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MODERN TRENDS IN ANIMAL HEALTH AND HUSBANDRY

ATARACTIC, HYPNOTIC AND NARCOTIC MIXTURES FOR THE CAPTURE AND HANDLING OF LARGE WILD ANIMALS*

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The handling of wild animals by means of prior injection of ataractic and similar drugs is receiving increasing interest from the veterinary profession. In Europe and America there is a growing awareness of the role of the veterinarian in caring for animals in zoological gardens, and there are many recent reports on anaesthetic techniques for captive wild animals (Martin, 1955; Louw, 1957; Fowler, 1960; Christoph & Elze, 1960; Clifford, Stowe & Good, 1961; Clifford, Good & Stowe, 1962; Graham-Jones, 1962*a*, *b*).

In Africa, recent investigations have demonstrated the use of wild animals as providers of meat (Crutchfield, 1960; Riney, 1960; Dasmann & Mossman, 1960, 1961; Dasmann, 1962; Ledger, Payne, Talbot & Zaphiro, 1961), and the value of these animals as a natural part of the African surroundings and thus as a tourist attraction is becoming more clearly evident. Large tracts of land have been set aside as national parks and reserves in the three territories in East Africa, and studies are being undertaken on the ecology of these areas, particularly as regards the large wild ungulates that inhabit them and these animals' requirements for space, natural foods and reproduction. For these studies, the capture of animals for marking plays a vital part (Buechner, 1961; Buechner, Harthoorn & Lock, 1960*a*; Harthoorn, Lock & Luck, 1961), and greatly facilitates their removal from one area to another (Harthoorn, 1962*a*).

Capture by means of drugs is playing an increasing role in the conservation of wild animals. It permits groups to be transported to areas from which they had been almost eradicated so that they are then less susceptible to extermination if some cataclysm overtakes the small remaining nucleus, as was done for the white (square-lipped) rhinoceros (Harthoorn, 1962*b*). They can also be moved from farm land or other areas where they might damage crops.

It has also become possible for the veterinarian to assist wild animals in national parks and game reserves when they have been wounded or caught in snares or natural hazards. Practitioners assist directly if they can reach the area in time, or indirectly, by giving guidance over telephone or radio to non-specialist personnel using the drug mixtures with wide safety margins that have

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been developed for immobilizing these animals. Reports of assistance given to animals by these means are becoming more frequent, and giraffes, buffaloes and rhinoceroses have been caught and given successful treatment. Lions (Campbell & Harthoorn, 1962) have also been caught with the use of drugs.

The use of paralysing drugs for this purpose was assessed some time ago (Buechner *et al.*, 1960*a*; Harthoorn & Lock, 1961) and a number of animals were captured, with only a few fatalities among them. These methods proved to have an insufficiently wide safety margin for general use, although in the hands of ecologists making a specialized study of particular animals they have been used with good effect (Talbot & Lamphrey, 1961; Talbot & Talbot, 1962). The mortality, under certain conditions, may tend to be high (Rausch & Ritcey, 1961). To obtain an injection that would be safe under most circumstances, work was begun on narcotic drug mixtures, particularly for the larger animals, in the expectation that the narcotics would have a wider margin of tolerance. This proved to be justified (Harthoorn, 1962*c*) and the new mixtures have margins of more than 100 per cent as compared to about 20 per cent for paralysing drugs.

REQUIREMENTS

The general properties of a drug-immobilizing mixture should be as follows:

(a) The margin of tolerance of the mixture used should be wider than the margin of error in estimation of the body weights of the animals to be injected. The exactitude of body-weight estimations differs considerably in relation to the species of animal, the area where it is found, the ability of the operator and the amount of experience he has had with the species in question. For example, the size and weight of most species of healthy adult antelopes in any particular area differs only slightly, and, if only adults are taken, the variation normally is slight. If however young animals and sub-adults are required the errors are inclined to be much larger, and in a new geographical area the difference in adult weights compared to those in other places is often surprising. When an ecologist spends a year or more in the study of antelope of one particular species, he is likely to become expert enough to enable him to judge weight with sufficient accuracy to use rapidly-acting paralysing drugs with safety and good effect. Those wishing to capture small numbers of different species would find the problem of weight estimation greater. The use of a mixture with a wide margin of tolerance is therefore mandatory if deaths are to be avoided.

