A PRELIMINARY ASSESSMENT OF THE REINTRODUCTION SUCCESS OF THE ASIAN ONE-HORNED RHINOCEROS (Rhinoceros unicornis) IN BARDIA WILDLIFE RESERVE, NEPAL

by Johannes J. Bauer

Introduction

The Asian one-horned rhinoceros has been successfully protected in Nepal's Royal Chitwan National Park (RCNP) and in Kaziranga in Assam, after having disappeared from most of its former habitat in the Indian and Nepalese Terai. Sale and Singh (1987) estimate the total remaining number of animals to be around 1,700, with 84% living in the two areas mentioned above.

Since 1984, it has been attempted to establish new populations by translocating rhinos from safe stocks, such as those in Chitwan and Kaziranga, into suitable areas within its former distributional range. Translocations were undertaken from Kaziranga National Park into Dudhwa National Park in 1984 (Sale and Singh, 1987). In order to establish a vigorous breeding nucleus, this reintroduction was aided by the translocation of four rhinos from RCNP into Dudhwa. Within Nepal, rhinos were translocated from RCNP to Bardia Wildlife Reserve in February and December 1987 (Mishra and Dinerstein, 1987).

A survey conducted between 21–27 February 1988 in Bardia Wildlife Reserve, attempted to assess the distribution and habitat utilisation of the animals.

Survey Area

Bardia Wildlife Reserve, located in the southwest of Nepal, encompasses an area of 968 sq.km. The Reserve was gazetted in 1976 and was enlarged threefold in 1982. Altitude ranges from 152–1, 441 m., rainfall ranges from 1,560 mm at Guleria to more than 2,200 mm in the Churia Hills. The cool, dry season lasts from November until mid-February. About 70% of the Reserve is covered with sal *(Shorea robusta)* forest, the remaining 30% is covered by grassland, savannah, riverine forest and gravel/silt.

Methods

While surveying the status of other endangered species in and around this reserve such as Blackbuck *(Antilope cervicapra)*, Swamp Deer *(Cervus duvaucelii)*, Gharial *(Gavialis gangeticus)*, Swamp Crocodile *(Crocodilus palustris)*, and Gangetic dolphin *(Platanista gangeticus)*, information was collected as to the fate of the translocated rhinos. Surveys were conducted on elephant back, by car and by boat. Most of the information could be collected by recording sightings and reports from local park staff. With this information it was attempted to establish movements and locations of the rhino population at the time of the survey.

Composition of the Founder Population

The introduction of rhinos into Bardia Wildlife Reserve took place in two translocations – one in February 1986 and the other in December 1986. The procedure is described in Mishra and Dinerstein (1987) and Anstey (1987).

The age and sex structure of the founder population is given in Table 1. The sex ratio of the founder animals (1 male: 2 females) is balanced and compares to values encountered in natural populations (Laurie, 1978).

The Release Site

The site chosen to release the animals during both translocations was situated around 8 km. north of Thakurdwara, in close proximity to the Geruwa River. The introduction site was close to the road in open sal woodland which changed to mixed and riverine forest in the west towards the river.

Table 1: Age and Sex Composition of the Founder Population of the Asian One-Horned Rhinoceros in Royal Bardia Wildlife Reserve, Nepal, 1986

Translocation	Total No. Animals	Adult Females	Subadult Females	Adult Males	Subadult Males
February 1986	4	3	0	0	1
December 1986	9	3	2	1	4
Total	13	6	2	1	5

Results

Dispersal of rhinos

One female rhino died within two weeks of its release in close proximity to the introduction site. Mortality was due to injuries received during transport, for which the animal in its stressed condition was unable to overcome. The remaining twelve animals have dispersed mainly along the Geruwa River (the east branch of the Karnali) mostly during the initial dispersal.

If the randomness of the direction in which the rhinos dispersed is determined by means of the Raleigh Test (Durand and Greenwood, 1958), this preference for riparian habitat becomes significant on the 95% confidence level.

