Table 11. Heterozygosity remaining at generation 200 as % of initial heterozygosity.

Annual growth	Generation growth	No migration	1 migrant	2 migrants	Panmixia
1.3%	25%	97	95	93	94
		66	81	84	94
2.4%	50%	96	92	95	96
	64	78	86	96	
5.0%	129%	93	95	95	97
	63	81	87	97	
7.0%	216%	95	94	95	96
	69	80	87	96	
8.0%	270%	97	98	92	96
	64	80	84	96	

Top values of each pair are average total gene diversity, bottom values are average within-population heterozygosities. Differences of less than 5% are probably not significant.

In each population, but the difference (in gene diversity preserved) between isolated populations, populations exchanging some migrants, and even a panmictic population is trivial for the rhinos.

Although total gene diversity is well maintained under all of the assumed population structures, heterozygosity is lost from within populations (i.e. some “inbreeding” occurs within each population). In the worst case (no migration), up to 35% of the heterozygosity would be lost, on average, from each isolated population. The average results from a much greater loss in the smaller populations (the Meru population would be expected to lose 64% of its heterozygosity ln 20 generations, even if it were begun at its carrying capacity of 20) countered”by lesser losses in the larger populations (Aberdare would lose about 180/s of its heterozygosity in 20 generations). As very rough rules-of-thumb, the effect (“‘inbreeding depression”) of a loss of less than 5% heterozygosity in any one generation is generally hard to detect, and animal breeders notice little or no effect of the loss of 1 % heterozygosity per generation continued over many generations. Thus, the small rhino reserves are probably too small to sustain populations for many generations, ln the absence of occasional inter-reserve movements of animals, free from genetic problems. Relatively low rates of migration, 1 or 2 migrants per generation per population, would probably be sufficient to prevent genetic problems. (This assumes migrants are as successful as are residents at breeding).

Neither starting the populations at carrying capacity (rather than 1985 levels) nor varying the population growth rate had much effect on the genetic results. This is because only rapidly growing populations were considered.. At even the lowest population growth, 25% per generation, most of the populations would reach carrying capacities in just a few generations. The genetic fates of these populations are much more determined by their limited sizes than by the number of founders.

General comments

Rhinos, both in the wild and in captivity, are probably not in Immediate danger of genetic problems arising from loss of diversity. Given the long generation time, all except the very smallest captive and wild stocks would experience minimal inbreeding in the next century or so. (For example, a population of 64 could be propagated for 6 generations with no matings between even distantly related animals). This optimistic genetic picture assumes, however, that protected rhino populations are currently at minima (i.e. they are at the worst phase of the population bottlenecks) and that they grow at reasonable rates over the next century.

Demographically, both wild and captive populations may be in serious trouble. The captive record is not good: as many as half of the animals have never reproduced, and birth rates approximately equal death rates. The large, and seemingly stable, captive population results in large part from the many wild-caught animals, not from a good record of captive breeding. As discussed in Cincinnati, there is reason to hope that this picture is changing, but the zoo community cannot yet claim to be able to sustain continuously growing stocks of black and white rhinos.

The small rhino reserves that are likely to receive adequate protection from poaching may not be large enough to prevent extinction due to random fluctuations in births and deaths, even under the most optimistic scenarios of environmental. and demographic constancy. The primary cause for hope for the African rhinos lies in the very long generation times and low-adult mortality (in the absence of poaching): traits that make population decline a very slow process, but also make rapid recovery difficult (witness the condor).

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DEVELOPING STRATEGIES FOR NORTHERN WHITE RHINOS

Session Chairman DAVID JONES

NORTHERN WHITE RHINOS IN GARAMBA NATIONAL PARK

Summary of presentation by Kes Hillman-Smith

Background

Garamba National Park in northern Zaire is now the last known place where the northern sub-species of white rhinoceros *(Ceratotherium simum cottoni)* exists in the wild with any chance of survival. At the turn of the century, the subspecies occurred from southern Chad, through South Sudan as far east as the Nile, and through the northern edge of Zaire to West Nile Province in Uganda (Hillman—Smith *et* al., 1986).

