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THE CAPTURE AND TRANSLOCATION OF THE BLACK RHINOCEROS

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Summary

Black rhinoceroses were hunted on foot, from a vehicle, or from a helicopter throughout their range of habitats. Animals weighing 370–1,260 kg could be handled an average of 13 min after darting with a mixture of etorphine (1.9 μg/kg) and acepromazine (19 μg/kg). Cases of respiratory depression at this dosage were reversed soon after immobilisation by the intravenous injection of cyprenorphine (1.0 μg/kg). The captured animal was transported to camp, lashed on its side to a sledge, for periods of up to 515 min without mishap. A rhinoceros that was unloaded 180 min after darting rose to its feet and tried to push its way through the corner of the pen until antidote was administered at 215 min. This action was not observed in animals that received a total dose of 3.4 μg/kg of cyprenorphine before being unloaded 90–413 min after darting.

The addition of hyoscine (at doses as low as 18 μg/kg) to etorphine and acepromazine improved the tractability of rhinoceroses that were only partially immobilised. However, sometimes at this dosage and always at doses above 35 μg/kg, hyoscine prolonged the 'pushing' phase for 175–410 min after darting despite the administration of cyprenorphine (4.0 μg/kg).

There were no mortalities due to drug action in the series of 59 healthy rhinoceroses that were dart-immobilised, but there were two deaths due to mishandling and one caused by subsequent mismanagement.

Introduction

The use of etorphine hydrochloride (M99) (Reckitt and Sons Limited, Hull, England) for the dart-immobilization of the white rhinoceros (*Ceratotherium simum simum* (Burchell)) (Harthoorn and Bligh, 1965; Wallach, 1966; Player, 1967) and the black rhinoceros (*Diceros bicornis bicornis* (Linnaeus)) (King and Carter, 1965; Jones, 1966; Roth, 1967) has contributed to the conservation of these animals.

This paper presents a continuation of the work of the Kenya Game Department Capture Unit on the capture and translocation of the black rhinoceros. Its purpose is to illustrate the application of the dart-immobilization technique within the exacting requirements of animal rescue operations, and to emphasize aspects of handling and husbandry after capture.

Materials and Methods

Dart-immobilization equipment

The standard Cap-Chur (Palmer Chemical and Equipment Company, Inc., Atlanta, Georgia, U.S.A.) 0.32 gauge rifle and a black powder cartridge were used in preference to the CO_2-operated gun. The projectile syringes were modified (D. Mackay and Son, East Road, Cambridge, England) to a design by Carter requiring reinforced barrel shoulders, and a needle with a blocked tip, side holes and barb (Plate 1a). The explosive injection mechanism was detonated by the impact of the dart on the rhinoceros and 2–2.5 ml of drug were injected. The contents of the needle (0.25 ml) were driven out by silicone grease on the front of the plunger.

Drugs

A narcotic mixture of etorphine, acepromazine (Acetyl promazine, Boots Pure Drug Company Limited, Nottingham, England) and hyoscine was used initially. Hyoscine was subsequently discarded. The etorphine antagonist cyprenorphine (M285) (Reckitt and Sons Limited, Hull, England) was given by injection into an ear vein. All dosages refer to the weight of salt used and have been calculated from actual body weights or weights derived from linear measurements taken at the time of capture (Freeman and King, 1969).

Prophylactics and therapeutics

After capture streptomycin (1g) was injected into the dart hole; the whole animal was swabbed with a diluted solution of Coopertox (Toxaphene, 75%: Cooper, McDougall and Robertson (East Africa) Limited, Nairobi, Kenya) including any sores under the neck, behind the shoulders and on the front of the udder. These were then covered with Cooper's Healing Oil (vegetable oil, 33% w/v; oleo resins, 57% w/v; phenoloids, 2.5% w/v: Cooper, McDougall and Robertson (East Africa) Limited, Nairobi, Kenya).

Septic wounds were treated by the topical application of a variety of antiseptic and antibiotic ointments supplied by E. T. Monks, Nairobi, e.g. sulphacetamide sodium, 10%; lindane, 0.1%; fly-repellent dimethyl toluamide, 30%; water, 10%; in emulsifiable base. Gentian violet sprays and chloramphenicol aerosols and eye ointments were also used on occasion. Streptomycin and oxytetracycline were injected intramuscularly when indicated, and the latter sometimes given in drinking water. Sulphadimidine tablets could be given by insertion into sugar cane (*Saccharum* sp.).

Methods

Black rhinoceroses were hunted in desert bush, open grassland, thorn bush, *Acacia-Commiphora* type woodland and scrub, and mountain forest, at altitudes which varied from 460–2,130 m (1,500–7,000 ft).

The hunting party usually set out at 0600 h local time but animals were darted up to 1730 h. Capture operations were usually confined to daylight hours but on one occasion continued past midnight. The rhinoceros was located on foot by tracking or hunting with dogs, or from a Land-Rover, Piper Super Cub light aircraft or Hughes 300 helicopter. The dart was fired from the ground, trees, a Land-Rover moving at speeds of up to 40 km/h or from the helicopter. After the rhinoceros had been darted, it was tracked on foot or followed by the aircraft or helicopter. The observers maintained radio (Pye Telecommunications Limited, Cambridge, England) contact with the lorry crews. The animal was usually captured lying on its brisket or side, or standing wedged into a bush. If it was slowly walking in circles and was very ataxic, it was roped from a Land-Rover, or sometimes a Ford catching truck. If the rhinoceros showed aggression it received a second dart with a dose of the narcotic mixture calculated to prevent the animal damaging itself or the vehicles.

Techniques of handling, loading and transportation were based on those described by Carter (1965). The recumbent animal was rolled onto the sledge, lashed securely on its side, winched up rollers on to the back of a Bedford 4 × 4 lorry and transported to camp. The unloading of the rhinoceros into the holding pen and the handling of the recovery phase varied with the narcotic mixture used.

Data collected during the capture operations were confined to noting the general condition of the animal, colour of the mucous membranes, and presence or absence of reflexes, and to monitoring pulse and respiration. Body measurements were taken and compared with live weights of 25 animals weighed in camp using a modification of the technique and equipment of Smith and Ledger (1965). A further 16 animals were weighed on Police Vehicle Inspection weighbridges an average of 9 d after capture. Body weight was found to be highly correlated ($r^2 > 0.98$) with certain expressions of linear measurements; these correlations involved log weight on log length + log girth, and weight on length × girth^2 (Freeman and King, 1969).

The rhinoceroses were transported to the National Parks an average of 9 d (range 4–25) after capture. They travelled facing forwards, in crates designed by Carter (1965), for periods of 3–10 h. The animals were kept in pens at the National Park for one month prior to release. The method of release and subsequent fate of some of these rhinoceroses has been described by Hamilton and King (1969).

RESULTS

Sixty cases of dart immobilization have been considered. Three of these concerned captive animals. A further six calves ranging in weight from 73–545 kg were caught by hand or roped by zoological collecting teams (professional trappers) who assisted with the provision of ground crews.

Hunting techniques

The efficiency of the various methods has been assessed in terms of the number of hunting hours per animal captured (Table 1). Hunting on foot was particularly discouraging because it was only used when all other techniques were impracticable and where the interaction between a rhinoceros population and agricultural settlement demanded action from the Game Department. These rhinoceroses were therefore extremely elusive and some of the bulls were very aggressive; three were shot in self-defence. Animals on the alert were rarely caught by surprise and they therefore presented a frontal target. The darts deflected off the horns, skull and sloping shoulders but one lodged in the upper lip. The chest, although a suitable target, was usually hidden in grass and foliage. When a rhinoceros was successfully distracted by dogs it was possible to lodge a dart at right-angles in the neck or shoulders. The range when darting on foot varied from 5–20 m.

Where the terrain permitted the driving of a Land-Rover or catching truck at speeds up to 48 km/h, the fleeing rhinoceros was darted in the rump at ranges varying from 1–20 m. The pursuit of the darted animal in a Land-Rover was often difficult and, in the absence of a spotter plane, the ground crew had to resort to tracking for as long as 135 min. In these circumstances it was more efficient to rope than to dart calves up to about 500 kg body weight. The helicopter was considered superior for locating the rhinoceros, darting it at ranges varying from 5–25 m, and observing and marking the position of the drugged animal. At the height of operations, 28 rhinoceroses were caught during 11 hunting days in 25 helicopter flying hours. The performance of the helicopter deteriorated at altitudes above 2,100 m due to lack of engine power and was limited to that of an autogyro.

