MANAGEMENT

Biological management of the high density black rhino population in Solio Game Reserve, central Kenya

Felix Patton, Petra Campbell, Edward Parfet

c/o Solio Ranch, PO Box 2, Naro Moru, Kenya; email: felixp@africaonline.co.ke

Abstract

Optimising breeding performance in a seriously endangered species such as the black rhinoceros (*Diceros bicornis*) is essential. Following an estimation of the population demography of the black rhinos in Solio Game Reserve, Kenya and a habitat evaluation, a model of the Ecological Carrying Capacity showed there was a serious overstocking. Data analysis of the first year of rhino monitoring indicated a poor breeding performance of 3.8% and a poor inter-calving interval in excess of 36 months. Biological management was required to improve the performance of the population by the removal of a significant number of individuals – 30 out of the 87. The criteria for selection were: to take no young animals i.e. around 3.5 years of age, to take no breeding females i.e. those with calves, to take care to maintain some breeding males in Solio, to attempt to ensure some breeding males are part of the 'new' population, to take care to leave a balanced population, to take care to create a balanced population in the 'new' population, to move those individuals that were hard to identify and to keep individuals which were easy for visitors to see. The need for careful candidate selection, the comparison of the population demography pre- and post-translocation, and the effect of the translocation activity on the remaining Solio population are discussed. While it will take many more months, even years, to fully ascertain the effect, beneficial or otherwise, of the biological management of the herd, preliminary results were encouraging.

Additional key words: translocation; population demography; monitoring; breeding performance; black rhino

Résumé

L'optimisation de la performance de reproduction chez une espèce sérieusement en danger tel que le rhinocéros noir (*Diceros bicornis*) est essentielle. Selon une estimation de la démographie de la population des rhinocéros noirs dans la réserve naturelle de Solio au Kenya et une évaluation de l'habitat, un modèle de Capacité de Charge Écologique a révélé qu'il y avait une surcharge sérieuse d'animaux. L'analyse des données de la première année de surveillance des rhinocéros a indiqué une faible performance de reproduction de 3,8% et un intervalle de l'intervêlage décevant dépassant les 36 mois. La gestion biologique était requise pour améliorer la performance de la population par l'enlèvement d'un nombre considérable d'individus, 30 sur 87. Les critères de sélection étaient: ne pas prendre un jeune animal c'est-à-dire âgé d'environ 3,5 ans, ne pas prendre une femelle de reproduction, c'est-à-dire celles ayant des bébés rhinocéros, prendre soin de retenir les mâles de reproduction dans Solio, essayer de s'assurer que des mâles de reproduction fassent partie de la 'nouvelle' population, prendre soin de laisser une population équilibrée, prendre soin de créer une population équilibrée dans la 'nouvelle' population, déplacer les individus qui étaient difficiles à identifier et garder les individus que les visiteurs pouvaient voir facilement. On discute de l'importance d'une sélection prudente des candidats, de la comparaison démographique de la population avant et après la translocation, et de l'effet de l'activité de translocation sur ceux qui restent à Solio. Même s'il faut de nombreux mois, voire des années, pour vérifier pleinement les effets salutaires ou autres de la gestion biologique sur le troupeau, les résultats préliminaires étaient encourageants.

Introduction

Following five years of heavy poaching activity when 9 black and 30 white rhinos were killed in Solio Game Reserve, Kenya, the management established a new rhino security and monitoring system at the end of 2005 (Patton et al. 2008). Over the first six months of monitoring, individual identification of the black rhinos - with the support of photographs - enabled the population demography to be estimated with a total herd size of 87. This was considered accurate although, despite all the care taken, there was the possibility of some duplications or some rhinos not found.

