THE CAPTURE AND RELOCATION OF BLACK AND WHITE RHINOCEROS IN ZIMBABWE

V.R. Booth
A.M. Coetzee
Matetsi Research Unit
Private Bag 5926
Victoria Falls, Zimbabwe

Abstract: In 1984 and 1985, in accordance with the conservation strategy of the Department of National Parks and Wildlife Management in Zimbabwe, 59 black rhinoceros (Diceros bicornis) and 12 white rhinoceros (Ceratotherium simum simum) were captured using a combination of etorphine hydrochloride and hyosine hydrobromide. Two strategies were employed when releasing the rhino in Hwange National Park and the Matetsi Safari Area, and the success of the translocations was monitored over a 15-month period. First the animals were kept in holding pens for up to 2 weeks prior to being released, and secondly the animals were released directly on arrival at the release site. Four white rhino died, and those held in pens prior to release proved difficult to get to feed. In contrast, animals released directly on arrival appeared unperturbed and commenced feeding immediately. In both instances, however, the 8 rhino that survived moved about extensively in the Matetsi Safari Area before settling down.

Black rhino were relatively easy to manage and took readily to feeding in holding pens. Three rhino were lost in the operation, 6 were exported, 4 were released in the Matetsi Safari Area, and 46 were released in Hwange National Park. It was found that the rhino were likely to move extensively or settle down in close proximity to the release site irrespective of whether they were penned or not. This response may be related to the creation of unusually high densities following mass release, and it is suggested that this should be avoided where large translocations are involved. It is concluded that little advantage is gained by holding black or white rhino in pens prior to release.

Key Words: Black rhinoceros, white rhinoceros, capture, translocation, readaptation success.

The conservation strategy for the Parks and Wildlife Estate in Zimbabwe includes the reintroduction of species believed to have occurred there in the recent past. During 1984 and 1985 it was necessary to capture and translocate black and white rhino that were threatened by poaching and drought conditions respectively. White rhino were caught in the Kyle Recreational Park and Matobo National Park whereas black rhino were captured in the Chewore, Nyakasanga, and Dande Safari Areas and Mana Pools National Park situated in the Zambezi Valley. A solitary black rhino cow was removed from the Hwange Communal Lands.

In all, 59 black rhino and 12 white rhino were captured. This paper discusses these operations and the subsequent survival of the rhino following their release in the Hwange National Park and Matetsi Safari Area.

Methods

Capture Procedure and Immobilization

A modified .50 rifle or 20-gauge shotgun using .22 Cash blanks (1.25 grain), and firing lightweight aluminium 2 cc capacity darts equipped with specially reinforced needles constructed from steel injector piping (Fig. 1), was used throughout this operation. Palmer Cap-Chur® 1-3 cc charges were used as the activating mechanism for injecting the drug.

All rhino were immobilized with a combination of etorphine hydrochloride (M99®, Reckitt) and hyoscine hydrobromide. The dosage rate (irrespective of size or age) for black rhino was 1.75 mg M99 and 100 mg hyoscine hydrobromide, whereas white rhino received 2 mg M99 and 50 mg hyoscine hydrobromide. Young animals weighing less than 500 kg were captured by hand and were not immobilized unless necessary. The use of hyoscine hydrobromide was discontinued in 1985, and thereafter only M99 was used in the immobilization of rhino. The antidote diprenorphine hydrochloride (M50-50®) was administered intravenously (IV) and intramuscularly (IM) at the rate of 4 mg IV and 2 mg IM in all cases.

The black rhino were located using a Piper Super Cub light aircraft that guided the capture team by using 2-way radio communications. The hunter was equipped with head phones to reduce the noise level, especially where black rhino were hunted at close quarters. The white rhino were

confined in a fenced national park and were thus easier to locate and follow on foot or by vehicle.

Once the dart was successfully placed, the aircraft followed the rhino and directed the capture team to the immobilized animal. If the animal had fallen in an inaccessible spot or had fallen in such manner as to cause serious injuries, then a quarter dose (1.5 mg M50-50) of antidote was administered IV in order to get the animal on its feet. The animal was then restrained by attaching ropes to the 4 legs and around the head behind the back horn. In this way it was possible to walk the rhino for up to 1 km to a suitable loading site.