While the techniques were being developed two animals that had been underdosed were lost by the trackers. Thereafter, every rhinoceros in which a dart lodged was caught. The presence of aerial spotters did not absolve the ground crews from the responsibility of being on terms with the hunted animal. The darted rhinoceros continued at a steady trot even when the narcotic mixture began to take effect and the animal was observed to blunder through bushes. The drugged animal was very difficult to turn and would move downhill into a valley, fail to negotiate the climb up the opposite slope, zig-zag across the gully, and finally collapse at the bottom. On two occasions it was fortunate that the anaesthetized animal fell with its nostrils out of water.

Dart immobilization equipment

The crossbow described by Short and King (1964) was discarded because its long range was not required and it was unwieldy to handle in thick bush. The CO_2 gun was also discarded because it could not be relied upon to penetrate up to 3 cm of rhinoceros hide at ranges from 4–25 m. The 0.32 gauge rifle accounted for 54 of the rhinoceroses immobilized. It can be seen from Table 2 that a galloping rhinoceros was not difficult to hit, provided the marksman was moving in the same direction as the quarry. Nevertheless it was important to place the dart at right-angles to the thick skin to avoid deflection, breakage or failure to penetrate (Plate 1a). The hide is composed of epidermis, vascular dermis and fibrous subcutis (Hofmann, pers.comm.). Signs of drug action were observed on only one occasion following incomplete penetration of the hide. If the charge used to project the dart was too strong, the needle bent, broke or recoiled on

TABLE 1

Efficiency of hunting techniques

Method			Animal numbers		Hunting hours per animal
Locate	Dart	Pursuit	Caught	Shot	
		non-selective			
Track	Foot	Track	1 ♂ 1 ♀	1 ♂	20
Dogs	Foot	Dogs	2 ♀	2 ♂	20
Land-Rover	Land-Rover	Track	2 ♂ 1 ♀	0	8
Aeroplane	Land-Rover	Aeroplane	2 ♂ 1 ♀	0	2
Helicopter	Helicopter	Track	1 ♂ 1 ♀	0	3
Helicopter	Helicopter	Helicopter	14 ♂ 13 ♀	0	1
		selective			
Helicopter	Helicopter	Helicopter	4 ♂ 9 ♀	0	2

impact; or, if the barb held, the needle was dragged out of the syringe barrel before the injection had been completed. The dart design has therefore to be modified to withstand recoil as well as impact.

Effect of Narcotic Mixtures

The darted animal was best observed from a helicopter at a height of 300 m above the ground. Signs of drug action were usually seen within 8–30 min of complete or partial injection. If at the end of that period the rhinoceros was observed to pause and urinate or defecate or swing its tail up over the back when approached, then a second dart was often required.

The animals have been divided into three groups based on the signs of drug action elicited by the different narcotic mixtures (Table 3). The mean dose of etorphine (E) and acepromazine (A) remained constant. However the mean dose of hyoscine (H) of 49 μg/kg in the group E/A/H was reduced to 26 μg/kg in the Intermediate group, and omitted from the group E/A.

Signs of drug action—'disturbed' animals

Phase 1. Ataxia

The first signs were often masked by the continuous trotting of the disturbed animal, until the hackney gait became accentuated, and the rhinoceros was blundering off the trail and through bushes. It then started to move in large circles of approximately 100 m diameter. The rhinoceros was still capable of a spirited charge if approached too closely and would follow the back of a vehicle moving a few metres ahead of it.

Phase 2. Catalepsy

The circles became smaller and the gait of the animals more ataxic. Individuals of groups E/A/H and Intermediate appeared unable to focus on people and were easily handled. Frequently the rhinoceros pushed its way into the centre of a bush and seemed unable to reverse out of the obstruction.

Animals of group E/A often appeared to be in phase 2, but (in the absence of hyoscine) they could focus and become aggressive when

TABLE 2

Efficiency of darting equipment

Projectile syringes (Plate 1a) were fired with a black powder charge from a 0.32 gauge Cap-Chur rifle

	All hunting techniques	Helicopter routine
NUMBER RHINOCEROSES CAUGHT	54	41
SUCCESSFUL SHOTS	52	40
PARTIAL FAILURES (fault)		
Recoil (dart/needle joint, excess charge)	8	7
Partial penetration	2	2
Plunger (jamming*)	5	5
COMPLETE FAILURES (fault)		
Miss (marksman)	5	1
Deflection (marksman)	5	1
Dart breakage (marksman, excess charge)	4	1
Unaccounted	2	0
TOTAL SHOTS	83	57

* In 58 darts that were recovered the injection charge had detonated in every dart.

TABLE 3

Narcotic mixtures used on black rhinoceroses

Group	Number of animals	Dose mean and (range) in μg kg		
		Etorphine hydrochloride	Acepromazine maleate	Hyoscine hydrobromide
E/A/H	17	1.9 (2.4–1.3)	18 (24–9)	49 (66–35)
Intermediate	15	1.8 (2.2–1.5)	17 (21–10)	26 (32–18)
E/A	28	1.9 (3.6–1.0)	19 (40–10)	0

handled 22 (15–30) min after darting. This was illustrated by a bull and a cow that fought the vehicle after being easily noosed, and by the behaviour of two cows that had been brought to a standstill by thick bushes. As the men jumped off the catching car with ropes, one cow reversed out of the bush and the other plunged through the obstruction; both rhinoceroses then attempted to gore men and vehicle.

Phase 3. Catatonia

Disturbed animals passed rapidly from a stage of ataxia to recumbency unless they had been halted by obstructions. Immobilization or catatonia was seldom observed.

Phase 4. Recumbency

The animal collapsed onto its brisket or side and rapidly became anaesthetized. Rhinoceroses caught standing in phase 2 also became unconscious once they had been cast onto their sides.

The phases that have been described applied to animals that had been sufficiently excited by the hunt to fight the narcotic mixture. On one occasion a rhinoceros was left undisturbed for 120 min after darting. It was eventually discovered by the tracking party, lying on its brisket asleep. When approached it rose, charged without hesitation, and reverted to phase 1.

Signs of drug action—'Tranquil' animals

Six of the animals darted were either captive, tranquil, lame or debilitated. These rhinoceroses reacted differently from the others to doses of the narcotic mixture ranging ± 20% about the mean.

The animals made little attempt to run forward after being darted.

Phase 3. Catatonia

The rhinoceros made no movement apart from lowering the head. The hindquarters then began to sway, and sometimes the animal adopted a 'dog-sitting' position, proceeding to Phase 4 (Recumbency).

Summary of chemical restraint (*Table* 4)

At the mean dosages used, disturbed rhinoceroses usually showed signs of drug action within 8 min and proceeded through phases 1–4 in the next 5 min, going down within an average of 13 min from darting. If the animal was not recumbent within 20 min it could usually be approached with caution. The inclusion of hyoscine (even at 20 μg/kg) in the narcotic mixture made the standing animal safer to handle. Tranquil animals that did not move far after darting usually went down within 9 min.

Physiology of the drugged animal

This section covers the period from capture, to rolling on to the sledge, winching up into the lorry, transporting to the catching pens, weighing and unloading. This amount of interference frequently caused transient disturbances to the physiological state of the animal.

General condition

The degree of sweating varied with the amount of exertion preceding capture and the ambient temperature. Fine muscular tremors were often observed in the standing and occasionally in the recumbent animal. Lightly anaesthetized rhinoceroses sometimes moved their ears and usually managed a slight struggle when being rolled on to the sledge.

The presence of palpebral and corneal

TABLE 4

Signs of drug action
Mean (range) time of onset (min)

Group:	E/A/H	Intermediate	E/A
	disturbed animals		
Phase 1 'ataxia'	8.5 (4–14)	8.5 (4–14)	8.5 (5–20)
Phase 2 'catalepsy'	13.0 (5–30)	13.0 (5–30)	11.0 (6–15)
Phase 3 'catatonia'		not observed	
Phase 4 'recumbency'	13.0 (5–20)	13.0 (5–20)	13.0 (5–20)
	tranquil animals		
Phase 1 'ataxia'		not observed	
Phase 2 'catalepsy'		not observed	
Phase 3 'catatonia'	3.0	4.5 (4–5)	5.0
Phase 4 'recumbency'	6.0	11.5 (8–15)	8.0

reflexes decreased with the depth of anaesthesia. The pupil was dilated in the presence of hyoscine even at a dose of 18 µg/kg, but appeared to be constricted in its absence.

After the rhinoceros had been lying on its side for about an hour, saliva and stomach contents were seen to leak out of the mouth and lower nostril.