Only two rhinos (one subadult male •1 and one adult female •2) have left the riparian zone and established home ranges in sal forest within the park (•1) and in agricultural land outside the park (•2). The remaining ten rhinos have dispersed predominantly southwards. Only one group of three animals moved north to Chisapani (15–18 km.). This group, however, was displaced from this area by the heavy disturbance of activity related to the construction of the Chisapani dam and construction of the bridge further downstream.

If the linear distances from the release site to the rhinos' present locations are determined, a considerable variability becomes evident. Distances in February 1988 varied from less than 2 km. to a maximum 22 km. One female rhino, which was presumably pregnant, deviated from this pattern by moving south to Nepalgunj, covering more than 100 km. during this journey. This female had to be chased back to the Reserve but, however, failed to reenter it. It has since joined two rhinos (1 male and one female) in agricultural land 5 km. south of Thakurdwara. This group ranges in the riparian zone of the Geruwa River, east of Lalpur. The overall frequency distribution of dispersal distances of rhinos in Bardia is non-normal with the highest frequencies in low dispersal distances.

Dispersal patterns, which depend to a large extent on the propensity of a particular species, can be affected by a number of environmental variables (see Discussion). It is also known that dispersal of animals is affected by sex and age. In the case of rhinos, no up-to-date information on this aspect exists; however, in the case of Bardia, the effects of sex, age and time might be interesting to note, no matter how small the sample may be. Since little time has passed since the release of the rhinos (24 months since the first introduction, 15 months since the second), and the subsequent dispersal can give little information on the rate of dispersal of rhinos (see Discussion), it is still extremely important information as it reflects the habitat suitability of the reintroduction site.

If the average distances of rhinos from the first release are compared with the distances of the second translocation, it is evident that animals of the latter group dispersed, in general, much further than the former. The mean distance of the first release was calculated as 7.41 + 3.06 km. (n=4). For the second release, mean distance was 17.9 + 17.09 km. (n=9). Despite the small sample size and high variability, this difference is almost significant on the 0.05 confidence level. (T-test, t=2.26, 0.05 p 0.1)

Regarding the factors of sex and age on dispersal, the low sample size only allows crude estimates. The mean dispersal of male rhinos (11.9 + 8.7 km.) is considerably higher than the mean dispersal distance of females (7.8 + 6.1 km.), excluding the female rhino which moved to Nepalgunj.

Present distribution

The rhinos have dispersed over a considerable range since their reintroduction and are now occupying an area of approximately 200 sq.km. Ten of them have maintained group cohesion (•3•4•5); only two of the wide dispersers are solitary (•1•2). Two groups (3 females/1 male; 3 females) occupy a core area of little more than 16 sq.km., relatively close to the release site. This corresponds to 58% of the total population or a density of 0.43 rhinos/sq.km.

Some behavioural observations related to dispersal

Although no systematic information was recorded for this reintroduction, some observations made by G. Singh, the senior game scout, might be worth noting. This information concerns some interactions of rhinos with local large species such as livestock, wild elephant, tiger and nilgai. The translocated rhinos, stressed and unfamiliar with their new surroundings and the species inhabiting it, apparently had some difficulties in adapting and displayed forms of aggression during this phase.

Discussion of the Survey Results

Evaluation of the translocation success

Whereas the present condition and distribution of rhinos suggests that the translocation attempts were successful, there are still several lessons to be learnt for the future. Four of the rhinos have left the Reserve and established themselves in agricultural land south of the introduction site. One of these rhinos is single and might be lost for breeding; the other group (1 male, 2 females) with regard to conflict, with people is undesirable breeding stock. While it does not seem likely that the emigration of these four animals from the Reserve was due to a saturation of the carrying capacity, indications are that the higher dispersal distances of the second introduction were at least partly due to the fact that the animals from the first release had already established territories, pushing the newcomers out. The effects of this (still hypothetical) dispersal cause could be alleviated if the founder population is moved in a single translocation, or, if two translocations are required, that different release sites are chosen. Another effect concerns mortality. Out of twenty-five rhinos that have been translocated so far, 3 have died (12%) (Bardia and Dudhwa), all of which were rather old females. Although it is premature to conclude that adult females are more susceptible to mortality during translocation, this point should be observed in the future, especially since the two wide-dispersers of the previous groups were also adult females.