While the recovery vehicle was guided in by the aircraft, the capture team monitored respiration and temperature. Eyes, skin abrasions, and dart wounds were routinely treated with an antibiotic aerosol or ointment. Each adult animal was given an IM injection of 100 ml long-acting Terramycin (Terramycin/LA® Injectable Solution, Pfizer, Harare). Standard body measurements were recorded, and a numbered ear tag was inserted for future identification.

The rhino were roped onto a sleigh and a grass pillow was placed under the head to prevent any injuries. The rhino were winched onto the back of the recovery truck which was fitted with rollers and could be tipped hydraulically to facilitate easier loading. The animal was then transported to a temporary holding pen and revived.

Captivity Period

Except for minor structural differences, the holding pens were similar in design to those described by Hitchins et al. (1972). The pen measured 5 x 5 x 1.75 m with the door wide enough to allow the sleigh to enter.

Black rhino were fed with local browse material consisting of Diospyros spp., Diplorhynchus condylocarpon, Colophospermum mopane, Euphorbia spp., and Combretum spp. while white rhino were offered dry lucerne and hay. Clean drinking water was supplied in a trough raised above the ground to prevent fouling and designed so that it could be cleaned from outside the pen without disturbing the rhino.

Once the rhino was on its feet, it was left alone and not disturbed. All noise and distractions were kept to a minimum and the progress of the rhino was monitored periodically. If it was noted that a rhino was

not feeding, then alternative forms of food were offered. With black rhino it was found that Euphorbia spp. were readily acceptable and usually prompted the rhino to accept other foods. In some instances black rhino would accept lucerne mixed with a commercial preparation of horse/dairy cubes approximately a week after capture. Fresh food was provided in the early morning and late evening.

Agalactia was noted in all black rhino cows with young calves. The calves were therefore removed from their mothers and fed on a commercial brand of powdered skimmed milk. It was noted that calves fed on powdered milk containing a high fat content suffered from diarrhea.

White rhino proved difficult, and a great deal of patience was required to get the animals to feed initially. Usually the animals had to be tempted with various foods such as carrots or lucerne and hay treated with molasses. Once this was overcome, the animals readily took a diet of lucerne, hay, and horse/dairy cubes. Black rhino were always penned separately, but it was possible to pen white rhino together provided they were of the opposite sex. Apart from those animals that were destined for export, the animals were held in the pens for a maximum of 2 weeks and in some cases only a few days before being transported to a release site.

Translocation

All the rhino were crated in order to move them to the release sites. The rhino crates consisted of a steel frame with 19-mm hardwood boards and hinged doors. The top of the crates were left open except for 4 steel bracing supports. At the head of the crate a band of conveyor belting 70 cm wide was fixed in position on the walls of the crate and also formed a roof. This protected the rhino from injury if it challenged the crate during translocation.

The crates were mounted on tubular skids to facilitate handling on the ground. A hole in the door at the head of the crate greatly helped if the rhino had to be pulled into the crate using ropes. Loading and offloading the crates was accomplished using a hydraulic crane mounted on the vehicle.

The dimensions of the black rhino crates were 295 x 112 x 200 cm while the white rhino crates were slightly larger measuring 320 x 147 x 200 cm. These crates allowed the rhino to stand or lie down comfortably,

but prevented them from moving back and forward or turning around. Occasionally rhino were held in these crates up to 17 hours before transporting them to the release sites. None of the rhino appeared to have suffered unduly from this exercise.

To load the rhino, the crates were placed in position at the entrance of the pen in such a way that the hinged door formed 1 wall of the loading chute. The rhino were then coaxed into the crate, and only in extreme cases were the animals slightly drugged in order to assist loading. The crates were loaded such that the animals faced forward. No tranquilizers were used in the transportation of the rhino which in some cases involved journeys of up to 1,500 km, mostly at night.

Results

Capture Success

Fifty-nine black rhino and 12 white rhino were captured. Six white rhino were captured in the Matobo National Park (3 adult bulls, 1 subadult bull, 1 yearling bull, and 1 adult cow, October 1984, Table 1) and another 6 rhino were captured in Kyle Recreational Park (4 adult cows, 1 subadult cow, and 1 adult bull, December 1984). All of the black rhino (with the exception of 1 adult cow) were captured in the Zambezi Valley. In 1984, 6 adult bulls, 2 subadult bulls, 11 adult cows, 4 subadult cows, and 2 male calves were captured (Table 1) and in 1985, 18 adult bulls, 2 subadult bulls, 8 adult cows, and 3 calves (2 males and 1 female) were captured (Table 2).

