become increasingly apparent that there is a real need to facilitate communication among and between people and programs involved with rhino conservation. Many are convinced that there are conflicting and competing agendas at work and that to support one aspect or approach necessarily detracts from another. Misinformation concerning the efficacy of the various approaches, especially captive breeding, needs to be eliminated. The AAZPA Rhino Advisory Group will use *Around The Horn, The Rhino Conservation Newsletter* to disseminate factual information and serve as a conduit through which individuals and institutions can communicate with everyone involved in the preservation of rhinos.

There must be a concerted effort to increase the amount of resources available to rhino conservation, especially in terms of money and space. While space allocation can be more efficient, the cost of developing and maintaining rhino programs such as research and *in situ* projects will be considerable. As a result, methods will have to be developed to provide these resources.

Progress Toward Goals

(1) The Rhino Advisory Group is in it's formative stages and has only begun to develop specific long- and short-range objectives. The membership selection process is nearly complete and is intended to be flexible so as to allow for the greatest influx of ideas and discussion.

(2) A Rhino strategic planning meeting was held at the New York Zoological Park in July 1991. Much progress was made in identifying major concerns and in outlining various programmatic needs. An additional meeting will be held in connection with the 1991 AAZPA Annual Conference in San Diego.

Short-term Goals for Upcoming Year

(1) Complete an assessment of captive holding space and how it is currently allocated in the North American region.

(2) Initiate an assessment of the rhino husbandry and management practices in institutions holding black and white rhinos.

(3) Formalize a research subcommittee and charge it with the responsibility of developing an aggressive research strategy designed to assist in the veterinary, husbandry and reproductive management of rhinos.

(4) In conjunction with the CBSG Rhino Captive Action Plan Working Group, initiate a concerted effort to address and resolve the black rhino subspecies question.
(5) Begin the development of a unified Regional Collection Plan for all rhinos under the TAG umbrella.

BLACK RHINOCEROS (*Diceros bicornis michaeli* and *D. bicornis minor*)

Species Coordinator: Edward J. Maruska, Cincinnati Zoo and Botanical Garden
Subspecies coordinator: Don Farst, D.V.M., Gladys Porter Zoo
International Studbook Keeper: H.G. Kloss, Berlin Zoo

Introduction

Population genetic analyses have shown that the minimum viable population size (MVP) for black rhinos necessary to maintain 90% of original genetic diversity for 200 years is 150 animals split up into 75 *michaeli* and 75 *minor*. At the present time, there are 67 *michaeli* in 23 institutions and 19 *minor* in seven institutions for a total of 86 animals in 30 institutions in North America. Even though the goal is to preserve 90% of the average heterozygosity in the gene pool for 200 years, in the case of the black rhino, there seems to be some "intuitive logic" in modifying this objective in terms of rhino generations; 10 rhino generations would represent 150-170 years.

At present growth rates, *michaeli* , with a population of 67, should be expected to reach the target "carrying capacity" of 75 in about five years. With a current population of *minor* at 19, it will obviously be some time before the SSP population can attain its target "carrying capacity" of 75. The black rhino SSP is in the mature stage.

In summary, the long-term goals of the Black Rhino SSP are: (1) to propagate black rhino in North America to reinforce wild populations in Africa as part of the IUCN global strategy; (2) toward this goal, to attempt to preserve 90% of the average heterozygosity obtained from wild populations for a period of at least 170 years (10 black rhino generations) and perhaps longer; (3) to respect, at least initially, the four geographical varieties and potential e.s.u.'s recognized by the 1986 Cincinnati African Rhino Workshop; (4) to develop an SSP population of 150 black rhino in North America; (5) to expand the captive habitat for black rhino in North America and emphasize reproduction of black rhino in the management recommendations to insure the self-sustainment and expansion of the captive population against the appreciable mortality still occurring.