When the Park was established ln 1938 there were probably not more than 100 white rhinos there (Curry-Lindahl, 1972). Black rhinos *(Diceros bicornis)* have never occurred in this part of Zaire. The rhino numbers increased, until by 1963 there

was estimated to be between 1 000 and 1 300 rhinos (Park reports in Curry-Lindahi, 1972). Then, during the "Simba" rebellion, the Park was occupied by guerillas and poaching from Sudan was rife Curry-Lindahi states that approximately 100 was a "rough and perhaps optimistic estimate" in 1966. In 1969, control of the Park was regained and it became legal to shoot poachers not responding to orders to surrender. Rhino numbers rose again, and an aerial census in 1976 estimated 490+/—270 in the Park (Savidge *et al.,* 1976). After the end of an FAO aid project, funds from the directorate of the wildlife department (now called the institut Zairois pour Ia Conservation do la Nature, IZCN), for salaries and for maintenance and running of vehicles, were limited and usually late in coming. Park staff were not only unable to control poaching but many were involved in it to support themselves. in 1980, when we visited the Park as part of a pan-African rhino survey for IUCN and the New York Zoological Society, a project was proposed with the primary aim of conserving the rhinos. In 1983, on the basis of an intensive aerial survey, we estimated that there were between 13 and 20 rhinos remaining In the Park. In March 1984, the IUCN Garamba Rehabilitation Project started, funded by the World Wildlife Fund for Nature (WWF), Frankfurt Zoological Society (FZS) and the United Nations Educational, Scientific and Cultural Organisation (UNESCO). Some funds were also obtained from the Kenya Rhino Action Group (KRAG) and the Fauna and Flora Preservation Society (FFPS) specifically for ancillary work to assess the status of and to monitor the rhino population. Later some support was given by the Wildlife Conservation Fund. The results reported here are based on that and a part-time continuation of that work, in conjunction with the Garamba Rehabilitation Project and the IZCN biologist, Mr. Mankoto and his short term replacement Dr. Mbieme.

This report summarizes observations made during the period April 1 1984 ——October 1986.

Habitat

The Park covers 4 900 sq. km in the ""Guinea savanna belt In the north-east of Zaire, bordering on southern Sudan. The mean annual southern rainfall is 1 500 mm, which falls mainly in a long wet season from April to November or December. The southern two-thirds of the Park are largely open long grass savanna, dominated by *Loudetia arundinacea* and various *Hyparrhenia* species, which reach 2-3 m in height, with patches of certain species growing even taller. Sparsely scattered throughout the grassland are mature trees, predominantly *Kigelia africana* and *Vitex doniana,* with some patches of *Crossopteryx febrifuga* on shallow soils. Towards the edges and in the north are medium to sparse denisty areas of the deciduous bush woodland that dominates the surrounding country, comprising particularly, *Combretum collinum, Nauclia letifolia, Crossopteryx febrifuga, Hymencardia acida* and *Piliostigma thonningii.* The grassland is richly dissected by watercourses, with flowing water, marshes and patches of relict gallery forest. In the far north, the Park rises in more wooded, broken ground and scattered inselbergs to the Zaire/Nile watershed. The Park is far more open than the surrounding country and, according to reports, has been for some time, probably before its gazetting. Human factors, of clearing and burning, and elephants are probably the principal causes. About 90% **of** the grassland is burnt each year and there is little evidence of regeneration of woody vegetation.

Poaching is now largely controlled in the southern third of the Park. It still exists in the north but is not as severe as in many countries and meat is one of the main motivations. The rhino have probably always been more densely distributed in the south, but now they are confined almost entirely to the central part of the southern section, as far from the penetration of the poachers as possible.