(b) The mixture per unit of body weight should be similar for most species. This requirement varies in relation to the conditions as set out above. Paralysing drugs such as suxamethonium and suxethonium differ vastly in their dosage rate from one animal to another, for example, 1·7 mg. suxamethonium/lb. is required for the kob antelope, *Adenota kob thomasi*, and 0·025–0·03 mg./lb. for the wildebeest, *Connochaetes taurinus albojubatus*. Suxamethonium has been used with great success on both these species (Buechner, Harthoorn & Lock, 1960*b*; Moore-Gilbert, 1962, personal communication). In both cases

however it should be noted that the animals were caught by workers specializing in the study of the animals in question.

(c) The action of the mixture should be sufficiently rapid for injected animals to be incapacitated before they can make a get-away in thick cover. This requirement differs greatly from one species to another according to whether they head rapidly for cover or not. Animals such as lions usually head rapidly for cover as soon as they feel they are being hunted or when the injected substance begins to take effect, and the rapid action of the mixture is required if they are not to be lost.

Plains antelope such as hartebeest will usually not run in any particular direction and can be watched from any convenient vantage point until they become sufficiently affected. Under certain conditions some slowness of action of an otherwise suitable drug mixture may be overcome by certain procedures; for example a horseback rider equipped with a small radio transmitter could follow the animal; this method has been used with excellent results to capture certain rhinoceros.

Where a rapidly acting drug is unsuitable owing to the susceptibility of the animal, and consequent danger of mortality, and a slow-acting mixture ineffective due to thick cover and the behaviour of the animal concerned, a combination of the two may be used. Experiments are in progress on nicotine alkaloids, which have an extremely rapid action, mixed with narcotic drugs. The nicotine is given in amounts sufficient to slow the animal rapidly, but not in large enough dosage to immobilize it. The danger, therefore, of fatality due to inadvertent over-dosage with a drug of only a narrow safety margin, or through the susceptibility of the animal to a full dose of the nicotine alkaloid, is avoided. After the animal has been slowed by the nicotine, the other drug(s) take(s) effect. Phencyclidine (1-(1-phenylcyclohexyl) piperidine monohydrochloride) is another substance with very rapid action that is being incorporated into mixtures principally for this reason, and it has the further advantage of being non-poisonous when applied to the skin and therefore not dangerous to the operator.

Some animals will allow unlimited time for the injection to work, and a Largactil (chlorpromazine hydrochloride) mixture is being used with considerable promise on giraffes captured on farmland. It takes between one and two hours to become sufficiently effective for the animals to be caught. Several animals may be injected before the first is roped. The giraffe, however, is exceptional in this, as in other respects, and a procedure that involves such a long time interval is not likely to be applicable to animals that are likely to be lost to sight during this time.

(d) It should be possible for the animal to recover without assistance. The administration of an antidote should, therefore, not be mandatory for the ideal immobilizing agent, nor should resuscitatory methods, such as the administration of oxygen. To achieve a sufficiently rapid action, paralysing drugs such as *d*-tubocurarine must be given in fairly large doses. It then becomes necessary to administer neostigmine to prevent paralysis of the respiratory muscles soon after the animal goes down. In country where a proportion of

the injected animals may be lost, and with a species that tries to hide in thick bush (both these conditions apply to buffaloes), this type of drug cannot be used without risk of mortality. The search for animals like buffaloes tends to be further delayed through the aggressive nature of this animal when molested, and the consequent need for reasonable care when beating through cover. When paralysing drugs of this nature are used on elephants, delay may be experienced while the friends of the paralysed animal are persuaded to leave him to expert help.

(e) There should be an adequate lower safety margin in relation to the security of the operator. On either side of the optimum immobilizing dosage rate lies a margin of tolerance, or safety. The upper one is the latitude between the immobilizing dose and death, and is somewhat varied by different means of resuscitation if these are possible under the circumstances. The lower margin is the difference between the immobilizing dose and the minimum needed to incapacitate the animal. This again is rendered indefinite by the rate of absorption and the breakdown of the drug by the animal. For example, if the absorption of a substance that is rapidly hydrolysed in the body, such as suxamethonium, is delayed for any reason, the breakdown tends to keep ahead of absorption of a dose that is sufficiently effective to incapacitate the animal. This may occur through a partly blocked needle, injection into tendonous or subcutaneous tissues, partial loss of pressure in the projectile syringe and so forth; similarly, excessively rapid absorption through intravenous injection into a very vascular area may cause the death of an animal even when a normally safe dose is used.