Data Table (current through 1 July 1991)

D.b. michaeli

	One year ago	Current year
Participating institutions	22	23
Captive Population	31.35	31.36
# SSP animals managed	66	67
# SSP animals not required to meet goals	0	0
# animals in non-participant collections but desirable to SSP	2	2
Total births in SSP program	5	1
# surviving to one year	4	1
# of desired births	5	1
# of undesired births	0	0
# of deaths of SSP animals	2	1
# of imports	0	0
# of exports	0	0
# of founders with represented descendants	78	78

D.b. minor

	One year ago	Current year
Participating institutions	7	7
Captive Population	7.12	7.12
# SSP animals managed	19	19
# SSP animals not required to meet goals	0	0
# animals in non-participant collections but desirable to SSP	0	0
Total births in SSP program	1	1
# surviving to one year	1	0
# of desired births	1	1
# of undesired births	0	0
# of deaths of SSP animals	0	1
# of imports	0	0
# of exports	0	0
# of founders with represented descendants	11	11

Current Population Status

The population of *michaeli* is approaching the proposed MVP of 75 animals as it currently numbers 67. The birth rate is minimum at best with an increase of only three animals in 1990 and one born in 1991 to date. Because the black rhino population in the wild dropped 85% in only thirty years, from 60,000 in 1960 to under 3,000 today, more emphasis needs to be focused on captive breeding in order to increase the birth rate for both *michaeli* and *minor*. In 1990, only one *minor* was born and in 1991, to date, only one has been born but it died the same day. There have been no imports or exports in 1990-1991. All black rhinos in the population are SSP non-surplus animals and two *michaeli* in the Mexico City Zoo have not been included in the North American population because they have not signed a Memorandum of Participation. The population size of *minor* needs to be increased.

Demographic Trends

The Black Rhino SSP is attempting to manage two of the four potential evolutionarily significant units (e.s.u.'s) for black rhino: *michaeli* and *minor*. Reproduction is occurring as explained above, but at a slower rate than is desirable. There have been no recommendations made to remove any animals from the breeding population. The Black Rhino Master Plan has been closely followed and almost every recommendation has been quickly accomplished.

Population Genetics

The addition of ten new founders of *minor* for the North American population is being planned through the International Black Rhino Foundation agreement with the Zimbabwean government. The U.S. Fish and Wildlife Service received a permit number on 1 July 1991 and it is anticipated that they will issue the permit by October. At the present time there are only 11 founders with represented descendents of *minor* in the North American population. There is an ongoing effort to increase founder representation. In Malaysia at Zoo Negra there is an adult male *michaeli* that may become available for import (in exchange for a pair of white rhino) and there is a 15 year-old female *michaeli* at the Buenos Aires Zoo, Argentina that may be available (in exchange for a young pair of black rhino).

Special Concerns

The population of *minor* needs to be increased and currently there is a dearth of space for *michaeli* which may have an eventual impact on space for *minor*. The Black Rhino SSP has been working with the White Rhino SSP in hopes of moving white rhino from selected institutions to open up more space for black rhino. The Black Rhino SSP may be forced to send some animals out of the U.S. in order to solve this problem. Presently there is a request from the San Diego Zoo to send a male to Japan. This male will probably be sent with the prerequisite that the Yokohama Zoo participate in the SSP. The question of whether or not to keep *michaeli* and *minor* as two subspecies still begs an answer and genetic analyses are ongoing even though there are no apparent morphological differences. Also, biochemical analyses to date have not yet demonstrated any differences between *michaeli* and *minor*.

It will be extremely important to evaluate and determine, over the next five years, the nutritional requirements for captive black rhino.

Research

Current research involves reproduction studies such as hormonal evaluations of urines, bloods, saliva, feces; ultrasound evaluations for pregnancy, ovarian observations and anatomy; semen freezing; anatomical studies at necropsy; development of instrumentation for embryo transfer; nutritional studies involving vitamin E; and disease related studies. There needs to be an increased focus on nutritional studies and problems involving diseases such as hemolytic anemia.

Field Conservation

The International Black Rhino Foundation agreement with the Zimbabwean government will help support field operations in Zimbabwe. Monies raised from the efforts of Michael Werikhe as he walks across the U.S. will benefit black rhino conservation in Africa.

Progress Toward Goals

(1) Completion of negotiations (through the Black Rhino Foundation) with the Zimbabwean government to obtain 10 new founders for the SSP population.

Short-term Goals for Upcoming Year

(1) Make all recommended transfers. The proposed number of *michaeli* transfers during the upcoming year should be approximately six or more depending upon numbers of births and sexes of calves.
(2) Attempt to breed to conception all recommended females.
(3) Make and communicate recommendation to wean calves as soon as possible to be able to expose post-lactational cows to bulls.
(4) Carefully evaluate management of new *minor* founders so that the entire population will be enhanced.
(5) Seek more space for both *michaeli* and *minor* in order to achieve the MVP of 150 animals.