The white rhino from Matobo National Park were in poor condition due to the severe drought prevailing at the time, and 1 animal died shortly after immobilization. Of the remaining 5 animals translocated to holding pens, 1 bull died from an apparent heart attack (an autopsy revealed large fat deposits in the ventricles of the heart and major arteries), a subadult bull died from suspected pneumonia, and a 3rd bull was found dead a day after being released. This animal had apparently died from massive septicaemia caused by the dart wound. None of the animals captured in Kyle Recreational Park were lost.

Three black rhino were lost in the operation. One died as a result of the dart penetrating the abdomen, 1 died in a fight with a resident bull shortly after release from holding pens in Hwange National Park,

and the other from unknown causes while being held in the pens prior to release.

Drug Immobilization

Data listing drug dosages, down times, time elapsed before antidote was administered, and respiration rates were taken initially and 30 minutes later (Tables 1 and 2). Immobilization times for black rhino in 1984 (Table 1) ranged from 6 to 21 minutes. In 1985 a problem was encountered with a batch of faulty drug delivery mechanisms which either failed to go off or only delivered part of the drug dose. As a result, the immobilization time tended to be longer, ranging from 5 to 156 minutes (Table 2). The immobilization times for white rhino (Table 1) ranged from 6 to 81 minutes. Data for the Kyle operation is not available. The distance covered by the rhino after darting varied from 600 to 4,000 m with a mean of 2,380 m.

The time elapsed before the antidote was administered to black rhino ranged from 72 to 495 minutes in 1984 (Table 1) and from 90 to 450 minutes in 1985 (Table 2). The rhino remained in deep narcosis for approximately 2 hours before gradually regaining consciousness, but provided the rhino were kept still and their eyes were covered, they did not show any undue signs of stress and remained sedated. It was not necessary, therefore, to administer any additional immobilizing drug en route.

Respiratory rates for black rhino taken shortly after the animal became recumbent ranged from 5 to 26/minute in 1984 (Table 1) and from 8 to 34/minute in 1985 (Table 2). After 30 minutes the respiratory rate had steadied to a mean of 12/minute (range 7-28). The time taken for rhino to get up on their feet ranged from 5 to 270 seconds (Table 1).

Release and Readaptation

Fifty-six black rhino and 8 white rhino were released. Seven white rhino (5 adult cows, 1 subadult cow, and 1 adult bull) and 4 black rhino bulls were released in the Matetsi Safari Area. Six black rhino were exported, and the remainder (46) were released in Hwange National Park together with 1 white rhino yearling bull. Two strategies were employed in releasing the rhino. First, the rhino were transported to holding pens where they were kept for periods of up to 2 weeks prior to release. Secondly, the rhino were offloaded at the release site and allowed to leave of their own accord. In such cases, the release site was selected in an

area with abundant water so that no matter in which direction the rhino moved, they would find water within a few kilometers. Their subsequent movements were then monitored from sightings, tracking, and recording spoor in the area. An attempt to radiotrack black rhino released in Hwange failed after the collars fell off the animals.

White Rhino. The white rhino from Matobo National Park were offered a diet of dry lucerne and hay, but apart from 1 bull, none of these animals fed prior to being released 10 days later. The 6 white rhino from Kyle Recreational Park were released immediately on arrival in the late afternoon. None of these animals appeared perturbed and all were observed to vocalize and greet each other on being released. Some animals began to feed immediately.

The solitary cow released from the holding pens was tracked continually for 3 days and was found to move about extensively, moving approximately 20 km a day without any apparent pattern. Of the 6 animals released directly, an adult cow and subadult cow were monitored over a 9-month period and were found to cover distances up to 60 km in a few days. Often the animals would move approximately 30 km overnight in 1 direction and then retrace their spoor and move off in a different direction. The remaining 4 white rhino moved approximately 45 km within a few days and, although they continued to wander around extensively in the Kazuma Pan National Park, they remained in contact with an existing population of 8 resident white rhino. Apart from these 4 animals, the remainder continued to move extensively throughout the area for the remaining 15 months before settling down. To date none of these animals have died nor have any of the cows produced calves.