The importance of a sufficiently wide upper margin of safety has already been discussed in relation to estimation of body weight under (a). It is also important when debilitated, starved or dehydrated animals are injected as a lower drug tolerance is evinced by these animals. The lower margin is important particularly when potentially dangerous animals are being injected. When animals such as the lion, buffalo, elephant, rhinoceros or hippopotamus are being captured, the operator should be reasonably confident that the injected animal is indeed incapacitated, even if it cannot be observed. If drugs whose margin is only about 10 per cent either side of the optimum dosage rate are used, this is virtually impossible when the body weight of the animal cannot be judged to that limit of accuracy. When kob antelopes fail to go down after injection, little is lost except the time and the syringe. When lions go into cover after injection, it is pleasing to know that about twice the minimum amount necessary to incapacitate the animal has been used. This margin of safety is possible with the mixture currently used (see below).

(f) It should be safe to inject the antidote to the immobilizing drug even in large quantities. The use of an agent for capture that has an antidote has many advantages, provided that the use of an antidote is not essential (d). Even though an animal is capable of breaking down the drug mixture without assistance, it is valuable to be able to hasten recovery for various reasons. If the animal is required for a short-term procedure such as marking, measuring or weighing, or for collection of blood or parasites, it is advantageous to get it

on to its feet as soon as the operation is completed. This lessens the trauma to the animal and saves the time of the operators, particularly as paralysed or narcotized animals cannot be left on their own without being in danger of attack from predators, particularly from the large birds such as marabou stork and vulture. When re-location is the object of capture, the timely transition from a paralysed or narcotized state to a tranquillized condition suitable for transport renders the crating or other means of transport quicker and safer. Animals can be transported for short distances while lying on their sides. However, considerable advantages attend their transport in an upright position, either in a crate or in groups in the darkened interior of a lorry. This has been achieved by capturing antelopes with suxamethonium and then administering a tranquillizer (Largactil), but for large animals it has only been found practicable following capture by reversible narcotic mixtures. Using this method, it has been possible to induce newly captured large animals, such as rhinoceroses and young elephants, to walk into a crate, and giraffes to walk back to a holding enclosure led by a collar and two light ropes (see below).

Reversibility of an immobilizing drug has further advantages when an animal gets into difficulties. Rhinoceroses that have become immobilized in stream beds have been saved by the speedy intravenous injection of antidote in a small amount, sufficient to enable them to rise and be led out of the danger area. Similarly, where they went down in an inaccessible region, they have been led to smoother ground accessible to lorry and crate (Player, 1962).

It should be noted in connection with the use of antagonism of the immobilizing drug to enable an animal to be crated or moved to a suitable area for crating, that considerable advantages are inherent in the use of morphine or Themalon (diethylthiambutene), for which Lethidrone (*N*-allylnormorphine) can be substituted, over the curare-like drugs whose action can be reversed by neostigmine. An intravenous injection of a small amount of neostigmine may, and has, enabled a paralysed rhinoceros to rise, charge and damage vehicles and personnel, before becoming paralysed a second time. The competitive antagonization by Lethidrone produces a gentle effect; the animal is able to rise, but it remains in a somnambulistic trance akin to "twilight sleep" (Harthoorn, 1962*d*), a state in which all animals so far examined have remained perfectly tractable. Furthermore, neostigmine in the hands of untrained personnel has proved highly dangerous for the subject.

(g) The volume of the mixture should not be excessive. For practical purposes a 20 ml. syringe is the maximum that can be used on large animals, and ballistics dictates the use of a much smaller syringe (3 ml. or maximum 5 ml.) for antelopes, which can be approached no nearer than 60 yards or so. A syringe larger than 20 ml. projected by a powder charge has been developed for use on elephants, but the impact of this is likely to be too great for more delicately skinned animals, such as rhinoceroses. A notable difference between the capture of animals in the wild and those in captivity in zoological gardens is that the former only allow one injection and are not very co-operative about even that one, except in the relatively rare instance of snared animals and those caught in pits.

METHODS

Syringes

The projectile syringe used is the type sold by the Palmer Chemical Company Inc. (Atlanta, Georgia, U.S.A.). The conventional soda-acid activating mechanism of the syringe has been used for the small syringes on those animals that could be approached sufficiently closely to use the carbon-dioxide powered projector or Capchur gun, supplied by the same company. For larger syringes and those projected by other means, a special activating mechanism of our own design has been used. An explosive cap to activate the syringe, supplied by the Palmer Company, has been used only on elephants and hippopotamuses; it is considered to be too severe in its action on smaller animals, as the speed and strength of the almost instantaneous injection drives the contents of the syringe deeply into the tissues, resulting in tissue damage and even haematoma formation.