Future prospects for Bardia rhinos

The translocated rhinos seem to have established themselves in Bardia. They are utilising stable home ranges and have commenced breeding (in April 1988).

As had been expected from Laurie's (1978) observations in RCNP, the majority of Bardia's rhino population utilises riverine habitat i.e. riverbeds, riparian grasslands and riverine forests dominated by sisoo *(Dahlbergia sisoo)* and gurel *(Trewia nudiflora)*. These plant communities are exceptionally well-developed and have been less disturbed so far by degrading influences such as cattle grazing, burning, fishing and other human activities, which are very prevalent in RCNP.

The extent of these habitats, including the zone of mixed forest where riverine elements are transformed into sal climax communities, stretches from about 23 km. south of Thakurdwara to Chisapani, thus occupying an area of a little more than 100 sq. km. Hajra and Shukla (1982) in their assessment of the habitat in Dudhwa National park for rhino reintroductions (on the India side of the Bardia reintroduction site), estimated that a suitable area of 90 sq.km. could support an ultimate maximum number of 90 rhinos. Assuming the same carrying capacity for Bardia (based on home range values of Laurie, 1978), the corresponding figure for this part of Bardia would be around 100 rhinos.

It cannot be anticipated in what way the road construction, the bridge and the Chisapani dam are going to affect this habitat; however, the extent of the impact is sure to be large. A considerable area will be lost as suitable rhino habitat and this can already be observed in the narrow zone of riverine forest on the east side of the Karnali. Two rhinos that had established home ranges in this region were driven away by the massive disturbance, in particular up to 25 daily seismic test explosions. Although observations in RCNP show that rhinos can be very tolerant of disturbance, it must be expected that the colonisation process of this area will be greatly affected by the many thousands of road, bridge and dam construction workers who are going to move into this area soon. A large amount of the construction material for the dam and bridge will be taken from the riverbed south of the projected bridge, which will not only bring massive disturbance but also considerable, and so far unpredictable, environmental changes. As well as these short term effects, long term trends must also be considered. Hirst (1987), in his Environmental Impact Assessment of the projected Chisapani dam, concludes that most of the future effects of this dam must remain in the field of speculation. The completely changed water regime accompanying this construction (reduction of monsoonal flood levels and the increase of dry season water levels) will lead to major changes in the geomorphology of the Karnali flood plain, as can be observed in the Mahakali River (Bauer, 1988)

One of the changes which can be anticipated is a reduction of the riverine element around the Karnali, with an acceleration of succession rates towards the climax vegetation type, i.e. sal, which is suboptimal rhino habitat (Laurie, 1978).

Reintroduction as a Management Tool

Reintroduction of animal species is becoming an increasingly important management tool for the reestablishment of species which have disappeared from their former ranges. The success of these operations depends very much on the ability of wildlife biologists to assess and evaluate the suitability of the release site and the ability of the animals to colonize this area and establish viable breeding populations.

Translocation can be a costly exercise, especially in the case of large species such as rhinos which, without proper assessment, have a high potential of failure. Insufficient evaluation of reintroduction sites and the species' ability for dispersal has already led to the failure of the reintroduction of the Blackbuck, another endangered species in Bardia (Bauer and Ellenberg, 1988).