Separating the population into sex class gave 48 males, 38 females and 1 unsexed calf. The three age classes were insufficient to fully describe the age profile of the population so three experienced evaluators - the main author, the Solio head of security and the rhino warden at Nairobi National Park - reviewed the photo database and further separated the age classes into seven: calves, 3.5-7 years, 7-10 years, 10-15 years, < 20 years, > 20 years, > 30 years. The evaluators' individual results were then averaged for the profile, which gave the number per class: 19 calves; three of 3.5-7 years; six of 7-10 years; 11 of 10-15 years; 16 < 20 years; 23 > 20 years; and 9 > 30 years. The 19 calves were further subdivided into age classes according to the African Rhino Specialist Group classification (Adcock and Emslie 2007) by comparing their size with that of their mother.

By the end of the first year of monitoring and using a minimum population estimate of 82 in the 68.3 km^2, there was a density of 1.2 per km^2 - very high compared with other similar enclosed Kenyan reserves, which is typically around 0.5 rhinos per km^2. Also, with six births and three natural deaths (that is, not caused by poaching) in the year and giving a net increase of three individuals, the growth rate over the year was 3.8% with only 6 of the 29 females (21%) having calved that year.

Benchmarks of breeding performance for black rhinos (du Toit 2001) class the annual (December 2005–November 2006) Solio growth rate of 3.8% as poor to moderate, and the percentage of cows with calves of that year of 21% as very poor to poor although single-year rates in small populations must be treated with caution. The 3.8% growth rate is below the Kenya Wildlife Service target of 5% per annum (KWS 2003) although single-year rates in small populations must also be treated with caution. A calving interval for the females was estimated to be over 36 months which is benchmarked as poor to moderate.

This poor performance may be due to foetal deaths caused by poor nutritional conditions as a result of habitat degradation, or just that poorer nutrition means it may be taking longer for females to build up sufficient condition to be able to successfully conceive and raise calves. Habitat monitoring had not been undertaken in the game reserve since a survey in the early 1990s had shown that *Acacia drepanolobium*, the main browsing species of the Solio black rhinos, had been severely depleted in the reserve compared to the stands in the ranch area (Brett 1993).

A habitat evaluation study was carried out by the Kenya Wildlife Service assisted by a specialist in many rhino reserves throughout Kenya, including Solio, in order to determine the Ecological Carrying Capacity for the black rhinos in each reserve. The carrying capacity for Solio was provisionally modelled at 42 individuals (Adcock 2006) giving a maximum sustainable yield (75% of carrying capacity) of 32. The habitat evaluation showed that there had been severe degradation of important rhino browse species although due to the permanent wetland area providing a nutrition 'bank' and low densities of other potentially competing browsers compared with other black rhino areas, it was thought that the carrying capacity could be higher than first modelled. (It was subsequently increased to 61 giving a maximum sustainable yield of 46). This showed that the population was well in excess of the reserve's carrying capacity (Adcock 2006).

The breeding performance analysis and the carrying capacity modelling both suggested a need for urgent population reduction of a significant number of individuals. This paper reports on the selection of candidates for translocation out of Solio and the immediate effect of removing a significant number of rhinos (28) on the remaining Solio population.

Materials and Methods

Solio Game Reserve covers 68.3 km^2 divided into seven security sectors varying in size between 4.5 and 13.2 km^2 (average 9.8 km^2). The first year's monitoring data was analysed in order to classify the population by age and sex into sub-units within each sector. A rigorous process, including discussions with rhino specialists, was carried out to arrive at a set of criteria to select appropriate candidates for translocation. The criteria for selection were in no order of importance:

i) take no young animals i.e. around 3.5 years of age - this age group has been found to be the poorest for surviving the stress of translocation.
ii) take no females with calves at heel - translocation stress may affect breeding performance.
iii) take care to maintain some breeding males in Solio - need to ensure no loss in breeding performance.
iv) attempt to ensure some breeding males are part of the 'new' population - need to establish breeding as soon as possible.
v) take care to leave a balanced population - need to ensure good performance of the population in the long-term.
vi) take care to create a balanced population in the 'new' population - need to ensure good performance of the population in the long-term.
vii) move those individuals hard to identify - all translocated rhinos would be ear notched making future identification easier.
viii) keep individuals which were easy for visitors to see - need to maintain a good visitor experience as revenue from tourism contributes to the cost of monitoring.