The soda-acid method of syringe activation relies on acid coming into contact with a carbonate pellet; the evolution of carbon dioxide gas behind the syringe plunger drives this forward and thus expels the contents of the syringe. With the conventional system, the acid is separated from the carbonate by a greased metal plug which becomes dislodged by the shock of firing and the acceleration of the projectile from the gun. In the system we have evolved the separation is achieved by a paper diaphragm coated with cellulose and silicone grease.

The latter mechanism has been built in the following manner:

A small alloy cup is let into the tail end of the dart and faces forwards. The cup holds a No. 3 lead fisherman's shot or a No. AAA Eley-Kynoch shot (weight about 850 mg.), and on top of or anterior to that, a Capchur tab. The open end of the cup is sealed with a small disc of newspaper which can be cut in quantity by a laboratory cork borer. It is sealed on with polyesterene (Polystyrene) glue. The top of the diaphragm is covered with a thin layer of the same material. Before assembly a layer of silicone grease is applied. The manufacture and assembly of the activating mechanism is as follows:

(1) Anterior recess of the syringe tail is slightly deepened and widened by drilling out with a $\frac{11}{32}$ in. bit, but drilling down only to the depth of the bevel of the bit.
(2) Alloy rod ($\frac{3}{8}$ in.) is turned down to fit tightly into this cavity.
(3) Sections of the rod are drilled out with $\frac{1}{4}$ in. bore.
(4) A section of the tube thus formed, $\frac{3}{8}$ in. long, is glued into the tail recess with Araldite glue.
(5) This forms a cup that holds the lead shot, and one tablet of carbonate.

The modification has successfully overcome the various difficulties experienced with the normal mechanism when this was used to activate the very large capacity syringe needed for large African ungulates when this was projected over long distances. It enables the syringes to be carried for reasonably long periods without danger of reaction between the acid and the carbonate. They can be carried on their tails, and therefore loaded. The adhesion which used to occur between the brass plug and the edge of the rubber plunger,

creating considerable hazard of syringe non-activation, cannot occur while this principle is employed. With this method, the strong acid results in rapid effervescence of the carbonate tablet, releasing sufficient gas to activate even the largest syringe in a very short time, usually only 15 seconds.

The mechanism works in the following way. As the syringe strikes the animal, the small lead pellet contained in the cup will shatter the carbonate tablet and the diaphragm which seals the cup and separates the carbonate from the acid. The force of the forward movement of the lead pellet throws the shattered pieces of the carbonate tablet into the acid. This results in a far greater surface area for the acid to work on than when the tablet is left intact, particularly if it remains in the recess of the plunger; insulation of the carbonate by gas bubbles cannot occur. Another fault, whereby the brass plug was driven forwards into the recess of the plunger, thereby jamming the whole mechanism, is also obviated by this method, as the lead pellet is considerably smaller in dimension than the conventional brass sealing plug, and fits only loosely into the recess of the plunger if it is carried forward at the moment of deceleration at impact. The assembly of this activating mechanism takes slightly longer than that of the conventional type, but it can be prepared days, or even weeks, before it is needed. Given, therefore, a reasonable quantity of tails, much time is saved in the field, when time is usually most precious.

Projectors

The gas-operated Capchur rifle or pistol is capable of projecting the syringe up to a maximum distance of 40 yards and an effective working distance of 35 yards. A projector working on the powder-charge principle was evolved by the Palmer Company and was, in effect, a metal sleeve for introduction into a 12-bore shot gun, with a smooth bore of the requisite size to take the projectile syringe. Metal cartridge cases were equipped with feather tails to ensure a straight flight with the greater distance and speeds involved. A small modification, whereby a cut-down empty 28-bore cartridge was used, allowed free-loading in quantity before the start of a field exercise. Black powder from 12-bore blank cartridges was used at a rate of 250 mg. per cartridge. A standard charge was found the most practicable. The range is adjusted according to the size and therefore the carrying distance of the syringe, the object being to reach the animal when the projectile syringe is almost at the end of its trajectory. The powder-charge gun was found to have a greater range and be more accurate than the gas-operated gun. The powder-charge gun was more destructive to syringes and, mostly owing to the greater range, resulted in greater loss of syringes than the gas-operated gun. Careful estimation of the minimum range is necessary to obviate damage to the syringe, with loss of contents and the animal. The maintenance of the feather flights is time-consuming unless a special jig is constructed for fletching. A new type, which has a rifled 20-bore barrel, uses the conventional worsted, instead of feather flights, and may do away with this disadvantage. It has been supplied to us for experimental purposes and awaits extensive trial. The larger diameter of the syringe may render it particularly suitable for elephants. Other types of long-range pro-

jectors, particularly when fired from a ·22 gun (Montgomery, 1961), have not progressed beyond the early experimental stages in our hands.