Although there is strong evidence that genetical factors are responsible for the dispersal ability of individual animals (Myers and Krebs et al, 1985a; 1985b; 1986), it is not known yet to what extent. As it is not possible to select individuals for a founder population according to this genetical principle, any randomly selected individual constitutes a suboptimal sample, lowering the maximum dispersal ability (or, if required, minimum dispersal ability) of a species. Bauer (1988) has evaluated reintroductions in the Nepalese Terai and provided a list of species for reintroduction and potential reintroduction sites. The success of these future management schemes depends greatly on the careful assessment of the following parameters:

Species Characteristics:

1. Habitat requirements
2. Habitat flexibility
3. Dispersal ability
4. Fecundity
5. Physical condition
6. Sex and age structure of the founder population
7. Size of founder population
8. Home range requirements

Reintroduction Site Characteristics:

1. Habitat suitability (key habitat features, for example waterholes for rhinos)
2. Food availability (for example presence of favourite food plants)
3. Predation pressure
4. Adverse effects (present/future)

5. Area size
6. Dispersal barriers
7. Potential conflicts with people
8. Presence/absence of potential disease vectors

Future Rhino Translocations

Laurie (1978) has suggested translocation sites for rhinos. Since his study, two of the proposed translocations have taken place, both of them most probably successful.

For Nepal, two more protected areas exist which fall into the former distribution of the Greater one-horned rhinoceros, namely Kosi Tappu in East Nepal and Suklaphanta in West Nepal.

Kosi Tappu: The critical state of Kosi Tappu (155 sq.km.) as an animal habitat has been evaluated several times after the severe monsoonal flooding in 1987 (Bauer, 1987a; 1987b; 1987c; Heinen, 1987; 1988). Barrage and dam-related changes in flooding patterns are continuously degrading the Reserve as an animal habitat with losses of thousands of animals last year (Bauer, 1987; Heinen, 1987). Even the relict population of around 90 buffaloes *(Bubalus bubalus)*, a species which is very well adapted to water, is severely affected and its translocation has been proposed various times (Dahmer, 1978; Bauer, 1987; Heinen, 1988).

The area is unsuitable as a possible reintroduction site, either in the short or long term (unless it is extended as proposed). The establishment of a small founder population, even of a robust species such as rhino, would be greatly hindered by exceptionally high monsoonal floods which can be expected in Kosi Tapu every few years. in the long term, the loss of the remaining riverine forest, as well as the so far unpredictable habitat changes, will most likely make this area unsuitable for many species.

Babai Valley – Bardia: The future prospects of this site have already been evaluated in preceding paragraphs. Although the site provides a very suitable and sufficiently large rhino habitat, the effects of the development schemes cannot be anticipated so far. The Babai Valley, after the human population has been relocated, might well prove a more ideal site for the future, as potential conflicts with people and development schemes would not exist. Active translocations could not anyway be considered as no road exists at present. The valley lies well in the dispersal potential of rhinos and has been already approached very closely by one rhino.

Suklaphanta: Suklaphanta, although very small, supports the largest elephant population of Nepal (Bauer, 1988) and has good areas of suitable rhino habitat to the west as well as in the east. The extension area to the east will add a large area of agricultural land which will revert to flood plain grasslands after the farmers have been resettled further south. There is a considerable number of oxbowlakes in this area, along with a small sized river, which would provide similar habitat conditions as the exist now at the northern side of RCNP, the centre of rhino distribution.

The irrigation channel which is currently being constructed to the east of this area could improve these conditions if provisions are made for outlets, artificial floodplains, etc. (see Bauer and Yonzon, 1988). The conditions in this area could become ideal for rhinos, swamp deer, Asian Buffalo, wild elephant, swamp crocodile and waterbirds.

Reintroductions as Scientific Experiments

Some remarks about animal dispersal

Dispersal of an animal or of animals within populations can be defined as the movement an animal makes from its place of origin (place of birth, translocation site) to the place where it reproduces or at least establishes a home range (Caughley, 1977). Dispersal is not synonymous with local movement within the boundaries of an animal's home range, or with migration (e.g. movements between summer and winter home ranges). Dispersal is a major event in the population dynamics of species and "the survival of a species depends on dispersal as much as on reproduction and longevity" (Caughley, 1977).