Respiration

Extreme values for normal rhinoceroses were obtained from a placid, captive animal (weight 600 kg) and from a wild calf (weight 257 kg) immediately after being chased, roped and cast. The rate of the resting, recumbent animal was 22/min and was often characterized by a slight catch in the middle of each expiration. After exertion, the calf breathed through the mouth at a rate of 45/min.

The respiration rates of all drugged animals, except one, were below normal and reached their lowest values 30–90 min after darting. There was little difference between the groups, although the presence of hyoscine (32–65 µg/kg) produced the largest individual range and was associated with a maximum range of pulse rate. The degree of anaesthesia was most easily assessed by the depth and frequency of respiration, and was related to the dose of etorphine: a rate of 18–32/min was recorded at 1.0 µg/kg and apnoea at 3.0–3.5 µg/kg. This relation was less apparent between 1.45 and 2.35 µg/kg: the mean, (range) and [maximum individual ranges] of respiration rate/min were 9 (2–20) and [5–15 and 12–20] respectively.

Respiration was considered adequate at rates above 6/min provided that it was not too shallow. It was stimulated by jumping on the rib cage or rolling the rhinoceros. The administration of oxygen was thought to be contraindicated and liable to cause apnoea. It was presumed that a morphine-like depression of the respiratory centre made it insensitive to carbon dioxide but not to hypoxia (Goodman and Gilman, 1965). The most efficient way to reverse respiratory depression was to administer cyprenorphine.

Pulse rate

The rate but not the character of the pulse was assessed. Extreme values for normal animals ranged from 40–140/min. The rates recorded from most of the drugged animals fell within this range (Table 5). The pulse rate was not related to the dose of etorphine or acepromazine. The largest range and the highest rates were found in the group E/A/H. These were recorded from two animals that had been given hyoscine at 65 µg/kg in the narcotic mixture. They were both still standing and trying to push their way through obstructions.

Effect of antidote

General condition

Prior to transportation cyprenorphine, at 1.0–2.6 µg/kg, was usually given to ensure the presence of a swallowing reflex and to decrease the risk of inhalation of regurgitated stomach contents. The higher dose of antidote lightened anaesthesia so that the animal tried to stand. It would then struggle violently against the ropes tying it to the sledge, thereby reintroducing the risk of choking.

Respiration

There was an increase in the frequency and depth of respiration within 3 min of the intravenous injection of cyprenorphine. This was sometimes associated with retraction of the corners of the upper lip and breathing through the mouth. The respiration was clearly audible and the catch in the middle of expiration was accentuated into an expiratory

TABLE 5

Effect of narcotic mixture followed by cyprenorphine (1.6 µg/kg) on pulse rate per minute

Group:	E/A/H	Intermediate	E/A
mean	101	93	81
range	(76–150)	(80–120)	(40–114)
max. individual range	[76–150]	[100–104]	[66–90]
	after antidote		
mean	83	82	88
range	(60–120)	(60–104)	(60–150)
max. individual range	[68–115]	[72–90]	[88–150]

grunt. Cyprenorphine at a dosage of 2.0 μg/kg, in a ratio to etorphine of 0.6:1.0 (C:E ratio), was sufficient to reverse apnoea (Figure 1).

Pulse rate

The high rates recorded in groups E/A/H and Intermediate dropped to the mean level of group E/A after the animals had remained quietly on their sides for about 30 min. The effect of a small dose of antidote given during this period was difficult to assess (Table 5). It was noted that whereas the mean values for groups E/A/H and Intermediate had decreased, the value for E/A had increased. This increase was largely due to one animal with a range of 88–150/min which raised the mean value from 85 to 88.

Recovery phase

The animal was unloaded into the pen on its sledge. If the pen door could be closed with the omission of the bottom two horizontal poles, the sledge could be pulled out by ropes after the rhinoceros had walked off it. If the door was made of solid planks the animal had to be rolled off the sledge which was removed before the door was closed. The handling of the animal during this phase, from unloading until it could be left in the pen without supervision, varied with the narcotic mixture used (Table 6).

Group E/A/H

In the absence of the antidote, cyprenorphine, the standing animal was aware of its surroundings, despite a dilated pupil, within about 420 min from darting. When antidote had been administered the period of helplessness was decreased to a mean of 300 min. The rhinoceros was on occasion encouraged to its feet within 120 min by the injection of cyprenorphine at 2.5 μg/kg (C:E ratio 1.8:1.0). Within 5 min of the intravenous antidote the rhinoceros would flick its ears, often give a deep sigh, lever itself from its side onto the brisket using its head, and straighten the hindlegs and finally the forelegs. It then stumbled forwards until it hit the side of the pen, and slid along the wall scraping the side of the head on any obstructions. It would come to a standstill in the corner and start to push.

Pushing

Once the horn was wedged the rhinoceros started to strain forwards with the hindlegs splayed for extra purchase; the tail was raised over the back, the skin became dark with sweat, the animal breathed through the mouth and the mucous membranes became cyanotic. It did not back away from the electric goad, water or any other deterrent. Eventually the forelegs would buckle and the exhausted animal would lie wedged in the corner.

Since the animals were often on their feet 240 min from darting, they had to be led round the pen and steered out of the corners with a rope on the front horn or round the upper jaw for about 60 min (Plate 1b). During this period several injections of cyprenorphine to a total of 7.7 μg/kg (C:E ratio 3.5:1.0) appeared to be no more effective in reversing the condition than were lower doses of 1.7 μg/kg (C:E ratio 0.8:1.0).

Group Intermediate

The rhinoceroses were kept tied to the sledges for an average of 260 min in order to decrease the time that they had to be led round the pens to about 30 min. The recovery period following the injection of cyprenorphine was the same as in the above group, i.e. about 295 min. There was however a marked change in the behaviour of animals given antidote and unloaded after 300 min. On getting to their feet they moved backwards, snorted, and swung round to chase the last person out of the pen. However when left undisturbed they usually relapsed into a drowsy state and slept on their feet.

Group E/A

One rhinoceros was encouraged to its feet after 180 min and, in the absence of antidote, started pushing in a corner. An injection of cyprenorphine, 3.7 μg/kg, after 215 min reversed this condition. Other animals receiving this dose of antidote were alert and aggressive within 90 min. However, an anaesthetized animal which received the same dose of cyprenorphine at 45 min did not awaken immediately. When lower doses of antidote (0.8 μg/kg) were used the animals sometimes remained sleeping for up to 330 min if undisturbed.

The mean time for unloading this group was 237 min. Most of the animals had received antidote and by this time were alert and aggressive. Traditional handling techniques were therefore used.

Use of ropes

In order to manage the rhinoceros as it rolled off the sledge, the limbs were controlled