Needles

The various types of needles catalogued by the Palmer Company are adequate for most purposes. For large animals a reinforcing piece running along the needle and deeply embedded into the nose-piece of the syringe is necessary, or the same result may be achieved by sleeving an outer thick needle on to the original. The nose-piece should also be thicker than normal when large needles and extra-large syringes are used. Short lengths of polythene tubing on the base of the needle are useful as a cushion buffering the animal and syringe against excessive impact.

Immobilizing drug mixtures

During the last twelve months a marked advance has been made in the formulation of drug mixtures for the capture of large animals. This is based on:

(a) The use of narcotic mixtures which have a much larger margin of tolerance than the paralysing drugs used earlier, and

(b) The principle of synergistic action between various drugs, enabling less to be used and facilitating excretion; the animal is enabled to use several different metabolic pathways, besides having a lower amount of drug to dispose of.

About 80 animals, of seven different species, have been captured with narcotic mixtures so far, with 100 per cent recovery rate.

The four compounds that have contributed most to the success of this method are: Largactil (chlorpromazine hydrochloride); phencyclidine (1-1-phenylcyclohexyl)piperidine monohydrochloride); Themalon (diethylthiambutene) and Lethidrone (*N*-allylnormorphine). Hyoscine hydrobromide has been included in all mixtures and Flaxedil (gallamine triethiodide) in mixtures for elephants and some other animals.

Largactil. This has been used as a tranquillizer to ensure a smooth induction by the other elements of the mixture. It is not itself able to render a wild animal tractable, but it appears to act synergistically with other compounds such as Themalon, and it prevents the excitement that may be induced by the morphine group of products. It also renders the animal more tractable during the stage of recovery when the antidote is substituted for morphine and Themalon. During this stage more Largactil is usually administered, the dose being timed so that the full effect is not felt until the animal has entered the crate. The object, particularly with rhinoceroses, is to induce the animal to lie down in its crate but to retain sufficient righting reflex to enable it to prevent itself from becoming cast. If given too early, the subject may go down before entering the crate. If there are ways of getting a 3,000-4,000 lb. animal into a crate other than by locomotion, we have not discovered them.

The disadvantages of Largactil are the large doses needed, and the large bulk due to the dilute form in which it is marketed. It is easily destroyed by sunlight and not more should be carried around in the tropics than is needed on

any particular trip. It is also absorbed rather slowly. We have found it the best among the tranquillizers tested and have had no fatalities which can be ascribed to its use. (It has also been used on all animals transported after capture by paralysing drugs). Because it has an adrenergic blocking action, care has been taken not to administer large doses to highly excited animals, particularly by intravenous injection, in case a precipitous fall in blood pressure should result.

Phencyclidine. This is a white, stable solid produced for experimental use only. It is soluble up to 25 per cent in water and ethanol. Its effect varies according to the species to which it is administered. Generally, it causes a cataleptic state in medium-low dosage, followed by a condition resembling anaesthesia at higher dosage rates. The animal receiving a low dosage appears to stay awake with its eyes open and dilated pupils which are sluggish in response to light. There is little relaxation of muscles and hypertonicity, especially of the forelimbs and neck, is usually present. Trembling and light clonic spasm involving all the body musculature may be present, particularly in dogs. The swallowing reflex appears to remain present even in very high doses, and cats usually swallow and protrude the tongue in licking motions even after high dosages (4 mg./lb.). At low dosages (0·5 mg./lb.) some cats are able to walk, but appear to suffer hallucinations; they sit with wide, staring eyes, while the head appears to follow something flying about above their heads. With a dose of 1 mg./lb. both cats and dogs would lie on their side (or belly in dogs) salivating and twitching; there is reaction to painful stimuli and the knee jerk is exaggerated. The salivation could be largely checked with large doses (0·5 mg./10 lb.) of atropine. The margin of safety of phencyclidine is high, and although 1 mg./lb. in cats produces prostration, 6 mg./lb. permits recovery, albeit after several days. At 4 mg./lb. the animal will rise after a few hours, but it will be disinclined to eat and drink, and it remains ataxic for three to five days, usually carrying the head stiffly, with slightly bent neck. Cattle given 0·25–0·5 mg./lb. would remain lying in sternal recumbency, often attempting to crawl forward.