Dispersal is without doubt the least investigated phenomena of the dynamics of species, and up to 1977 it was not possible to make any generalisations on dispersal for lack of basic information on single elements of the process (sex and age of dispersing individuals, randomness of dispersal, density dependence, mean and variances of distances moved, genetic differences between dispersing individuals (Caughley, 1977).

Caughley (1977), in his analysis of dispersal, concludes that it is the most difficult of all population processes to investigate and for this reason it tends to be glossed over or ignored in most ecological studies. Although there are a number of theoretical models to describe dispersal (which are again summarized in Caughley, 1977), actual research, especially on large mammals is still greatly lacking.

Most of the research on large mammals up to date has concentrated on rates of dispersal (e.g. Caughley, 1963, 1967; Briedermann, 1968; Bannikov, 1965; Pielowski, 1969, 1970; Andrzejewski, 1970; Bauer, 1983) and the time particular species require to colonize geographic regions (Nowak, 1970). It is still very much a matter of speculation as to what degree the dispersal of particular species is innate (Howard, 1965) and to what extent it is influenced by external, mostly environmental, factors. The analysis of large samples of marked Roe deer *(Capreolus capreolus)* in middle Europe (Bauer, in prep.) has shown that dispersal can be influenced , by the structure of particular populations (sex ratio, age structure), which in turn is influenced by pressures acting on the populations, e.g. hunting.

Animal Translocations, Dispersal Ability and Genetics

The success of animal introductions and translocations depends on the factors described earlier and probably many more. The introduction success of nearly 20 species of ungulates into New Zealand (Wodzicki, 1961), depended to a large extent on the size of the founder population (Bauer, 1983). The subsequent colonisation of New Zealand by these species was determined again by their rate of dispersal. Moose in eastern Europe (Nowak, 1975; Briedermann, 1969) can serve as an example for the explosive dispersal of a very large mammal species in even densely populated areas after the reduction of hunting pressure and total protection in some areas. Wild boar can serve as an example of how a medium-sized mammal of high ecological flexibility and reproduction potential can expand its distribution by approximately 80,000 sq.km. per year. Nowak (1975) lists the three most important population criteria which determine the dispersal ability of species as: 1) Innate dispersal ability; 2) Ecological plasticity; 3) Productivity. Myers and Krebs (1971), summarized in Caughley (1977), studied population characteristics of dispersing individuals of vole (*Microtus* sp.) and found that genotypes of two polymorphic plasma proteins differed in frequency between dispersing and sedentary individuals.

Translocations and minimum population size

There is much speculation, as to the effects of small population size on the genetical heterozygosity of animal populations and a number of models have been developed to simulate its effect (Nei et al, 1975; Howard, 1965; Chakraborty and Nei, 1977). Detailed studies, however, on large mammals are relatively few.

Research on introduced populations of chamois (Miller, 1987) has shown that founder populations which have undergone a process of rapid expansion and dispersal (Bauer, 1986) can regain their original level of heterozygosity after less than 50 years. The question as to what extent dispersal has influenced this genetical revolution (see Mayr, 1969) is still unknown and highly interesting from a scientific point of view.

In rare and endangered species such as one-horned rhinoceros, it would be therefore extremely important to complement the expensive translocation procedure with a comparatively inexpensive applied and theoretical research component.

Selected References

Anstey, D. 1987. **Report on stage two of the reintroduction of the Greater One-horned Rhinoceros to the Royal Bardia Wildlife Reserve, Nepal.** Report, DNPWC/KMTN 12 pp.

Bauer, J.J. 1983. **Factors affecting the success of**

ungulate species introduced into New Zealand. Unpublish, Manuscript, Freiburg.

Bauer, J.J. 1988. **The analysis of river morphological changes due to hydroelectrical control schemes in Nepal.** Proposal DNPWC/ FAO Proj Nep. 85/011. 6 pp.