Black Rhino. The 4 mature black rhino bulls translocated from the Zambezi Valley in June 1985 were released in the Matetsi Safari Area in an area where no resident black rhino occurred. The animals were not held in pens and were released individually from crates after the previous animal was out of sight. Movement of these rhino was monitored during the following 10 months. One animal moved approximately 4 km and established itself on the periphery of the Safari Area in the adjacent commercial farming area, negotiating a 9-strand steel game fence in the process. This animal was recaptured approximately 3 weeks later and released

back in the Safari Area where it settled down.

It was noted that within 2 weeks these rhino had deposited several dung piles and there were extensive signs of where the animals had scraped the ground with their legs in the immediate area, especially along vehicle bush tracks where scraping and dung deposits occurred approximately every 20 m over a distance of 2-3 km. None of these rhino, however, had moved more than 5 km from the release site after 6 months and it appeared that their home ranges tended to overlap. Thereafter there was evidence that 1 animal had begun to move further afield and dung piles and scraping were noted up to 10 km from the release site.

This behavior is contrary to that which occurred in Hwange National Park. In 1984 the rhino were penned at Shapi for approximately 2 weeks before being released in batches of 6 animals, and in 1985 the animals were released directly after arrival. In 1984, 1 animal which was radiotracked briefly moved approximately 15 km before settling in a scrub thicket. Other animals were recorded in the Sinamatella region approximately 35 km from the release site within a few days. Three other animals traveled approximately 50 km and settled in the region of Manga I Pan. Few sightings were made of the animals released in 1985, but it is concluded that the majority of the animals scattered widely after release (M.A. Jones and A. Conybeare, pers. commun.).

Discussion and Conclusion

Capture and translocation operations of both black and white rhino using etorphine hydrochloride in combination with other drugs have been successfully achieved in various parts of Africa since 1962. Some of these operations have been described in the literature by Harthoorn (1962, 1965, 1973), King and Carter (1965), Wallach (1966), Player (1967), Roth (1967), Rochat and Steel (1968), Denney (1969), Keep et al. (1969), King (1969), Keep (1971, 1973a, 1973b). Hitchins et al. (1972), Hofmeyr and de Bruine (1973), Hofmeyr (1975) and Hofmeyr et al. (1975). The capture and translocation operations described here do not vary greatly from those described by these workers.

Darting Equipment and Drug Dosages

A major problem encountered with the capture of rhino, particularly

black rhino, has been the failure of the dart on impact (King, 1969; Hofmeyr et al., 1975). Usually the needle either breaks, fails to penetrate, or the syringe explodes on impact. The use of reinforced needles described here appears to have overcome these problems, and although the needle was bent on occasions, no failures occurred because of breakages. It was also noted that the risk of failures could be further reduced if a 2-cc rather than a 3-cc syringe was used because the former did not impart as much momentum on impact when striking the animal obliquely.

The most notable differences to previously described operations are the low drug dosages used for black rhino (Table 3) and the exclusion of any form of tranquilizer both in the capture and translocation of the rhino. Various workers have used a variety of tranquilizers at varying dosage rates, and all have achieved comparable immobilization times (10-22 min) using 1-2 mg of etorphine hydrochloride (Table 3), the exception being where the use of high dosages of M99 (2-5 mg), have resulted in immobilization times of less than 10 minutes. This quicker immobilization time would appear to be more beneficial because it would reduce the degree of stress, but there are inherent risks in this procedure.

If one takes into consideration the type of terrain that black rhino tend to favor, the speed at which they move after receiving the dart, and the difficulty of locating and reaching the rhino, despite aircraft assistance, it is advisable to use the minimum amount of drug as this reduces the risk of asphyxia before the capture team arrives with the antidote. Of notable exception is when a helicopter is used as the capture team can administer the antidote immediately, if necessary, in order to reverse apnoea should it occur.

The use of hyoscine is highly recommended because it induces a state of catalepsy as well as mydriasis which makes the partially immobilized animal easier to handle. Some workers prefer to use a tranquilizer such as azaperone (Janssen), acetylpromazine (Boots), or xylazine hydrochloride (Bayer). King (1969) found that the inclusion of hyoscine in the drug mixture resulted in a "pushing syndrome" that led to exhaustion and even death of black rhino. This symptom was not observed in any of the capture operations described here, and the use of hyoscine was preferred, but it was unavailable for the 1985 operations. Little difference was noted

in the capture and handling of the rhino when this drug was excluded, but this could have been due to the experience and confidence of the capture team.