Reports of attempted immobilization of captive buffaloes and elands with this drug admitted that there had been fatal results, apparently from lung oedema. This may have been due to insufficient or no atropinization; several species of antelope have been caught by use of this drug together with tranquillizer and a parasympatholytic agent.

Animals recovering from prostration induced by phencyclidine still have hyperextended forelimbs and stiffness of the neck muscles well into the stage of recovery. The animal may make repeated efforts to rise, only to fall as it overbalances through lack of control, mainly of the forelimbs.

Both clinically and in the field, phencyclidine is most valuable when it is used in conjunction with other substances. Combined with anaesthetic agents such as barbiturates it shows little evidence of its catatonic effect, but hastens induction and reduces the amount of anaesthetic needed. Similarly, in the field, its principal value lies in its rapid absorption, and thus the induction of narcotics such as pethidine and Themalon or morphine. When it is given with

tranquillizers such as promazine or chlorpromazine to the *Felidae*, it produces a state resembling anaesthesia which is further enhanced by the addition of pethidine and hyoscine.

As well as causing rapid induction, phencyclidine has a distinct potentiating effect on narcotics, lessening the amount needed for full effect. It has an advantage over the other potentiators in that, in small doses, it does not destroy the righting reflexes.

Given on its own and in larger quantities, for the capture of wild animals, it has the disadvantage of a long recovery stage. Large animals may cause considerable damage to themselves during this period, and by the time they can stand upright they will have recovered much of their powers of resistance and aggression. Tranquillizers cannot be administered before near-complete recovery as they are with phencyclidine/morphine/scopolamine narcosis, as the addition of tranquillizer will delay the time taken to rise. When phencyclidine is used in large doses to capture rhinoceroses, the animals have to be tied and winched into a vehicle much as is done after they are caught with a lasso, albeit with the advantage that less restraint is required and fear and stress are therefore reduced.

The advantages of phencyclidine and its analogues for capture purposes may be summarized as follows: very rapid absorption resembling that of suxamethonium; rapid induction of narcotics; a potentiating effect on narcotics and anaesthetics; retention of righting reflexes in low dosage rates; wide margin of safety; rapid breakdown and excretion at therapeutic levels.

Themalon. This has an effect almost identical to that of morphine, but it has fewer side-effects and appears to be less poisonous. Its value lies in its reversibility and the fact that the subject seems to retain the righting reflexes even under high dosages. Given alone, it has little apparent effect and even 5 or 6 grams given to a 600 lb. ruminant will enable it to retain its locomotory power. When Themalon is mixed with hyoscine and phencyclidine, a fraction of this dose will bring the animal down but allow it to remain in sternal recumbency. Unless an excessive amount of phencyclidine has been added, the administration of Lethidrone will allow it to rise. A similar effect is obtained when Largactil is added to the Themalon/hyoscine mixture, and in that case the animal is more inclined to remain standing, although usually it can be easily caught. This is the method of choice with certain animals, particularly giraffes.

Themalon has the disadvantage that it is absorbed slowly, especially by subcutaneous routes, and there is a consequent delay in immobilization. Solutions have to be made up freshly for each animal as they keep effectively only for a day. Together with Lethidrone it has made the large-scale capture of the valuable white rhinoceros possible, and approximately fifty of these animals have been captured with its use.

Lethidrone. This substance is a competitive antagonist to morphine and related compounds such as pethidine and Themalon. Its great advantage for use in the field is its safety, particularly as compared with neostigmine. The quantity given is limited principally by its expense. It does not keep very well and for field use on large animals it is best made up as required. The routine provision

of small weighed amounts can easily be performed some days before the solution is required and obviates the storage of large quantities of Lethidrone solution. The quantity given to large animals depends upon the requirements. Two hundred mg. is often sufficient to bring them to their feet, and 0·5 to 1 g. is usually given at the end of the journey before release. Although its expense is high it is not wasted in missed shots as are the immobilizing compounds.

Flaxedil. This drug has some disadvantages, since large doses from which the animal could not recover spontaneously are needed and since paralysis recurs after resuscitation with neostigmine, but most of these drawbacks may be resolved by the use of Flaxedil/hypnotic mixtures. Work on the African elephant (Harthoorn & Luck, 1962) first revealed that the immobilizing dose of Flaxedil for the elephant could be cut down from 1·2 mg./lb. to 0·9 mg./lb., which is a considerable reduction, especially as 0·8 mg./lb. is apparently enough to halt the animal.