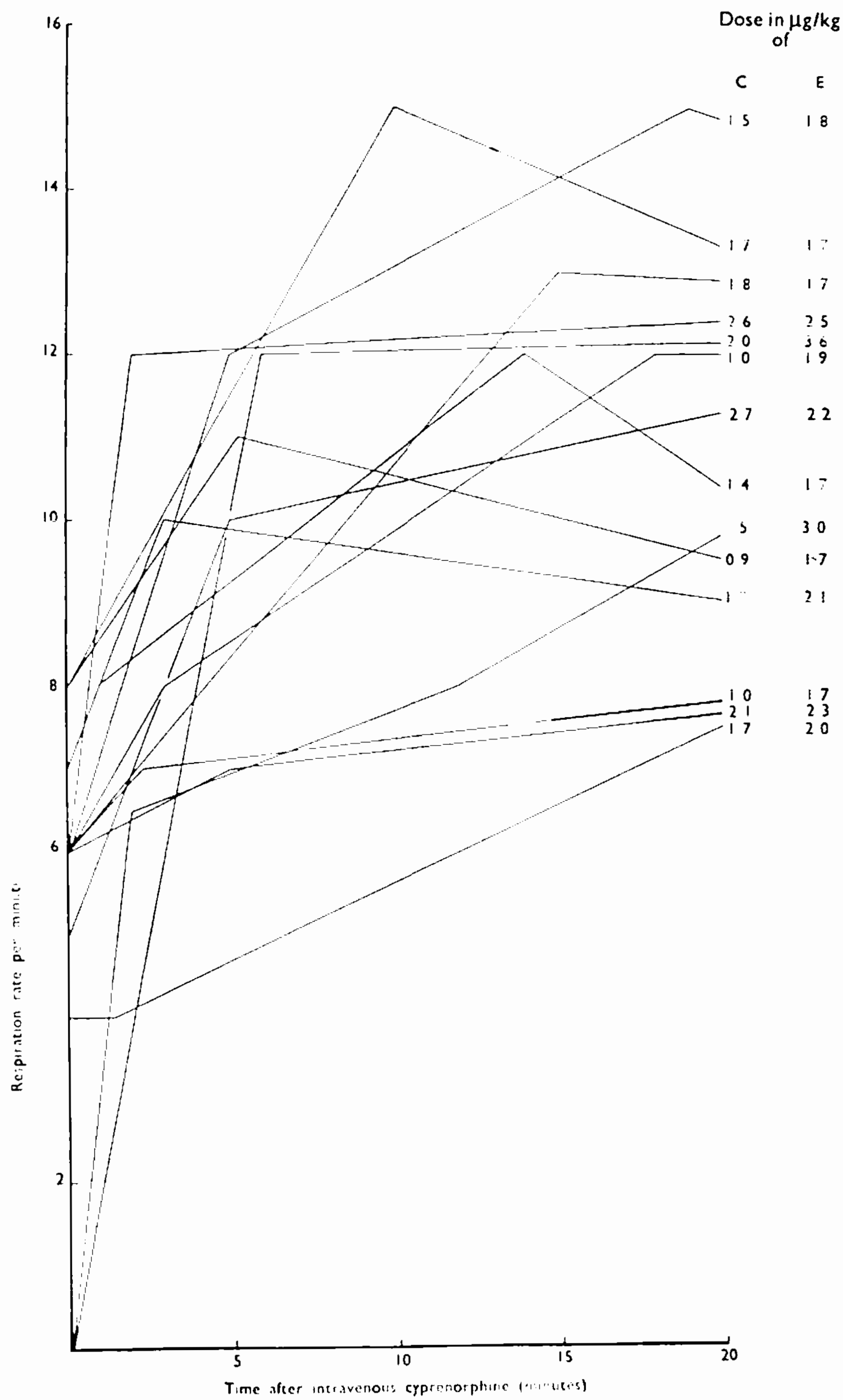

Figure 1

The effect of cyprenorphine (C) on respiration rate depressed by etorphine (E).

between ropes stretched across the pen (Plate 2a). The sledge was then removed and the pen door shut; the feet were kept suspended above the ground until after the final injection of antidote (Plate 2b). When the pen had been evacuated the lines were slackened and the nooses slipped off as the rhinoceros struggled to its feet. If the sledge could be removed after the animal was standing there was no need to roll the rhinoceros but merely to suspend its feet in the air while the sledge lashings were untied.

Effect of recumbency

Rhinoceroses were kept on their sides, lashed to the sledge, for periods of up to 515 min. Weight was taken off the side of the face by placing a small rubber tyre under the head. The animal was firmly secured to avoid self-inflicted injuries caused by violent struggling as it became conscious. No ill effects were observed apart from half a dozen cases of a slight limp affecting the forelimb on which the animal had been lying. The limp usually disappeared within a few minutes but on one occasion it persisted for a few hours.

Husbandry

Holding pens

These were constructed from 1.8 m wide portable sections consisting of planks of 3.8 cm thick camphor wood (*Ocotea usambarensis* Engl.) bolted on to an iron frame. The pen was 5.5 m square with smooth walls and a smooth top rail at a height of 1.8 m (Plates 2a and 2b). The rhinoceroses were able to rest their chins. and on one occasion both forelegs, on the top rail. However, the smooth sides offered no purchase for climbing and the smooth top rail did not graze the chin and back of the forelegs as the animal slid back into the pen. Shade and a water trough were also provided. The latter was covered with a lid during the recovery phase. Initially water was provided in metal half drums (capacity 100 l), but these were often trampled flat during the first night and were discarded in favour of concrete troughs.

Crates

The crates were designed by Carter (1965) with drop doors at one or both ends. The top was open at the ends to allow for upward thrusts of large horns and was supported across the middle by three metal crossbars. The largest crate measured 4.10 m long, 1.55 m wide and 2.35 m high.

After one mortality, animals were not crated during the 'pushing' phase of the recovery period. Two animals were crated for 120 min, while a pen was repaired, only 390 min after they had been darted. Although these new captives charged into the crates at a moving branch they did not require tranquillization when the doors were closed behind them. Usually the rhinoceros was not given access to the crate for the first two nights in case it felt particularly destructive. Thereafter it was fed in the crate and was usually ready to travel within four days. On the morning of departure the lorry and loading ramps were positioned and then the rhinoceros was crated. Once the door had been closed the crate was loaded and the lorry drove off without delay. The movement of the vehicle distracted the rhinoceros from smashing the crate and the animal travelled quietly facing forwards, standing or lying down, and feeding at the halts.

No animals suffered damage during transportation except for the one animal crated during the 'pushing' phase.

Release pens

The pens located in the National Parks

TABLE 6

Effect of cyprenorphine (C) on the recovery from different narcotic mixtures

Times from darting are in minutes; mean values are followed by range in parentheses

Narcotic mixture:	E/A/H	Intermediate	E/A
Total dose C in µg/kg	4.0 (1.7–7.7)	2.8 (1.8–4.6)	3.4 (0.6–10.0)
Ratio of C: Etorphine	2.0 (0.8–3.5)	1.7 (1.1–2.8)	1.8 (0.5–3.1)
Time of last C dose	238 (103–410)	198 (95–304)	193 (45–405)
Time unloaded	213 (103–410)	260 (190–343)	237 (45–405)
Time up	217 (115–390)	277 (195–343)	240 (90–413)
Time of awareness	300 (175–410)	294 (230–420)	240 (90–413)
Time of awareness without C	between 410 and 514	no record	no record

were twice the size of the pens in camp, and had a central partition for ease of cleaning. If the walls were made of horizontal poles they had to be at least 2 m high. The floor required a solid base of hardcore topped with murram especially during the rains.

Rhinoceroses moved from the hot dry desert scrub of the low country (altitude 460 m) found the cold wet climate of Nairobi National Park (1,750 m) rather a contrast. The provision of a wooden bench, 20 cm off the ground, covered with dry grass and placed under a shelter proved to be very popular. Rhinoceroses would use it as a bed sometimes within an hour of arrival.

Food

The rhinoceroses in the holding pens were fed with browse cut in the area in which they had been caught. Many suitable plants have been listed by Goddard (1968) who noted that the animals consumed a wide variety of the spectrum of plants available but were highly selective for herbs and shrubs. Since a considerable amount of browse had to be cut for the rhinoceroses in the morning and the evening, the larger plants were chosen rather than the smaller herbs.

Animals caught in the Nyeri Forest (altitude 2,100 m) were fed mainly on *Buddleja polystachya* Fresen., *Grewia similis* K. Schum. and *Abutilon longicuspe* Hochst. Those caught on the Kapiti plains (altitude 1,525 m) lost condition when fed on the dry plants of *Aspilia mossambicensis* (Oliv.) Wild., *Acacia stuhlmannii* Taub. and *Achyranthes aspera* L., and had to be moved to Nairobi National Park. In the park they were fed mainly on the following plants (identified by Mr. J. B. Gillett, East African Herbarium): *Rhus natalensis* Bernh. ex Krauss, *Euphorbia tirucalli* L., *Grewia tembensis* Fresen. var. *kakothamnos* (K. Schum.) Burret, *Aspilia mossambicensis*, *Grewia similis*, and *Ficus thonningii* Blume. Captive rhinoceroses were also seen to eat the dry grass that was supplied as bedding. Adults that had lost condition were fed a supplement of lucerne, and calves destined for zoological gardens received a porridge of powdered milk and maize meal with mineral and vitamin supplements.

Mortalities

Healthy wild animals

Mishandling

The routine of lashing the drugged rhinoceros to a sledge for transport to camp was not followed on one occasion when four rhinoceroses were caught within 150 min. Since there were not enough sledges and lorries available the last animal, weighing 915 kg, had to be transported in the back of a catching truck with its head bent upwards against the back of the cab and its hindquarters stretching on to the tail board. During the journey it struggled vigorously and regurgitated stomach contents. It was unloaded and rose to its feet without difficulty. However a day later its respiration rate had increased to 45/min and was associated with occasional grunts of discomfort. Inhalation pneumonia was suspected. It did not respond to intramuscular streptomycin and died three days later. Post mortem revealed congested lungs with areas of necrosis. Histological examination at the Diagnosis Section, Department of Veterinary Services, Kabete showed circulatory disturbances in the lung tissue and failed to confirm the presence of ingesta; nevertheless death was assumed to have been caused by inhalation of regurgitated stomach contents during the journey to camp.