The exclusion of any form of tranquilizer in the capture and transport of the animals was favored because it was found that the rhino could be maintained in a state of narcosis for up to 7 hours using M99 alone. In this state it was easier to translocate the animals to the temporary holding pens without any undue stress. Care had to be taken that the animals did not regurgitate and choke or inhale ingesta during translocation for this could lead to the death of the animal.

When the rhino were crated pending translocation to the release site it was found that they settled down quickly once the recovery truck began to move. Furthermore, if the rhino were to be released directly on arrival, it was preferable that they were fully aware of their new surroundings and thus able to avoid confrontations with hazards such as gullies, pans, resident rhino, or predators.

Release and Readaptation

Data on the fate and readaptation of rhino following their release has been published by Hamilton and King (1969), Pienaar (1970), Hofmeyr (1975), Hillman (1982), and Booth et al. (1984). Keep (1973a) comments briefly on the reaction of black rhino following their release in Kruger National Park. The general consensus is that rhino need to be penned at the release site for up to 2 months in order to become oriented to their new environment. Unless this is done, there is a tendency for the animals to disperse to all points of the compass on being released. This hypothesis does not appear to be supported in practice. In many instances rhino have been released into sanctuaries that are fenced, which tend to restrict their mobility. The benefits of penning rhino prior to release are therefore unclear.

White Rhino. One of the difficulties involved with penning white rhino is to get the animals to feed, which can take up to 14 days. Experience has shown that despite penning the animals, they still tend to disperse widely after release. Pienaar (1970), in recording the recolonization history of white rhino in Kruger National Park, noted that new immigrants wandered great distances in search of suitable habitats. Herbert and Austen (1972)

reported that white rhino released in Hwange National Park took a considerable time to settle down, and some animals traveled great distances -- up to 225 km in some instances.

In 1975, 10 white rhino were released in the Kazuma Pan National Park (Booth et al., 1984). These animals were initially penned for up to 11 days, but because of their refusal to feed, they were released. Individual groups were followed, and it was found that the animals split up and moved up to 12 km in the 1st day. They had also begun to feed. These rhino moved about extensively; 2 animals were eventually located 130 km from the release site in Hwange National Park (A. Ferrar, unpubl. rep.).

A similar experience was noted in this exercise. The initial batch of rhino refused to feed and, being in poor condition to begin with, 3 of the animals died within 10 days. However, the animals that were released directly from the crates showed little sign of stress and began to feed immediately upon release. In both instances, however, the animals roamed extensively before settling down. The post-movement behavior of white rhino does not appear to be influenced by penning the animals prior to being released. It is clear, however, that any attempt to settle the animals in areas of unsuitable habitat is almost certain to end in complete failure.

Black Rhino. There does not appear to be any consistency in the response of black rhino following their release whether they are penned or not. Hamilton and King (1969) report that black rhino released into Nairobi National Park were penned approximately 1 month prior to release. Some of these animals remained in close proximity to the release site for up to 6 months before finally dispersing. Keep (1973a) comments that black rhino tended to disperse long distances following their direct release in Kruger National Park. However, when the animals were penned for 10-14 days prior to release, the animals did not move far away. Hofmeyr (1975) suggests that a prolonged captivity period should be avoided and it may be advisable to introduce and release rhino over a longer period.

In August 1975, 7 black rhino were released in the Zambezi National Park where there were no other resident rhino (Booth et al., 1984). These rhino were released directly from the translocation crates 8 hours after arrival, and their movements closely monitored over a 30-day period. One bull covered approximately 11 km in a day and was located

approximately 20 km away 12 days later. A cow moved off approximately 22 km within a few days while another remained within 1 km of the release site (A. Ferrar, unpubl. data). A hiatus of observations occurred thereafter until 1980 when the rhino, having bred, were relocated within 15 km of the release site. Regular reports since then confirm that these rhino are sedentary within the area.

A similar observation was made in the Gona re Zhou National Park (Zimbabwe) following the introduction of black rhino in 1971. The animals were released immediately on arrival, but 1 bull had to be recaptured a few days later having traveled approximately 60 km outside the national park (Dep. Nat. Parks and Wildl. Mgmt., unpubl. rep.).

Hillman (1982) reports that black rhino released directly into Pilanesberg Game Reserve where there were no resident rhino moved an average of 6.8 km in the 1st day and 23 km in the 1st month. When released after an unspecified time from holding pens, the rhino moved an average of 1.2 km in the first days and 11.2 km in the first month. Direct release into the area where there were already resident rhino resulted in movements of over 7 km in the 1st day and over 45 km in the 1st month. Hillman (1982) concluded from these observations that release from pens is preferable because it leads to less stress and risk, less post-release movement, and more chance of establishing rhino where required.