An additional consideration was to remove those rhinos most at risk from poaching, that is, those in the sector and areas that abutted the north fence which ran parallel to and within 10 m of a main road. The overall aim was for the recipient population to comprise of a balance of individuals which would have the potential to achieve good breeding performance as soon as possible while leaving the Solio population with a balance of individuals where breeding performance would improve and, in the worst case, not reduce. The initial plan was for Solio to provide the recipient 'new' population with 20 male and 10 female rhinos.

A Microsoft™ Excel spreadsheet with details of the population demography of the Solio rhinos by sector was created. The data were then colour coded to distinguish females with calves, rhinos under 3.5 years of age, rhinos easily identified and possible breeding males. To determine this latter group, with insufficient sighting data to analyse which males had been seen mating, an analysis was undertaken of the interactions between males and breeding age females with the assumption that those males seen most regularly with females were the more likely to be breeding males. A second spreadsheet was prepared which excluded those females with calves, rhinos under 3.5 years of age, and rhinos easily identified. Where possible, candidates were selected from this remaining data. To ensure a balanced and well spread population, a third spreadsheet was prepared to represent the demography of those rhinos that were to remain.

The final step in the selection of candidates was a personal assessment by the main author of how best to meet the needs of both the recipient and remaining population based on experience in both reserves. A cow/calf combination was included in the final selection although which individuals this would include was left open, subject to an 'in-field' assessment of the best pair for the procedure.

Three weeks prior to the start of the translocation, as many as possible of the candidates selected were closely observed (and photographed) to check their health status and ensure they were in sufficient condition to withstand the stress involved in the capture and transport. The recent photographs were made into photo-identification booklets and photo-sheets to assist in the correct identification of the rhinos to be moved during the translocation.

The translocation was carried out over a 14-day period in February 2007 during which time 30 rhinos were caught, of which one died on site (shown post-mortem to have had an enlarged heart), one was released due to anaesthesia complications and one was released following incorrect in-field identification.

In order to review the effect of the removals on the behaviour of the rhinos remaining in Solio, monitoring data were analysed for the six month period post translocation (March-August 2007) and compared to the six month period pre translocation (July-December 2006).

Results

For security, data are summarized and not presented in detail.

The removal strategy adopted was to maintain the twenty or so young individuals (calves and sub-adults) to 'refresh' the Solio population, with the very old rhino (over 30 years) remaining in the reserve to die naturally, while selecting individuals for movement from only those animals from around 10 years to below 30 years old.

Table 1. The Solio black rhino population classified by sector and sex

	MALES			FEMALES			ALL		
Sector	Pre-T	Cand.	Rem.	Pre-T	Cand.	Rem.	Pre-T	Cand.	Rem.
1	9.49	5.40	3.82	5.21	0.00	5.21	14.70	5.40	8.93
2	9.52	3.93	6.11	7.14	0.78	6.94	16.66	4.71	13.05
3	5.50	3.23	2.57	6.14	3.10	3.80	11.64	6.33	6.37
4	3.41	2.41	3.00	5.64	2.00	4.28	9.05	4.41	7.28
5	11.99	5.18	7.55	10.93	5.12	6.93	22.92	10.30	14.48
6+7	7.42	5.85	3.95	3.57	1.00	2.94	10.99	6.85	6.89
TOTAL	47.33	26.00	27.00	38.63	12.00	30.10	85.96	38.00	57.00

Pre-T is the population prior to translocation
Cand. is the population of candidates for translocation
Rem. is the population remaining after translocation