Another rhinoceros was transported to Nairobi after it had walked into its crate during the 'pushing' phase 200 min after being darted with the E/A/H mixture. Frequent stops were made during the journey to drag the animal away from the front of the crate. It arrived at the Park pens 480 min later, exhausted, recumbent and barely able to move. The following morning it was alert, aggressive and charging on its knees. It could raise its hindquarters but could not straighten the forelimbs. Since this condition is extremely difficult to reverse (Carter, 1965; King and Carter, 1965) it was decided to try radical treatment. The animal was immobilized with 1.9 μg kg of etorphine, trenches were dug for the fore and hindlimbs, antidote (C:E—1.7:1) was given after 90 min, and the animal was rolled over so that its legs were placed in the trenches and much of the body weight was taken on the brisket. The rhinoceros never stopped struggling to get out of the trenches until it died 60 min later.

Mismanagement

The dogs that were used to bay up the rhinoceroses might have lacked the courage to do so if they had been muzzled. Unfortunately on one occasion the pack savaged a 135 kg calf while the hunting party waited for the infuriated cow to become immobilized.

The calf suffered deep lacerations on the vulva and left ear, and scratches on muzzle, legs and right ear. Nevertheless, within 240 min of capture the calf was suckling from the cow. A day later the calf was showing reluctance to move, despite antibiotic treatment, and the cow started tossing it into the air. The two were separated but the calf died the following day. Although Carter (1965) has kept a cow and calf together, the experience of some professional trappers recommended that they be separated, especially if the calf was not well (Carr-Hartley—pers. comm.).

One series of rhinoceroses was left in the care of a professional trapper with lower standards of hygiene and husbandry than the team usually employed. The holding pens were rather smaller than those previously described and constructed from upright poles to a height of 2.5 m. Water for the animals to drink was supplied from a nearby Masai well and poured into a depression in the ground which quickly became contaminated with faeces because the pens were not cleaned regularly. Four days after capture a magnificent bull broke his 79 cm front horn off at the base after pushing the horn between the uprights and trying to lever them apart. Two days later he was reported dead. *Salmonella typhimurim* was isolated in pure culture from the liver by the Department of Veterinary Services, Kabete. At the time of this inspection two other animals were observed to be covered with flies, and to have lost condition owing to the poor quality and small quantity of dry browse being fed to them. They were moved to Nairobi Park and responded rapidly to a diet of abundant green browse and to clean living quarters.

Sick wild animals

A male rhinoceros was removed from the vicinity of Treetops at the request of the National Parks because it was lame and debilitated. It was approached on foot and darted with the mean dose of the E/A/H mixture. The journey to the pens was completed within 120 min: the animal recovered consciousness after the administration of antidote but was unable to stand. During the next few days it ate well; it frequently straightened the hindlegs but could not use the sound or the suppurating forelimb even with the assistance of a chest sling suspended from a block and tackle. The animal died.

Treatment of sick animals

Two fresh spear wounds, one under the eye and one in the forelimb, were treated with the ointments described above ('Materials'). The lame animal was sufficiently robust to regain its feet after capture and transportation. However, as a precaution it was restrained on its sledge until fully conscious. The original plan had been to prevent this animal from going down and to crate it. However it retreated to the edge of a river bank and had to be completely immobilized where it stood.

There were a number of cases of minor injuries that decreased as pen design and handling techniques improved. These included: scraped chin and forelegs, small abscesses above a toenail, conjunctivitis and two cases of broken front horns. These injuries became septic very easily and required daily treatment with ointments and oral or parenteral antibiotics. The patients were trained to come for treatment every day by feeding into an examination crate. Chemical restraint was used rarely and as a last resort.

DISCUSSION

The exacting requirements of animal rescue operations have exposed limitations in the techniques described, despite the success of the overall result.

The problems of hunting on foot make the successful series of black rhinoceroses darted by Thomson and Fothergill in Rhodesia particularly notable (Jones, 1966). It is difficult to understand the remark by Player (1967) from Natal Parks that "the black rhino's first reaction on getting a fright was to charge. This made darting simple." In the forests of Kenya where the undergrowth often reduced visibility to a few metres and the grass and bushes in the glades grew head high, darting the black rhinoceros was not simple. Darts fired at charging animals usually bounced off but also deflected the charge. No bullets were fired in self-defence at a distance of more than about four metres. Darting from a helicopter proved to be the method of choice, but in many areas where it was possible to dart from a vehicle, a light aircraft was sufficient to locate and follow the rhinoceros. If the animal weighed less than 500 kg, a noose in the hands of an experienced team was just as effective as a dart.

No difficulty was experienced in arriving at a suitable immobilizing dose. The effect of the etorphine narcotic mixture is similar in many wild ungulates including the black rhinoceros. However, this species is usually very reluctant to stop running or to be hazed or driven after it has been darted. The ground crews have to be on the alert to save the animal from stumbling into natural hazards; high immobilizing doses were used to stop rhinoceroses darted in or near a gorge, dam, road, railway, international airport and army barrack. One animal in every ten was an exception to the rule, and succumbed to drug-immobilization almost without moving. This tranquil reaction to dart-immobilization occurred in a few healthy, truly wild animals as well as in debilitated and captive ones. The latter were immobilized during the initial phase of captivity with doses within the normal range when allowance was made for a loss of at least 100 kg body weight (Freeman and King, 1969). An increased susceptibility to drug action could also be related to the loss of condition during this period. These considerations were not given sufficient weight by Harthoorn (1967) when he stated that "the psychological impact of confinement renders captured wild animals more susceptible to the action of major tranquillisers." Consequently this statement is not supported by the records that he quotes. The point that should be emphasized is not primarily "that the drive of flight or aggression in truly wild animals is more difficult to depress chemically than in domestic stock or captured wild animals" (Harthoorn, 1967), but that the former category are much more easily disturbed. In this context animals in National Parks often react to dart-immobilization like captive rather than like truly wild animals. It is also much easier to avoid disturbance when darting tame rather than suspicious animals. This factor of excitement may have little bearing on the final successful dart-immobilization of the black rhinoceros but may become more significant in other animals such as the adult African elephant (*Loxodonta africana africana* Blumenbach) (Pienaar *et al.*, 1966a; King, unpublished observation).

The composition of the narcotic mixture was varied by the addition or exclusion of hyoscine. This drug made the partially immobilized rhinoceros much safer to approach by inducing a state of catalepsy as well as mydriasis. Hyoscine has undoubtedly contributed to the success of the black rhinoceros rescue operations in Rhodesia (Jones, 1966) although its importance may have been overlooked. Condy (1966) refers to this work and states that "1 mg M99 is quite sufficient for a fully mature black rhinoceros." This is about half the amount of etorphine used in Kenya, but it was supplemented with about double the amount of hyoscine (100 mg). The latter drug in therapeutic doses causes "drowsiness, fatigue, and dreamless sleep" in man and may potentiate the narcotic analgesic (Goodman and Gilman, 1965). Thus the low etorphine/high hyoscine mixture rendered the animal helpless without the risk of asphyxia before the tracking party arrived with antidote as late as 277 min after darting. Another point in its favour was that it could be used on almost any adult or adolescent rhinoceros encountered. When hunting on foot one must be prepared to take snap shots, and the size of the spoor is not a very accurate indication of the weight of the quarry (Freeman and King, 1969). These actions of hyoscine could probably be achieved at a dose of 35 μg/kg, i.e. 35 mg for an adult animal.

An alternative explanation for Condy's remark that "1 mg M99 is sufficient" is that the Rhodesian rhinoceros is half the size of those found in Kenya. Although unlikely, this explanation does focus attention on one of the difficulties of comparing the results of different field workers in different areas. Dosages of immobilizing drugs are commonly given in μg or mg per kg, having been based on estimated weights. Since other information on the animal is supplied, e.g. age and total amount of drug administered, these estimates are seldom called to account. However the dosage recommended by one field worker can be ineffective or lethal in the hands of another and it is useful to be able to differentiate between deterioration of drug activity at high ambient temperatures (Short and Spinage, 1967), variations in body weight of a species in different areas (Sachs, 1967), the significance of supposedly mild ataractics included in the narcotic mixture (Hanks, 1967) and variations in handling. The latter is seldom considered worthy of mention and yet it can be seen from these results that no mortalities would have occurred if the dart-immobilization had been confined to the marking and immediate release of healthy wild rhinoceroses. In an effort to eliminate the variable of unknown weight, the rhinoceroses caught in this series were weighed and measured. There is an extremely good correlation between linear measurements and weight in the black rhinoceros (Freeman and King, 1969), far better than can be obtained from many other African animals (McCulloch and Talbot, 1965).