Hamilton and King (1969) make the point that the problem of released rhino is not primarily one of survival against predators, but relates to the provision of suitable habitat and adequate space within the sanctuary and often the acceptance of a newcomer by a resident rhino population. Goddard (1967) has shown that black rhino, whose home ranges overlap, are reasonably sociable, but that neither sex is very tolerant of a strange rhino. Furthermore, it appears that the size of the home range varies considerably according to the availability of food and surface water (Goddard, 1967; Hitchins, 1969; Mukinya, 1973). The response of black rhino following their release may therefore be influenced by these factors. The black rhino released in the Matetsi Safari Area were able to occupy an area that had adequate cover, food, and water. In addition, there were no resident rhino to challenge their arrival and human disturbance was minimal.

On the other hand, the black rhino translocated to Hwange National Park were released in an area that was poorly watered and already had a resident population of rhino. The released animals therefore had to compete with resident rhino, and on 1 occasion this led to the death of a bull due to a fight. This behavior was recorded in the Nairobi National Park (Hamilton and King, 1969). In Etosha National Park, where both male and female animals were involved in fighting (Hofmeyr, 1975), and in the Addo Elephant National Park, where serious fighting was attributed to an unusually high density, meeting of strange animals and aggression associated with mating (Hall-Martin and Penzhorn, 1977). It is possible that the long distances traveled by black rhino following release may be prompted by adverse habitat conditions, the presence of an existing rhino population, or a combination of these factors.

To conclude, the capture and translocation of black and white rhino and its inherent difficulties have been well documented. Little advantage is seen in holding the rhino in pens prior to release, however, and it is advisable to release the rhino directly on arrival if at all possible. The advantages of this procedure include a reduction in disease risks, stress, and loss of condition. In addition, there is a considerable saving in the costs of constructing pens, feeding, and logistics. The disadvantage is that the rhino cannot be monitored effectively unless they can be radiotracked.

Black rhino appear to be relatively easy animals to manage if they are penned. No difficulties are experienced in feeding and the animals settle down rapidly. Care should be taken in the selection of release sites to ensure that all the prerequisites for their survival are available. Where large translocations are involved, it may be advisable not to saturate the area and create unusually high densities, but rather to inoculate a wider area with a small nucleus of up to 6 animals at a time.

Acknowledgements

The authors wish to thank their colleagues for their keen interest in this project and for ensuring its success. This paper is published with the permission of the Director of National Parks and Wildlife Management, Zimbabwe.

Literature Cited

Booth, V.R., M.A. Jones, and N.E. Morris. 1984. Black and white rhino introductions in north-west Zimbabwe. Oryx 18:237-240.

Denney, R.N. 1969. Black rhinoceros immobilization utilizing a tranquilizing agent. East Afr. Wildl. J. 7:159-165.

Goddard, J. 1967. Home range, behaviour, and recruitment rates of two black rhinoceros populations. East Afr. Wildl. J. 5:133-150.

Hall-Martin, A.J., and B.L. Penzhorn. 1977. Behaviour and recruitment of translocated black rhinoceros Diceros bicornis. Koedoe 20:147-162.

Hamilton, P.H., and J.M. King. 1969. The fate of black rhinoceroses released in Nairobi National Park. East Afr. Wildl. J. 7:73-84.

Harthoorn, A.M. 1962. The capture and relocation of the white (square-lipped) rhinoceros Ceratotherium simum simum. Lammergeyer 2:1-9.

_____. 1965. Application of pharmacological and physiological principles in restraint of wild animals. Wild. Monogr. 14. 78pp.

_____. 1973. The drug immobilization of large herbivores other than antelopes. Pages 51-61 in E. Young, ed. The capture and care of wild animals. Human and Rousseau, Cape Town.

Herbert, H.J., and B. Austen. 1972. The past and present distribution of the black and square lipped rhinoceros in the Wankie National Park. Arnoldia 26:1-6.

Hitchins, P.M. 1969. The influence of vegetation types on sizes of home ranges of black rhinoceroses in Hluhluwe Game Reserve, Zululand. Lammergeyer 10:81-86.

_____, M.E. Keep, and K. Rochat. 1972. The capture of black rhinoceros in Hluhluwe Game Reserve and their translocation to the Kruger National Park. Lammergeyer 17:18-30.