Table 2. The demography of the Solio black rhino population at four time periods

Age Cl. & period	MALES				FEMALES				ALL			
	2006	TSL	AT07	2007	2006	TSL	AT07	2007	2006	TSL	AT07	2007
CALVES	12	1	8	9	6+1	0	6+4	7+2	19	1	18	18
3.5-7 yrs	1	1	4	5	2	0	3	5	3	1	7	10
7-10 yrs	5	2	2	2	1	1	0	0	6	3	2	2
10-15 yrs	7	6	1	1	4	2	2	2	11	8	3	3
15-20 yrs	7	2	5	5	9	3	5	5	16	5	10	10
20-30 yrs	10	4	5	4	13	2	12	12	23	6	17	16
30+ yrs	6	2	4	4	3	0	3	3	9	2	7	7
TOTAL	48	18	29	30	38+1	8	31+4	34+2	87	26	64	66

Note: 2006 – end of year population; TSL – population translocated; AT07 – population after translocation; 2007 – end of year population

Table 3. Breeding performance benchmarks before and after translocation

BENCHMARKS	Before translocation		After translocation		Improvement
Growth rate per annum	7.1%	Moderate-good	10.3%	Good-excellent	45%
% cows with calves of that year	23.3%	Very poor-poor	36.4%	Moderate-good	+56%
Intercalving interval (estimated months)	39.5m	Poor-moderate	39.5m	Poor-moderate	None

The Solio black rhino population divided by sector before and after the translocation and including the population of potential candidates is summarised in Table 1. Some rhinos ranged between sectors and this is accounted for by using the proportion of sightings in each sector.

The sex/age profile of the Solio population at the end of 2006, the rhinos removed from Solio, the rhinos remaining after translocation and the population at the end of 2007 is shown in table 2.

Table 3 represents the breeding performance of the Solio herd for the year 2007 in two ways – firstly including the rhinos translocated, that is as if there had been no management intervention, and secondly as the population actually was on 31 December 2007 after management intervention, that is without the translocated rhinos.

Six months after the end of the translocation, analysis of the ranging areas of the remaining population showed that only 3 individuals had made major changes:-

The male Opondo, who had been a candidate for translocation and had been caught but released following complications, had moved from the sector 1.5 in the west of the reserve to sector 1.4 in the east. The two females Wambui and Ruai moved north or west into (mostly) sector 1.5.

The proportion of monitoring sightings on the plain compared to in the bush varied slightly at 35% pre translocation to 38% post translocation. However on an individual basis while there was little change for 20 rhinos, four were found more often on the plain than before the translocations, and 14 more often in the bush than before.

Table 4. Rhinos active in translocation activity found more often in bush

RHINO	Pre Transl'n % in bush	Post Transl'n	Change % increase	Notes role of rhino in translocation
Pasuka	75	86	11	Candidate companion, chased together
Yasa	40	69	29	Candidate, chased not caught twice
Kawira	56	86	30	Candidate, chased not caught twice
Opondo	40	69	29	Candidate, released due to complications
Tarimbo	76	90	24	Non-candidate, released mistaken identity
Lomore	71	100	29	Candidate, chased but companion caught
Mpya	100	100	0	Candidate chased out of normal range
Rwua	35	96	61	Non-candidate, ear notched and released

Table 5. Rhinos not active in translocation activity found more often in bush

RHINO	Pre Transl'n % in bush	Post Transl'n	Change % increase	Notes rhinos with no translocation role
Soroa	71	92	21	New calf early Jan
Cicilia	51	93	42	New calf late Jan
Naomi	65	91	26	Late to come into open, older calf
Nanjala	85	100	15	Late to come into open, older calf
Nyota	70	100	30	New calf early Feb
Sungari	76	93	17	Older male

Discussion

1. The need

Biological management of black rhino requires the management of rhinos (and where necessary also of their habitats and other competing species) to achieve a sustained rhino metapopulation growth of at least 5% per annum and where possible to manage populations to achieve demographic and genetic goals (du Toit 2006). A metapopulation is defined as geographically separated groups that amount to a single population in genetic terms by the interchange of genetic material between sub-populations, i.e. the exchange of breeding animals (or, potentially, their semen, ova or embryos). The reason for maintaining a metapopulation is to avoid losing genetic diversity that is essential for the long-term evolutionary potential of rhino species, which means the ability to adapt to changing environments (du Toit 2006).