Methods

Recognition of individuals has been the main means of emunerating and monitoring the rhinos end their social and population dynamics. They are found by a combination of ground and aerial work, since they are sparsely distributed. in the first few months, it was predominantly ground work, on foot in the Park. Effective ground work is, however, limited to the dry and early wet seasons, from January to May or June, after which the grass is too long. Now, due to other committments and lack of funds, the rhino monitoring is part-time and predominantly aerial, although reports are also made by the guards patrolling on foot in the rhino areas.

Horn configurations and ear and tail marks are the main characteristics used for recognition, although apart from one female with a large chunk missing from an ear and a young male missing half his tail, horn configurations are all that can be seen from the air. The most effective way to find them from the ground is with aerial support and ground-to-air contact. The most effective method of aerial monitoring has been found to be a series of flights over a few days, intensively searching as much of the area as practical, in blocks.

For each observation, the age, sex and identification of the individual is recorded as far as possible, together with the location, habitat, activity and any other notes. On the ground, activity is recorded over a period of time and notes made on behaviour and feeding. All spoor found are measured and locations of these, defecation sites, old skulls and any other marks are recorded.

Age classification is based on the criteria outlined In Hillman-Smith *et al.* (1986). Sub-adults are classified as being those animals three years or older, whether with their mothers or not and those who on the basis of horn and body size and behaviour appear to be less than adults. For the purpose of this analysis, infants and juveniles have been classified together as juveniles.

Numbers

We know that at least 18 individuals exist, or existed very recently, in the Park. Individual distinction is not always 100% certain from the air, nor is it always possible to sex an individual in quick aerial passes if the grass is very long or the animals do not display themselves well. This accounts for the fact that we are still not precisely sure how many adults there are, because some of these records may be re-sightings of the same animal appearing different under different conditions. We do know that in a recent series of recce flights we saw at least 17 different individuals, possibly 18, though we cannot confirm one pair of observations that could have been the same individuals at different times. Shortly after that series, the most recent calf was born, bringing the number to a minimum of 18. individual characteristics, however, indicate there are possibly more. Since April this year, we do not have confirmed observations of either of the sub-adults that left their dams when the next calf was born. This could indicate that something has happened to them, but more likely that they have dispersed out of the area we frequently search. it is not uncommon for any given animal to be unrecorded for some time and then to be seen again. This may be due to simply missing it or to temporary dispersals. The returns per unit effort in searching the most peripheral areas are so low, that in practice monitoring flights are mainly carried out over the central 5-6 000 sq. km.

Population Dynamics

The sex ratio of the confirmed sexed and known animals is 9 males to 8 females, excluding one calf and other possible adults. The age ratio of 22% male adults, 28% sub-adults and 22% juveniles is similar to that found by Owen-Smith (1973) for southern white rhinos (C.s.*simum),* although in his population the proportion of sub-adults was slightly higher. Unfortunately, in this population the majority of sub-adults appear to be males.

Reproduction has been good throughout the period of observation. Starting annual periods from the time of the March 1983. census, three calves were born and survived in 1983/4, one in *1984/5,* another three in 1985/6 and one more so far in this period. Two of the females have had an approximately two year inter-calf interval. All the confirmed known females at present have a juvenile with them, although one juvenile is around three years old and currently classified as a sub-adult.

We have no evidence of deaths throughout the effective period of the project. Mankoto and the guards reported one dead rhino in 1983 before the project, and a poacher was caught in 1984, before the project had vehicles and had become effective, who claimed to have killed two rhinos that year and two the year before. Two elephant carcasses that were found in the southern section on monitoring flights both had their tusks and the animals appeared to have died from "natural causes".

The sample size is too small for a statistical analysis, but during the operation of the project the mean population increase appears to have been greater than 10% per annum.

Range

The overall area in which we have observed rhinos is 676 sq. km, although guards have reported spoor sightings further afield than that. Observed ranges of individuals to date vary from 57 to 259 sq. km, with the females tending to have smaller ranges. The ranges are, however, of the order of 10 times greater than those recorded for southern white rhinos (Owen-Smith, 1973). This may be due to the low density, but there appear to be factors (one of which is probably the burning) that lead to changes in ranges. One female and two males, for example, were commonly found north of the Garamba River last year, but now are usually south of it. The move coincided with a time when burning had been particularly severe to the north, while some areas had deliberately been left unburnt to the south. For the one female, F4, the two parts of her range coincided with two different calves, but this has not occurred with other animals.