In this way, Flaxedil is a valuable adjunct to immobilizing mixtures, particularly for the elephant. It is also highly soluble and therefore easy to use in a syringe. A concentration of 900 mg./ml. is employed as the stock solution in the field (1 ml. for every 1,000 lb. body weight), but this is diluted in the syringe. It has an added advantage in that it paralyses the elephant's trunk, so that the ears, even of the standing animal, can be reached for marking purposes. If the elephant goes down, a single dose of neostigmine is sufficient at this low dosage rate to enable him to rise. Also the animal, if not found, appears to have no difficulty in excreting the drug mixture unaided.

Dosage employed

A great advantage of mixtures of narcotic compounds over paralysing drugs is that the dosage rate for all ungulates is approximately the same. This balances the disadvantage of a more complex procedure inherent in employing drug mixtures. A ready dosage scale applicable to all the large ungulates and using either Largactil or phencyclidine for induction of narcosis is given in Table I.

TABLE I

SUGGESTED DOSAGE RATES OF PHENCYCLIDINE OR LARGACTIL, THEMALON AND HYOSCINE. PHENCYCLIDINE OR LARGACTIL IS GIVEN IN THE IMMOBILIZING DOSE

Estimated body wt. (lb.)	*Phencyclidine (mg.)*	*Largactil (5% solution in ml.)*	*Themalon (g.)*	*Hyoscine (mg.)*
1,000	100*	5	1½	50
1,500	150	7½	2¼	75
2,000	200	10	3	100
2,500	250	12½	3¾	125
3,000	300	15	4½	150

* (Additional) Largactil may be injected after capture.

The mixing of the ingredients in the syringe under field conditions is less cumbersome than it seems. Themalon tablets (50 mg. each, packed in vials holding 20 tablets) are readily soluble in water or other aqueous solutions of substances

with which they are compatible. They dissolve in about three minutes or less under mild agitation.

Phencyclidine and hyoscine in solution form a stable mixture which seems to keep reasonably well. As with other drugs, stock solutions should be kept as much as possible in the refrigerator; to avoid excessive heat little more than the day's requirements should be taken into the field. Solutions are prepared in concentrations suitable for a particular species, as follows:

The dose of phencyclidine for the black rhinoceros is unlikely to exceed 300 mg. and a convenient solution is 200 mg./ml. The dose of hyoscine is about 50–60 mg./1,000 lb. body weight. If we assume that the optimum dose of phencyclidine for a 2,500 lb. rhinoceros is 250–300 mg., or 1·25–1·5 ml., a convenient concentration of hyoscine is 100 mg. per ml. The technique now resolves itself into mixing about 1·5 ml. of the fluid mixture with the contents of three vials of Themalon and adding water.

A spreading factor may be used to hasten absorption and Rondase (Evans Medical Supply Ltd., Speke, Liverpool) is a suitable one; the contents of one vial (1,500 i.u.) should be added to each syringe.

The logical sequence of procedure is now as follows:

(1) Estimate the weight of the rhinoceros.
(2) Place a measured dose of phencyclidine/hyoscine solution in a convenient 25 ml. polythene bottle, fitted with a water-tight cap. Add a number of Themalon tablets; at the most, it is only necessary to count the tablets in one vial.
(3) Add about 3 ml. water (Themalon dissolves in 40 per cent strength), replace the cap and shake the bottle.
(4) Shake in the contents of one vial of Rondase.
(5) Pour the mixture into the syringe of, say, 10 ml. capacity.
(6) Rinse the bottle with about 2 ml. water and pour this also into the syringe.

Clearly, the method has application to the large and valuable animals of which only one or two are captured daily, rather than to small antelopes of which many must be captured and which entail many missed shots. For these animals a stable mixture is being formulated which should entail measuring one dose from a stock bottle. For the large animals, the more complicated method described here has proved practicable and effective.

RESULTS

Rhinoceros (*Rhinocerotidae*)

The method of animal capture with hypnotic and narcotic drugs was first elaborated for the capture of rhinoceroses. At one time they presented the greatest problem in large animal capture, as they are big, strong and yet very delicate animals which die easily from bruising or from incapacitating drugs. The capture with paralysing drugs proved successful only in the restricted surroundings of immerging islands in the Kariba Lake, and hypnotic drugs used alone provided insufficient margin since the animals either slept for 24 hours or longer or were disturbed by injections that failed to bring them down. When Themalon or morphine and hyoscine are added to the hypnotic or tranquillizer,

the safety margin is more than 100 per cent on either side of the optimum dose, and no rhinoceros has failed to go down except in cases of demonstrable injection failure.