Bauer, J.J. and Ellenberg, H. 1988. **Status and management of blackbuck *(Antilope cervicapra)* in Nepal – with observations on behaviour and factors affecting its population size.** Report, 27 pp. DNPWC/FAO Proj. Nep/85/011.

Bauer, J.J. 1988.**The plight of the Arna *(Bubalus bubalus)* – Nepal's last wild buffalos struggle for their survival.** Himal – for development and conservation (i. print).

Bauer, J.J. 1988. **Recommendations for species and habitat management Kosi Tappu Wildlife Reserve after severe monsoonal flooding in 1987.** Report, DNPWC/FAO Proj Nep/ 85/011, Kathmandu, Nepal. 11 pp.

Bauer, J.J. 1988. **Reintroductions as a management tool for critical species in Nepal.** Int. Symp. on the Biology of Pacific Mammals, Bejiing, China, 26.7. – 31.7. 1988.

Bolton, M. 1976. **Royal Karnali Wildlife Reserve, Management Plan, 1976–1981.** UNDP/ FAO Fo Nep/72/002 Field Document No. 6. 70 pp.

Caughley, G. 1963 **Dispersal rates of several ungulate rates introduced into New Zealand.** Nature, 200: 280 – 281.

Caughley, G. 1977. **Analysis of vertebrate populations** John Wiley and Sons, London, Sydney, New York Toronto.

Chakraborty, R., M. Nei. 1977. **Bottleneck effects on average heterozygosity and genetic distance with the stepwise mutation model.** *Evolution,* 31: 347–356.

Dinerstein, E. **An ecological survey of the Royal Karnali Wildlife Reserve, Nepal, Part 1: Vegetation, modifying factors and successional relationships.** *Biol. Conserv.* 15(2): 127 – 150.

Hajra, P.K. and Shukla, V. 1982. **Dudhwa National Park: Some botanical aspects of the proposed new habitat for rhinos.** Botanical survey of India Howrah.

Hamiltion, P.H. 1979. **Translocated leopards: Where do they go?** *Wildlife News* 14(3), 2–6, African Wildlife Foundation, Nairobi and Washington, D.C.

Heinen, J. 1988 **The current situation at Kosi Tappu.** Report, DNPWC, Kathmandu, Nepal. 5 pp.

Hirst, S.M. 1987. **The Karnali (Chisapani) multipurpose project, Environmental Impact Assessment Stage A.** Him. Power Consultants, Kathmandu, Nepal.

Howard, W.E. 1965. **Interaction of behaviour, ecology and genetics of introduced mammals.** In: *The genetics of colonizing species",* H.G. Baker et. al. (ed.), New York, pp. 461–484.

Laurie, W.A. 1978. **The ecology and behaviour of the greater One-horned Rhinoceros.** PhD Thesis. Univ. of Cambridge, UK.

Mishra, H. and Dinerstein, E. 1987 **New ZIP Codes for resident rhinos in Nepal.** KMTNC/Smithson. Nepal Terai Ecology Project.

Nei, M., Maruyama, R. Chakroborty. 1975. **The bottleneck effect and genetic variability in populations** *Evolution,* 29: 1–10.

Nowak, E. 1975. **Die Ausbreitung der Tiere (The dispersal of animals).** Die Neue Brehm Buecherei, Ziemsen Verlag, Lutherstadt. 144 pp.

Sale, J.B. and S. Singh. 1987 **Reintroduction of greater Indian Rhinoceros into Dudhwa National Park.** *Oryx,* 21 (2), 81 – 84.

Wodzicki, K.A. 1961. **Ecology and management of introduced ungulates in New Zealand.** La terre et lavie 1, 130 – 157.

The author was formerly the Ecologist of FAO project NEP/85/011. His current address is: Joseph-Krugstr. 12, 7967 Bad Waldsee, Federal Republic of Germany.