There is a central core area, where the chances of finding rhinos at any one time are greater than elsewhere. There are some indicators of territoriality among dominant bulls who nevertheless tolerate sub-adult or subordinate bulls, as was found by Owen-Smith (1973). This was not found by van Gyseghem (1979) on northern whites in Uganda, but his population was too small. Defecation and marking sites do not remain long or accumulate in this high rainfall, high termite-density environment, but the ranges of some of the older males remain peripheral to the central area, which is occupied primarily by one apparently dominant bull. We have also observed the aftermath of a fight between two bulls, who were unusually close to the core area.

Social Groups

Social relations are also similar to those found among southern white rhinos. 48% of observations were of groups of 2, the majority of which were mothers and calves. 35% of observations were of lone animals, the majority of which were adult males. Sub-adults are most commonly found with other animals, usually other sub-adults or females.

Larger, temporary amalgamations are only occasionally found, but it is not uncommon to find a number of groups, particularly those of females, remaining In the vicinity of each other and changing locations more or less together.

Discussion of future status

This is a very small population and as such is precarious, but observations during the period of the project are very encouraging. Reproductive success has been good, and while the project exists the status of the rhinos appear to be stable. The IZCN is now on a better footing with the new President Delegue General, Mankoto ma Mbaelele. Salaries have significantly increased and arrive in better time. However, if international support were to end at this stage the situation would deteriorate again to the detriment of the rhinos and this whole World Heritage Site. We therefore feel it is important that the Rehabilitation Project continues in at least some form at the end of its initial three years.

Further to the existing efforts, I have proposed the need for an assistant who could be based out in the field full-time, studying and monitoring the rhinos and the ecosystem, working with the guards who patrol the area and with an IZCN counterpart, in conjunction with the author's continued part-time work and aerial support. The proposal has been approved by IZCN but funds are needed. A long term continuation of the research in various forms would also be valuable for monitoring the situation and maintaining an international link without having to rely on the organisations that fund the Rehabilitation Project.

In the long term, the development of tourism would increase the national and local value of the Park and enable some form of self-support. This is not easy to sustain in such a remote area but it would be possible to develop specialist, but inevitably expensive tourism, beyond the limited local tourism that already operates. The existence at the Park of the only African elephant domestication centre is a major attraction and it is hoped that future funds could therefore be invested to re-develop the elephant school and the tourist facilities as well as to help to maintain the Park and the anti-poaching activities.

If the rhinos could be adequately protected, I estimate, on the basis of the current population structure, an inter-calf interval of 2-3 years and a projected loss of one animal a year. The doubling time of the population would be in the region of ten years. It is Therefore vital that this wild population is backed up by improving breeding of the captive population, which currently numbers 11 animals. If the various techniques for improving reproduction could be developed and successfully applied to the captive rhinos, it might be possible to envisage a future link in the management of the captive and wild groups to improve the status of both, by genetic exchange and re-introductions, It could be an exciting example of complementary action to save a sub-species from extinction and as a result to help conserve a valuable ecosystem and National Park.

Table 12. Some results from observations of northern white rhinos ln Garamba National Park, April 1984—October 1986.

A. AGE AND SEX RATIOS

Age ratio of confirmed known animals		
MA	4	22%
FA	5	28 %
S	5	28 %
J	4	22%

B. OBSERVED HOME RANGES

Individual	Size (sq. km)	Dates of observation
M2	185	Mar 84 - Oct 86
M3	112	May 84 - Oct 86
M4	259	Aug 84 - Oct 86
M5	105	Apr 85 - Oct 86
M6	218	Mar 86 - Oct 86
M7	174	Feb 86 - Sep 86
M8	86	Apr 86 - Sep 86
M9	132	Mar 86 - Oct 86
F1 and 1a	138	Apr 84 - Oct 86
F3, 3a and 3b	137	Apr 84 - Oct 86
F4, 4a and 4b	196	Jan 85 - Oct 86
F4 and 4a	82	Jan 85 - Apr 86
F4 and 4b	65	Aug 85 - Oct 86
F5 and 5a	93	Apr 84 - Oct 86
F6 and 6a	57	Mar 86 - Oct 86
3a/4a	90	Jul 85 - Oct 86