The target growth rate for a population or metapopulation of at least 5% per annum requires an average intercalving interval (in a population with normal age and sex structure) of three years or less per breeding-age female. Appropriate biological management means measures to prevent overstocking, to prevent inbreeding and to meet other animal husbandry needs. This can be done by harvesting rhinos at a significant rate (du Toit 2006). For Solio rhinos in 2006, the 3.8% growth rate, the intercalving interval over three years and the overshooting of the modelled carrying capacity were clear indicators of the need for biological management and, therefore, the need for carefully targeted removals.

2. The Selection

A guideline of the IUCN Re-Introduction Specialist Group (IUCN 1998) is that any re-introduction project should not diminish the viability of the source population. Individuals should only be removed from a wild population after the effects of translocation on the donor population have been assessed, and after it is guaranteed that these effects will not be negative. The age and sex structure of the donor population should be considered when choosing which animals to remove. For example, the selective removal of young female rhinos over a long period may potentially skew the age (and sex) structure of a donor population, reducing its future performance (du Toit 2006).

According to du Toit (2006), prime female candidates for translocation are young cows that are close to attaining the age of first conception or which are in the first trimester of their first pregnancy. This is supported by Morkel and Kennedy-Benson (2007) who state that young females between four and six years old, before they have bred or when in early pregnancy, are ideal to move. For males, if the donor population is well established (50 or more animals, with several generations) then it will be least disruptive to that population to harvest 'subsidiary' or sub-adult males. This age class is the one in which natural dispersion is most likely to occur (du Toit 2006).

The well-established Solio black rhino population has been the source of 67 rhinos moved to other sanctuaries in the past 25 years. Of these, 37 have been removed since 1990 and most of these are believed, due to lack of records, to have been sub-adults. Over the years, the net effect of this approach to removal was to contribute to an unbalanced age profile, as shown in table 2 (see columns '2006'), with only nine individuals out of 87 (10.3%) between 3.5 and 10 years of age. After removals, these age groups represented an improvement to 12 individuals of 66 (18.2%).

As reported by Balfour (2001), any removal strategy needs to be planned spatially and temporally with regards to specific individuals to minimise disruption to the rhino social network. Reduced social disruption will lead to decreased conflict, and potentially increase the productivity of the population. Special attention was paid to maintaining a balance in the social organisation of the Solio population by selecting the individuals to be removed from all sectors of the reserve and then ensuring that only those selected were translocated. An imbalanced social structure in an area can result in shifts in home ranges and might, as suggested by Reid et al. (2007), cause a reduction in productivity because more energy is expended in creating new home ranges rather than in reproduction (Reid et al. 2007).

Another reason for ensuring candidates were selected from all sectors throughout the reserve and not from one sector was to account for the known poor dispersal of black rhinos which can lead to vacuum areas with the remaining rhinos failing to disperse into areas vacated by removed individuals.

3. The Outcome

The removal of 26 individuals, of which only one was a calving female, significantly improved the breeding performance analysis of the Solio herd (table 3). However, these are single year results representing a mathematical improvement in performance and must be treated with caution. It will not be for another two or three years that any real improvements can be assessed. Similarly any improvement in the habitat – due to the reduced density enabling recovery of the more nutritious browse species such as *Acacia drepanolobium* – will not be seen for several years. In the first six months after the translocation, changes in range areas were minor and could not be attributed directly to the translocation activity although they might have been. Monitoring rangers reported that some rhinos had become more difficult to find after the translocation favouring bush areas to plain. Analysis of the sighting data unequivocally shows that changes in rhino activity were due to the translocation activity rather than seasonal effects, behavioural and other changes. However over the 14-day period, the activity was intense involving the noise and smell at one time or another from the movement of four trucks with loading crates, two Landcruisers, two tractors, two fixed wing aircraft (one of which was taking off and landing on a strip within the reserve), other attending vehicles and the many people involved. Solio rhinos had previously been used to minimal human disturbance.