The physiology of the anaesthetized animal resembled the picture described for laboratory animals (Blane *et al.*, 1967) and equines (King and Klingel, 1965). Contrary to the generalization made by Harthoorn (1967), essential body functions such as breathing were markedly affected by the etorphine: hyoscine: acepromazine mixture under normal dosage rates and, in the absence of hyoscine, doses of etorphine above 3 μg/kg caused apnoea. Since Ebedes (1966) used an estimated dose of 5 μg/kg on a black rhinoceros and recorded a respiration rate of 10/min during the 30 min after darting and prior to the administration of antidote, the apnoea experienced at lower doses might only have been transient. Mean values for pulse rates recorded after darting were higher in animals that received hyoscine than in those that did not, implying antagonism of etorphine-induced bradycardia (Blane *et al.*, 1967). Although the actions of etorphine and hyoscine could be recognized and distinguished, those of acepromazine could not. This phenothiazine was administered at a dose of 10–40 μg/kg, i.e. half the recommended dose for large domestic animals, and was omitted from most of the series described by Jones (1966). Thus although the potentiation of etorphine by low doses of acepromazine has been well documented (e.g. Pienaar *et al.*, 1966b), the term neurolept-analgesia may not be strictly correct in the context of this paper.

The choice of sledges or crates to transport the immobilized animal is a point of controversy. Carter (1965) used sledges for both black and white rhinoceroses (Savidge, 1965). This ensured that the animal was restrained during the stage of narcotic excitement associated with the use of the drug phencyclidine (Sernylan. Parke. Davis and Company, Hounslow, Middlesex, England) in rhinoceroses and many other species (Kroll, 1962; Lentfer, 1968). Parallel development of the capture and translocation of the white rhinoceros occurred in Natal Parks. The animals were dart-immobilized with neurolept-analgesic mixtures containing morphine or diethylthiambutene (Themalon. Burroughs Wellcome and Company Limited, London N.W.1) which could be antagonized with nalorphine (Lethidrone. Burroughs Wellcome and Company Limited, London N.W.1) (Harthoorn and Player, 1964). These mixtures achieved a hitherto unknown degree of chemical control and the animals were walked into crates for transportation. It appeared that the sledge had become outmoded and Harthoorn (1965) pointed out that "the transport of large animals in this position is fraught with considerable hazard, particularly when breakdown of the lorry may occur, or negotiation of natural obstacles causes undue delay." However in practice it has been found that a crate doubles the height of a lorry and its load, thereby effectively limiting the density of cover it can penetrate, the gradients it can negotiate, and the mud and sand it can traverse. Since black rhinoceroses harassed by the encroachment of human settlement retired to the most inaccessible corners of their habitats, the crate was better left in camp. Sledges were used both in Kenya and Rhodesia and even then the black rhinoceros sometimes had to be walked to the lorry (Jones, 1966). The animals in the present series were kept lying on their sides lashed to the sledge for up to 514 min. There were no cases of severe radial paralysis comparable to one that occurred after 1,060 min recumbency (King and Carter, 1965), although a few animals limped slightly for a short while after getting to their feet.

The recovery phase raised two problems. In the presence of hyoscine the 'pushing' phase remained for an average of 300 min, although the depressant actions of etorphine had been reversed by cyprenorphine. Since the rhinoceroses were often unloaded within 240 min of darting, they had to be walked round the pens for about 60 min. This often delayed the unloading of one or two more rhinoceroses and prompted the discarding of hyoscine from the immobilizing mixture. Its omission shortened the mean recovery time by about 60 min after the administration of cyprenorphine and often gave the men an extremely lively animal to unload. The new problem was overcome by using traditional methods of handling the conscious animal with ropes.

It has been noted that cyprenorphine at doses up to 7.7 μg/kg did not entirely reverse the undesirable effects of the E/A/H mixture, but it was a much more effective etorphine antagonist than it had appeared to be in the presence of phencyclidine and hyoscine (King and Carter, 1965). In the latter series it was suspected of prolonging recumbency, and at doses of 13 μg/kg has been shown to have depressant actions in laboratory animals (Bentley *et al.*, 1965). However, reluctance to increase the dose of antidote may not be warranted since Ebedes (1967) has used approximately 20 μg/kg in the presence of tranquillizers prior to crating.

The record of three mortalities in 59 cases of dart-immobilization could be glossed over by the rather dubious practice of stating that no deaths could be directly attributed to drugs. However, with modern neuroleptic and analgesic mixtures low drug mortalities should be the rule rather than the exception and more emphasis must be placed on wild animal handling and husbandry. Player (1967) illustrates this point with reference to 456 white rhinoceroses that were immobilized for relocation in zoological gardens and other game reserves in Southern Africa. Two deaths were attributed to drugs, ten occurred during capture and 41 in captivity. The three mortalities that occurred in the present series could probably have been avoided. The suspected inhalation pneumonia might not have occurred if the animal had been secured to a sledge; the case of typhoid was a rather spectacular but not improbable result of poor hygiene and husbandry; the animal that collapsed exhausted from pushing in the crate would probably have been discouraged from doing so by the administration of tranquillizer prior to antidote (Harthoorn, 1962; Player, 1967). This 'pushing' phase may not extend beyond 90 min in the absence of hyoscine, and tranquillization with acepromazine has proved adequate for crating and transporting a black rhinoceros 450 km (Ebedes, 1966). The role of the phenothiazines at this stage could theoretically be displaced by some of the butyrophenone derivatives (Marsboom and Mortelmans, 1964; Pienaar, 1969); in practice the constant noise and movement of the lorry may provide all the tranquillization that is needed. It is worth stressing that one of the main reasons for crating a tranquillized white rhinoceros immediately after capture is to avoid the delays experienced in persuading the species to accept captivity. The white rhinoceros rarely feeds before 4–14 days in captivity (Player, 1967) and crate training may take eight weeks (Wallach, 1966). Both these authors remarked that the black rhinoceros was easier to tame. In the present series, some animals were encouraged into crates shortly after they had regained consciousness, and others were transported prematurely. These black rhinoceroses could usually be distracted from damaging their crates or themselves. Most animals began feeding on the first night in captivity and would come and take browse from the hand within 24 h. They were trained to use a crate within two or three days and could then be transported to a National Park.

The most serious cases of sickness have been described and did not include any case of trypanosomiasis, although half the rhinoceroses caught by trappers in the same area at the same time of year are reported to have shown clinical signs. The parasite has also been a problem in other black rhinoceros translocations (Davison, 1966). The most common injuries were self-inflicted and often related to badly designed pens. Cuts and abrasions became septic very easily, took many weeks to heal, and lowered the condition of the animal. Treatment was effected by training the rhinoceros to walk into a crate. Chemical restraint was considered as a last resort and felt to be contra-indicated in cases of liver dysfunction, bearing in mind that the major route of etorphine excretion in the rat is via the bile (Dobbs, 1968). The sequel to dart-immobilization of a sick wild rhinoceros was the recovery of consciousness but not of strength in the forelimbs. Since the rhinoceros raises the hindquarters first, the centre of gravity is shifted to the brisket and if one forelimb is damaged the sound limb may lack the strength to stand even with the assistance of a sling. Lame animals that had been dart-immobilized were therefore tied down until fully conscious to ensure that their first efforts to rise were successful; otherwise the animal might have so exhausted itself while semi-conscious that the state of recumbency would have become irreversible (King and Carter, 1965).

The final phase of the translocation operations, namely the release, has been studied by Hamilton and King (1969) with reference to the black rhinoceroses introduced into Nairobi National Park.

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REFERENCES

BENTLEY, K. W., BOURA, A. L. A., FITZGERALD, A. E., HARDY, D. G., MCCOUBREY, A., AIKMAN, M. L. and LISTER, R. E. (1965). Compounds possessing morphine-antagonising or powerful analgesic properties. *Nature, Lond.*, **206**: 102–103.

BLANE, G. F., BOURA, A. L. A., FITZGERALD, A. E. and LISTER, R. E. (1967). Actions of etorphine hydrochloride (M.99): a potent morphine-like agent. *Br. J. Pharmac. Chemother.*, **30**:11–22.

CARTER, B. H. (1965). The Arm'd Rhinoceros. *Andre Deutsch Ltd., London.*

CONDY, J. B. (1966). M-Series, Veterinary Applications report No. 50. *Reckitt and Sons Ltd., Hull.*

DAVISON, E. (1966). Capture and translocation of game animals. *News Bull. Soc. sth Afr.*, 7(2):1–5.