Mean range for adult males	183 sq. km(well known only)
Mean range for adult females	124 sq. km
Mean range for S2	143 sq. km
Range for S1	90 sq. km
Total range of direct Observations	676 sq. km

C. FREQUENCY OF OBSERVED SOCIAL GROUPS

Group composition	No. Observations	% of total
MA	103	32
FA	6	2
MA+FA	14	4
AU	9	3
MA+FA+S	11	3
MA + FA/s + J/s	27	8
MA + FA + S +J	3	0.9
MA + S/s	3	0.9
FA + S	8	2
FA + J	115	35
FAs + Js	1	0.3
FA + S + J	9	3
FAs + Ss + Js	1	0.3
S	5	2
S	18	6

M = male; F = female; U = unknown; A = adult; S = sub-adult; J = juvenile.

GARAMBA NATIONAL PARK — MANAGEMENT

Information presented by Charles Mackie (Garamba Rehabilitation Project)

The rehabilitation of Garamba is an IUCN project in collaboration with the Zairois Institute for Conservation of Nature, funded by the World Wide Fund for Nature (WWF), the Frankfurt Zoological Society and UNESCO. The objectives of the project are:

— to re-equip the Park;
— to restore the infrastructure;
— to retrain staff to control poaching.

Efforts are directed at the conservation of the entire Garamba ecosystem (not specifically at rhino conservation).

By the end of its initial three-year period, the project will have cost US$600 000. Two expatriates are employed full-time to assist in the Park management.

Guards are constantly on patrol in the main rhino area, with other guards nearby at a radio base, in constant contact with the Park headquarters. There are 24 patrol posts around the periphery of the Park with 4-6 guards living under uncomfortable conditions in each.

A major constraint to the management of the Park is the dense grass growth, which severely restricts horizontal visibility for at least half the year, and makes patrolling difficult. Hence an aircraft is particularly valuable for surveillance work.

At present, it would not be sensible to attempt to translocate the Garamba rhinos elsewhere; this is against government policy, and the animals appear to be relatively secure, and breeding well. A long-term international commitment to Garamba is necessary if current levels of support are to be maintained until the rhino population has at least doubled; this will require an investment of about US$1 million, in addition to the US$0.6 million already spent. To support a field biologist to closely monitor the rhinos and study various biological and ecological aspects, the initial annual cost would be about US$42 000 with continuation costs of US$26 000. Generation of revenue through tourism could not be significant until the Park's tourist facilities are considerably Improved; if tourism does develop, a procedure exists whereby the funds could be returned directly to the Park.

NORTHERN WHITE RHINOS IN CAPTIVITY

Information presented by David Jones (Zoological Society of London), Ulysses Seal (IUCN Captive Breeding Specialist Group), and Oliver Ryder (Zoological Society of San Die go).

When Dr. Faust of Frankfurt Zoo carried out a survey of northern white rhinos in captivity he determined that there was an old animal at San Diego, another at London, and one at Antwerp which has since died. There were also animals of doubtful origin at Riyadh and a male at Khartoum. The largest captive group was (and still is) at Dvur Kralove in Czechoslovakia. At the invitation of the zoo managers at Dvur Kralove, D. Jones and U. Seal visited this zoo in February 1986. The Czechoslovakian authorities indicated a strong interest in developing a constructive breeding programme and have maintained close liaison with the Captive Breeding Specialist Group (CBSG). Some work has been done to facilitate the management system so that more females can become productive. As part of this plan, the male from London was sent to Dvur Kralove in the summer of 1986.