Hofmeyr, J.M. 1975. The adaptation of wild animals translocated to new areas in South West Africa. Pages 126-131 in R. Reid, ed. Proceedings of the Third World Conference on animal production. Univ. Press, Sidney.

_____, and J.R. de Bruine. 1973. The problems associated with the capture, translocation and keeping of wild ungulates in South West Africa. Lammergeyer 18:21-29.

_____, H. Ebedes, R.E.M. Fryer, and J.R. de Bruine. 1975. The capture and translocation of the black rhinoceros, Diceros bicornis Linn. in South West Africa. Madoqua 9:35-44.

Keep, M.E. 1971. Etorphine hydrochloride antagonists used in the capture of white rhinoceros Ceratotherium simum simum. Lammergeyer 13:60-68.

_____. 1973a. The problems associated with the capture and translocation of the black rhinoceros in Zululand, Republic of South Africa. Lammergeyer 18:15-20.

Keep, M.E. 1973b. The use of etorphine hydrochloride (M99) (Reckitt), fentanyl (Janssen) and hyoscine hydrochloride combination for field capture of white rhinoceros. Lammergeyer 19:28-30.

____, J.L. Tinley, K. Rochat, and J.V. Clark. 1969. The immobilization and translocation of black rhinoceros Diceros bicornis using etorphine hydrochloride (M99). Lammergeyer 10:4-11.

King, J.M. 1969. The capture and translocation of the black rhinoceros. East Afr. Wildl. J. 7:115-130.

____, and B.H. Carter. 1965. The use of the oripavine derivative M99 for the immobilization of the black rhinoceros (Diceros bicornis) and its antagonism with the related compound M285 or nalorphine. East Afr. Wildl. J. 3:19-26.

Mukinya, J.G. 1973. Density, distribution, population structure and social organization of the black rhinoceros in Masai Mara Game Reserve. East Afr. Wildl. J. 11:385-400.

Pienaar, U. de V. 1970. The recolonization history of the square-lipped (white) rhinoceros Ceratotherium simum simum (Burchell) in the Kruger National Park (October 1961- November 1969). Koedoe 13:157-169.

Player, I.C. 1967. Translocation of the white rhinoceros in South Africa. Oryx 9:137-154.

Rochat, K., and N.A. Steel. 1968. Operation Rhodesian rhino. Lammergeyer 8:15-24.

Roth, H.H. 1967. White and black rhinoceros in Rhodesia. Oryx 14:145-150.

Wallach, J.D. 1966. The immobilization and translocation of the white rhinoceros. J. Am. Vet. Med. Assoc. 149:871-874.

* * * * * *

Table 1. Drug immobilization data for black and white rhinoceros operations in 1984. [a]

An. no.	Age/sex	Shoulder ht. (cm)	Time darted to time down (min)	Time down to time antidote (min)	Time up (sec)	Respiration rate/min. (init. + 30 min)	
Black Rhinoceros							
1	Ad/F	171	10	192	115	12	12
2	Ju/M	114	12	78			
3	Ad/F	160	8	107			
4	Ad/M	162	- [3.5 mg]	82	120	11	9
5	Ad/M	158	6	123	270	11	
6	SubAd/F	150		113	100	8	
7	Ad/F	160	13	153	100	22	14
8	Ad/F	160		154	90		
9	Ad/M	162	13	249	140	22	14
10	Ad/F	160	7	384	70	9	8
11	Ju/M	109	12	495	105	7	
12	SubAd/M	145	7	455	95	10	
13	SubAd/F	145	8		104	10	
14	Ad/M	154	14	134	90	8	10
15	Ad/F	164	14	121	140	8	9
16	Ad/F	165			5	14	
17	SubAd/F	146		280	97	17	12
18	Ad/F	160	7	247	91	18	14
19	SubAd/F	140	21	141	11	26	28
20	SubAd/M	141	10	126	95	5	9
21	Ad/F	170	12	161	111	10	8
22	Ad/M	157		306	30	20	13
23	Ad/M	163	15	167	120	22	
24	Ad/F	161	13	90	120	20	
25	Ad/F	171	6	72	120	12	
White Rhinoceros							
1	Ad/M	178		48	42	9	10
2	Ad/F		16	49	300	7	
3	Ad/M	183	- [4 mg M99]	33		6	
4	SubAd/M	173	81	16		14	9
5	Ad/M	157	6	Died		11	8
6	Ju/M	95	Captured by hand				

[a] The drug dosage was fixed at 1.75 mg M99® and 100 mg hyoscine hydrobromide for black rhino and 2 mg M99® and 50 mg hyoscine hydrobromide for white rhino. The antidote M50-50® was administered at the rate of 6 mg (4 mg IV, 2 mg IM) in all cases.