DOBBS, H. E. (1968). Effect of cyprenorphine (M.285), a morphine antagonist, on the distribution and excretion of etorphine (M.99), a potent morphine-like drug. *J. Pharmac. exp. Ther.*, **106**:407–414.

EBEDES, H. (1966). Gemsbok and black rhinoceros immobilisation with M.99. M-Series, Veterinary applications report, No. 48. *Reckitt and Sons Ltd., Hull.*

............(1967). Gemsbok and black rhinoceros immobilisation with etorphine. M-Series, Veterinary applications report, No. 57. *Reckitt and Sons Ltd., Hull.*

FREEMAN, G. H. and KING, J. M. (1969). Relations amongst various linear measurements and weight for black rhinoceroses in Kenya. *E. Afr. Wildl. J.*, **7**: 67–72.

GODDARD, J. (1968). Food preferences of two black rhinoceros populations. *E. Afr. Wildl. J.*, **6**:1–18.

GOODMAN, L. S. and GILMAN, A. (1965). The pharmacological basis of therapeutics. 3rd ed. *Collier-Macmillan, London.*

HAMILTON, P. H. and KING, J. M. (1969). The fate of black rhinoceroses released in Nairobi National Park. *E. Afr. Wildl. J.*, **7**: 73–83.

HANKS, J. (1967). The use of M.99 for the immobilisation of the defassa waterbuck (*Kobus defassa penricei*). *E. Afr. Wildl. J.*, **5**: 96–105.

HARTHOORN, A. M. (1962). Capture of the white (square-lipped) rhinoceros *Ceratotherium simum simum* (Burchell) with the use of drug immobilization technique. *Can. J. comp. Med.*, **26**: 203–208.

............(1965). Application of pharmacological and physiological principles in restraint of wild animals. *Wildl. Monogr.* No. 14: 1–78.

............(1967). Comparative pharmacological reactions of certain wild and domestic mammals to thebaine derivatives in the M-series of compounds. *Fedn Proc. Fedn Am. Socs exp. Biol.*, **26**: 1251–1261.

HARTHOORN, A. M. and BLIGH, J. (1965). The use of a new oripavine derivative with potent morphine-like activity for the restraint of hoofed wild animals. *Res. vet. Sci.*, **6**: 290–299.

HARTHOORN, A. M. and PLAYER, I. C. (1964). The narcosis of the white rhinoceros. A series of eighteen case histories. Fifth International Symposium on Diseases in Zoo-Animals (1963). *Tijdschr. Diergeneesk.*, **89**, Suppl. **1**: 225–229.

JONES, R. D. (1966). A comparison between morphine and M.99 as narcotics for the immobilisation of the black rhinoceros (*Diceros bicornis*). M-Series, Veterinary Applications report, No. 46. *Reckitt and Sons Ltd., Hull.*

KING, J. M. and CARTER, B. H. (1965). The use of the oripavine derivative M.99 for the immobilisation of the black rhinoceros (*Diceros bicornis*) and its antagonism with the related compound M.285 or nalorphine. *E. Afr. Wildl. J.*, **3**: 19–26.

KING, J. M. and KLINGEL, H. (1965). The use of the oripavine derivative M.99 for the restraint of equine animals and its antagonism with the related compound M.285. *Res. vet. Sci.*, **6**: 447–455.

KROLL, W. R. (1962). Experience with Sernylan in zoo animals. *Int. Zoo Yb.*, **4**: 131–141.

LENTFER, W. J. (1968). A technique for immobilising and marking polar bears. *J. Wildl. Mgmt*, **32**: 317–321.

MARSBOOM, R. and MORTELMANS, J. (1964). Some pharmacological aspects of analgesics and neuroleptics and their use for neuroleptanalgesia in primates and lower monkeys, *in* Small Animal Anaesthesia, pp. 31–44. *Pergamon Press, London.*

MCCULLOCH, J. S. G. and TALBOT, L. M. (1965). Comparison of weight estimation methods for wild animals and domestic livestock. *J. appl. Ecol.*, **2**: 59–69.

PIENAAR, U. de V. (1969). Recent advances in the field immobilization and restraint of wild ungulates in South African National Parks. In press.

PIENAAR, U. de V., VAN NIEKERK, J. W., YOUNG, E., VAN WYK, P. and FAIRALL, N. (1966a). The use of oripavine hydrochloride (M.99) in the drug immobilization and marking of wild African elephant (*Loxodonta africana* Blumenbach) in the Kruger National Park. *Koedoe*, **9**: 108–124.

............(1966b). Neuroleptic narcosis of large wild herbivores in South African National Parks with the new potent morphine analogues M.99 and M.183. *Jl. S. Afr. vet. med. Ass.*, **37**: 277–291.

PLAYER, I. (1967). Translocation of white rhinoceros in South Africa. *Oryx*, **9**:137–150.

ROTH, H. H. (1967). White and black rhinoceros in Rhodesia. *Oryx*, **9**: 217–231.

SACHS, R. (1967). Liveweights and body measurements of Serengeti game animals. *E. Afr. Wildl. J.*, **5**: 24–27.

SAVIDGE, J. M. (1965). Catching and carting white rhino in Uganda. *Oryx*, 8: 89–93.

SHORT, R. V. and KING, J. M. (1964). The design of a crossbow and dart for the immobilisation of wild animals. *Vet. Rec.*, 76: 628–630.

SHORT, R. V. and SPINAGE, C. A. (1967). Drug immobilisation of the Defassa Waterbuck. *Vet. Rec.*, 79: 336–340.

SMITH, N. S. and LEDGER, H. P. (1965). A portable tripod and weighing assembly for large animals. *J. Wildl. Mgmt*, 29: 208–209.

WALLACH, J. D. (1966). Immobilization and translocation of the white (square-lipped) rhinoceros. *J. Am. vet. med. Ass.*, 149: 871–874.

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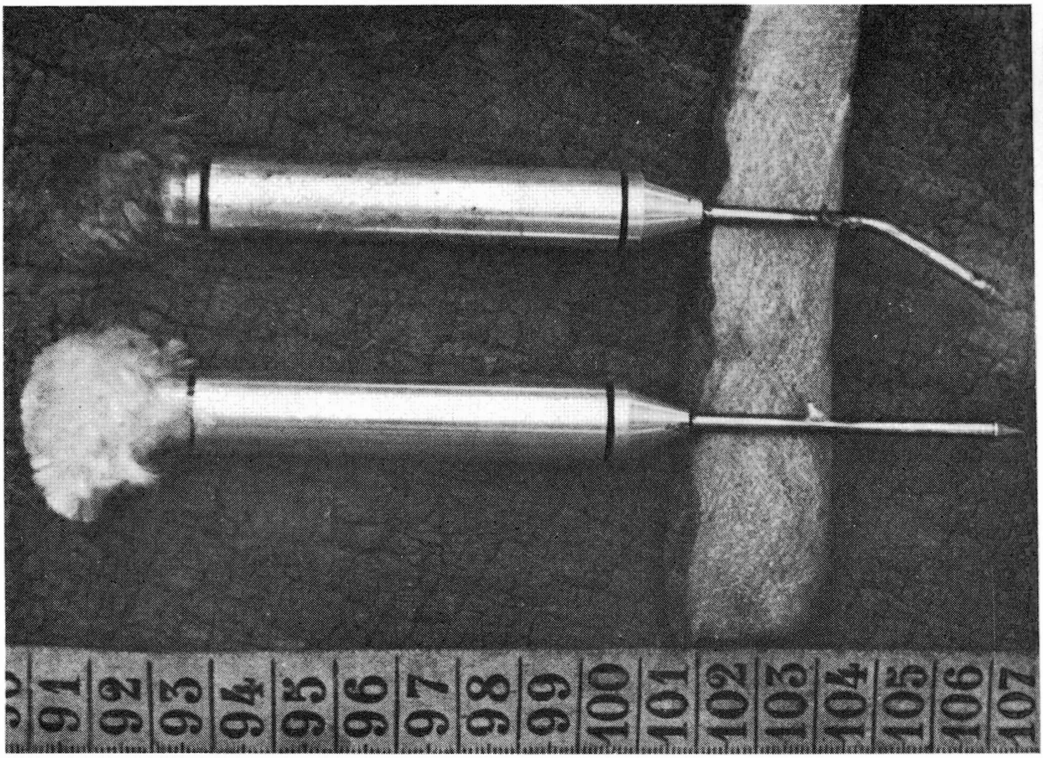

Plate 1a
Used and unused projectile syringes have been placed on a cross section of rhinoceros hide to show the degree of strength and penetration required. Scale is in cm.