The analysis showed that overall there had been no change in the proportion of sightings made in bush and plain areas pre and post translocation. However, as shown in tables 4 and 5, 14 of the 38 rhinos (37%) independent in July 2006 were found significantly more often in the bush post translocation than pre translocation. Eight of these were directly affected in the translocation as shown in the notes of table 4 and became much more secretive after the translocation. The other six, as shown in table 5, may have been indirectly affected by the translocation activity. The three females with new calves have remained longer (over six months) in the bush than would have been normally expected - usually three months or less for those females using the plains areas. It is likely that such a unique hiatus of activity as experienced in a large translocation would have had an effect on at least some of the Solio black rhinos.

In summary, as stated by du Toit (2006), it is not sufficient only to protect rhinos in order to conserve them. The animals also need appropriate biological management which means measures to prevent overstocking, to prevent inbreeding and to meet other animal husbandry needs. The effect of East Africa's largest black rhino translocation as a biological management tool on the breeding performance of the Solio population will not be seen immediately but on initial analysis of data from the first six months after the operation, the results are encouraging.

Acknowledgements

The translocation was a major cooperative effort between the management and staff of Kenya Wildlife Service, Solio Game Reserve, Ol Pejeta Conservancy and Lewa Wildlife Conservancy.

References

Adcock K. 2006. Estimates of black rhino carrying capacity at Ol Pejeta's new rhino area. Kenya Wildlife Service. Unpublished.

Adcock K, Emslie R. 2007. Monitoring African Rhino, Trainee's Workbook – 5th edition. IUCN SSC African Rhino Specialist Group.

Balfour D. 2001. Managing black rhino for productivity. Some questions about current RMG assumptions and guidelines, and some idea about data use. In: Emslie R, ed. *SADC rhino management group (RMG) workshop on biological management to meet continental and national black rhino conservation goals: Proceedings*. South African Development Community, Harare.

Brett RA. ed. 1993. Conservation strategy and management plan for the black rhinoceros (*Diceros bicornis*) in Kenya. Kenya Wildlife Service, Nairobi.

du Toit RF. 2001. Benchmarks for rhino population performance in the wild. In: Emslie R, ed. *SADC rhino management group (RMG) workshop on biological management to meet continental and national black rhino conservation goals: proceedings*. South African Development Community, Harare

du Toit R. ed. 2006. Guidelines for Implementing SADC Rhino Conservation Strategies. SADC Regional Programme for Rhino Conservation, Harare (Zimbabwe).

Hitchins PM. 1970. Field criteria for ageing immature black rhinoceros (*Diceros bicornis*). *Lammergeyer* 12:48–55.

[KWS] Kenya Wildlife Service. 2003. Conservation and management strategy for the black rhino (*Diceros bicornis michaeli*) in Kenya (2001-2005), revised March 2003. Kenya Wildlife Service, Nairobi.

Morkel P, Kennedy-Benson A. 2007. Translocating black rhino: current techniques for capture, transport, boma care, release and post-release monitoring.

Patton F, Campbell P, Parfet, E. 2008. Establishing a monitoring system for black rhinos in the Solio Game Reserve, central Kenya. *Pachyderm* 44:36-45.

Reid C, Slotow R, Howison O, Balfour D. 2007. Habitat changes reduce the carrying capacity of Hluhluwe-Umfolozi Park, South Africa, for Critically Endangered black rhinoceros *Diceros bicornis*. *Oryx* 41(2):247-254.

IUCN. 1998. Guidelines for Re-introductions. Prepared by the IUCN/SSC Re-introduction Specialist Group, IUCN, Gland, Switzerland and Cambridge, UK. 10 p.