Table 2. Drug immobilization data for black rhinoceros operations in 1985.[a]

An. no.	Age/sex	Shoulder ht. (cm)	Time darted to time down (min)	Time down to time antidote (min)	Time up (sec)	Respiration rate/min. (init. + 30 min)	
1	Ad/M	173	14	106	173	12	10
2	Ad/M	160	7	120	160	12	
3	Ad/M	168	10			10	
4	Ad/M	185		450			
5	Ad/M	169	11			13	9
6	Ad/M	180					8
7	Ad/M	172	17			18	13
8	Ad/M	187	30[b]			8	7
9	Ad/M	175	15			14	12
10	Ad/M	179	18	90		18	16
11	Ad/M	175	100[b]			34	27
12	Ad/F	161	28[b]			10	9
13	Ad/M	160	34[b]			21	13
14	Ad/F	168	29[b]			10	
	Ju/F	86	Captured by hand				
15	Ad/M	173	15			16	
16	Ad/F	169	22[b]			9	9
17	Ju/M	95	5			15	16
18	Ad/F	150	11			19	14
19	Ad/M	165	20[b]			18	
20	Ad/M	179	10			12	
21	Ju/M	122	156[b]			12	12
22	Ad/F	161	18			13	
23	Ad/M	175	12			15	16
24	Ad/M	165	6			11	11
25	Ad/M	168	14			13	12
26	SubAd/M	145	16			11	7
27	Ad/F	158	19			15	13
28	Ad/F	176	14			11	12
29	SubAd/M	155	18			18	14
30	Ad/F	173	28			17	16

[a] The drug dosage was fixed at 1.75 mg M99® and the antidote M50-50® was administered at the rate of 6 mg (4 mg IV, 2 mg IM) in all cases.

[b] Faulty Cap-Chur® charges -- suspect only partial dose delivered.

Table 3. A comparison of the drug dosages and the mean immobilization time achieved by various workers in the capture of black rhinoceros.

Estimated wt. (kg)	Etorphine hydrochloride (mg)	$\bar{x}$ immobilization time (min)	N captured	References
400-1,185	1.0-2.0	22.8	4	Denney (1969)
818-1,196	2.0	20.0	2	Denney (1969)
700-1,100	1.2-1.5	16.8	5	King and Carter (1965)
250- 900	1.0-3.0	13.1	14	Keep et al. (1969)
	1.9	13.0	59	King (1969)
	2.0	11.4	19	Hitchins et al. (1972)
400- 820	2.0-2.5	10.6	3	Denney (1969)
	1.75	10.9	25	This study
500-1,300	3.0	8.4	20	Hofmeyr et al. (1975)
	5.0	7.0	3	G. Sharp (pers. commun.)

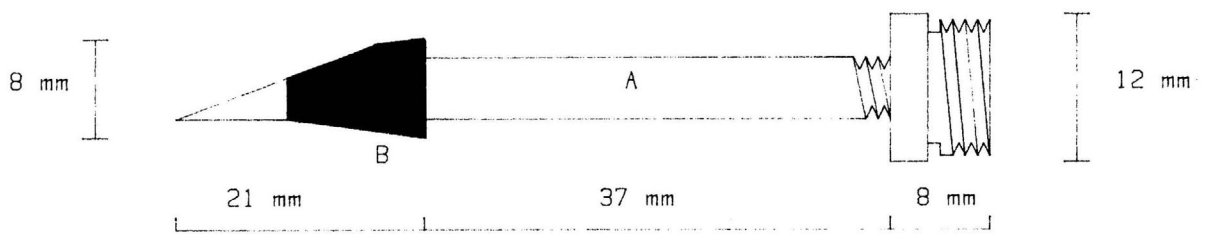

Figure 1: Black rhino capture dart constructed from 5 mm diameter steel injector tube (A) and reinforced with a steel or brass cone (B). This is fitted to a 2 cc or 3 cc aluminium tube equipped with a rubber plunger and 1 thru 3 Capchur charge.