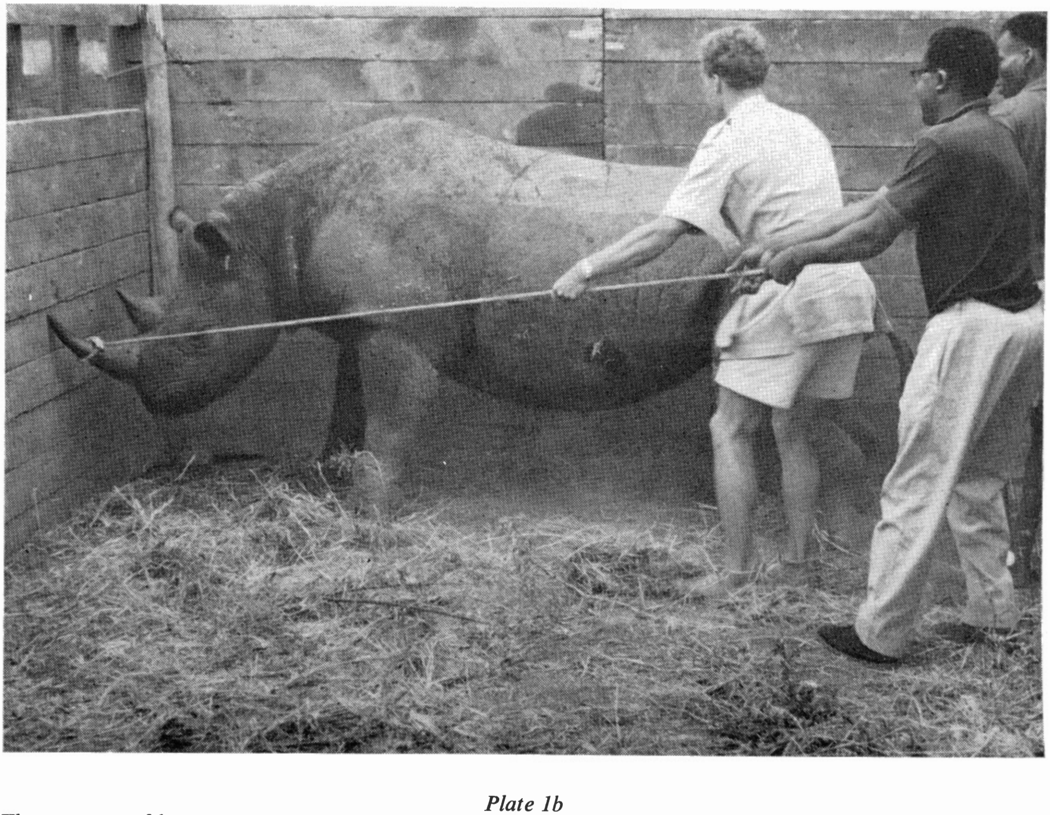

Plate 1b
The presence of hyoscine in the narcotic mixture prolonged the recovery phase even after the administration of antidote. The animal had to be led round in circles and prevented from pushing into the corners.

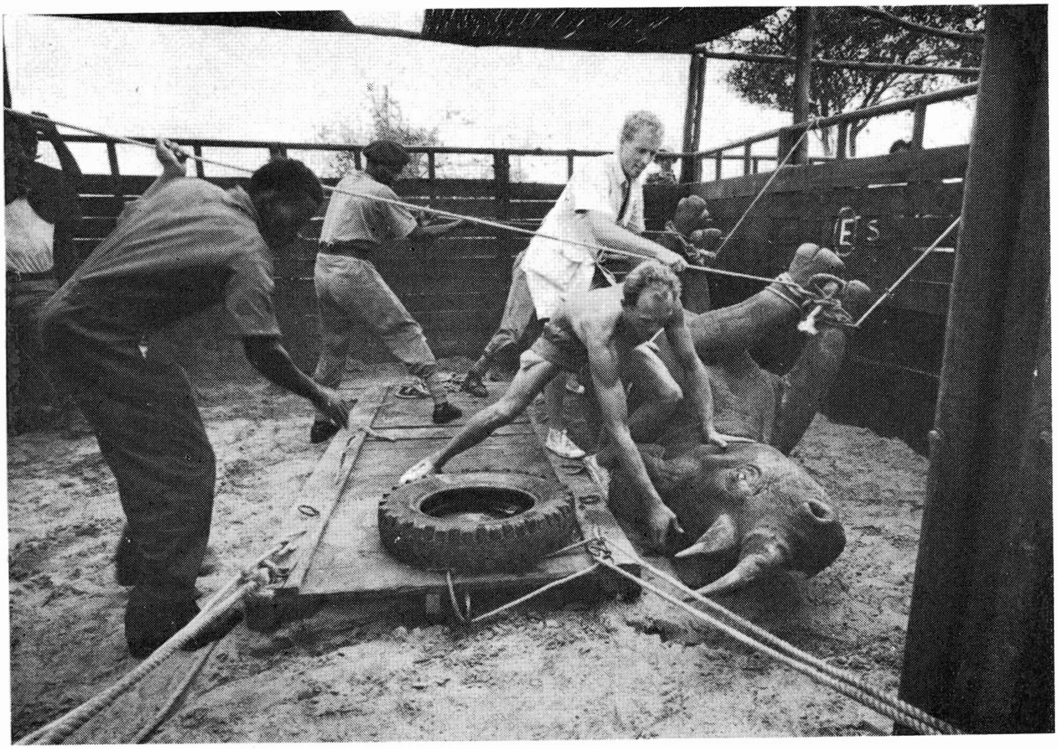

Plate 2a
The omission of hyoscine from the narcotic mixture gave the ground crew a lively animal to unload. The rhinoceros was controlled by tension being maintained on the leg ropes as it was rolled off the sledge.

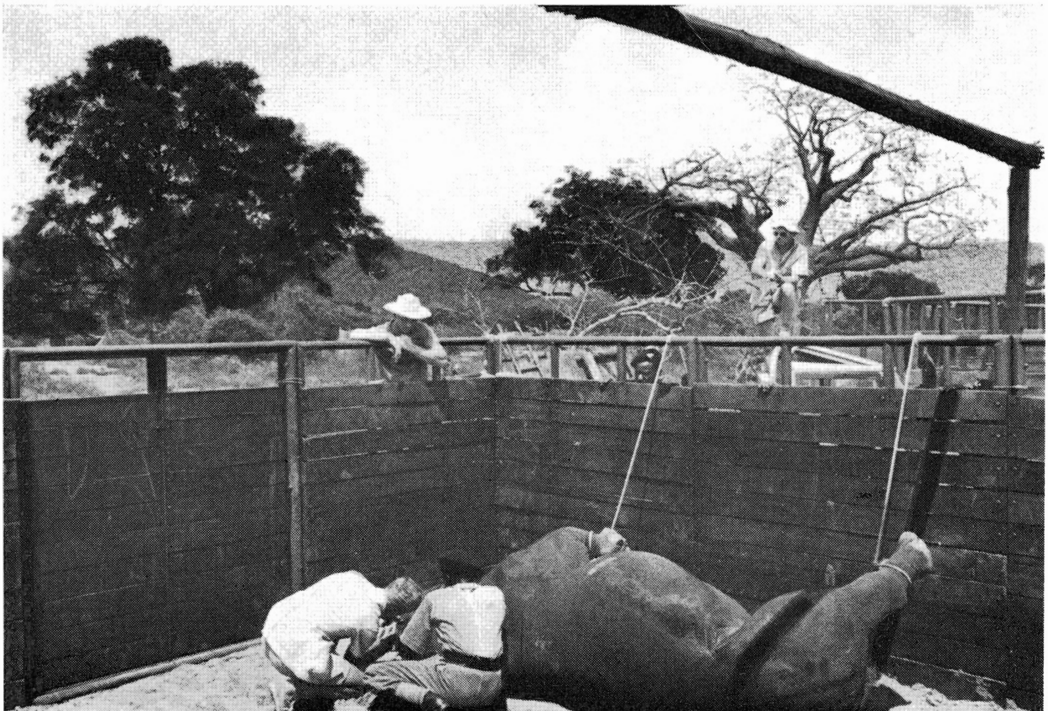

Plate 2b
The semi-conscious rhinoceros was controlled by keeping its feet suspended above the ground while antidote was injected into an ear vein.