The mixture favoured for white rhinoceros (*Ceratotherium simum*) is Largactil and Themalon. This animal has an equable temperament and the use of Largactil usually permits it to remain standing when immobilized. As it is not exceptionally wild by nature, it will not usually run prodigious distances on feeling the injection, and the country permits the use of horses for following. For this reason, the somewhat slower action of Largactil as compared to phencyclidine is considered no disadvantage. Furthermore, the animal caught with a Largactil mixture is usually easier to crate than one caught by the hypnotic adjuvant, as it is thoroughly tranquillized by the time the crate arrives. When caught with phencyclidine, a light dose of Largactil alone can be given before crating so that the animal does not go down and delay the procedure.

The black rhinoceros (*Diceros bicornis*) is an animal of volatile temperament that usually runs with speed and deliberation. A mixture is needed that will take effect rapidly and preferably put the animal down on the ground, as no one likes approaching the standing black rhinoceros. Phencyclidine acts rapidly and is very suitable for this purpose, particularly as it also brings the animal down. When using phencyclidine in doses sufficient to bring the animal down rapidly, it is usually not possible to get it on its feet immediately by antagonizing the narcotic. The procedure of choice is to lighten the narcotic sufficiently to ensure comfort, but not completely. Under medium phencyclidine dosage, the black rhinoceros is inclined to fight, making repeated unsuccessful attempts to rise and in the process beating its head on the ground.

Sixty-three rhinoceroses have now been caught with the mixture described in Table I. Details of 18 cases are given in Table II. These 18 represent all rhinoceroses caught after the first 12. The numbers represent the actual numbers of animals caught, all of which recovered from the immobilizing dose.

Whereas undoubtedly there is room for improvement in the method employed, the mixture described is giving satisfaction and is adequate for the purpose for which it is required, i.e. that of moving rhinoceroses from an overcrowded or threatened area to (other) game reserves, and promoting the safety of individual animals and the preservation of the species.

Giraffe (*Giraffa camelopardalis*)

Whereas giraffes have been caught successfully and safely with the use of paralysing drugs, this method did not prove usable in the hands of a catching team enlisted to remove giraffes from farmland for relocation in a national park. Problems of weight estimation were encountered, errors of 50 per cent being demonstrated; there were also difficulties in winching grown giraffes on to a lorry and in resuscitating the animals, which were inclined to become reparalysed in the holding enclosure—where it is difficult to get the animal back on its feet.

A Largactil/morphine/hyoscine mixture proved to have considerable advantages over the method first used, and also some disadvantages. The principal disadvantage is that the morphine takes about two hours to be absorbed in

TABLE II

DOSES OF LARGACTIL, MORPHINE/THEMALON AND HYOSCINE GIVEN TO WILD, WHITE (SQUARE-LIPPED) RHINOCEROS TRANSPORTED TO OTHER AREAS (CONDENSED FROM HARTHOORN & PLAYER, 1962)

No.	*Sex*	*Estimated body wt.* (*lb.*)	*Dose of Largactil* (*mg.*)	*Dose of Morphine* (*g.*)	*Dose of Hyoscine* (*mg.*)	*Distance transported and method employed*
13*	M	3,500	705	1·5	175	Taken to boma† and transported to Kruger Park (400 miles) one week later
14	F	3,000	625	1·28	125	Taken to boma and transported to Kruger Park six days later
15	F	3,000	725	1·5	150	Taken to boma and transported to Kruger Park five days later
16	M	2,700	500	1·25	100	Taken to boma and transported to Kruger Park four days later
17	F	2,000	700	1·25	100	Transported 40 miles immediately in crate
18	F	3,400	700	1·25	100	Rhino was not crated but loaded direct on to lorry
19	F	2,800	725+500	1·5	100	Transported 40 miles to boma, then to Ndumu Game Reserve 200 miles away
20	M	4,000	800+500	2·25	100	Crated and transported 200 miles to Ndumu Game Reserve
21	M	1,000	525	4 (Themalon)	125	Loaded direct on to lorry and taken 40 miles to boma
22	F	2,500	800	3 (Themalon)	150	Loaded direct on to lorry and taken 10 miles to boma
23	F	3,000	700	3 (Themalon)	150	Crated and transported 200 miles to Ndumu Game Reserve
24	M	2,800	700	2 (Themalon)	100	Loaded in crate and transported 15 miles
25	M	4,000	700	2 (Themalon)	100	Captured for wound treatment only; given 6 mega units penicillin and released
26	M	2,500	725	3·5 (Themalon)	100	Transported 475 miles to Free State Game Park
27	F	3,000	725	3·5 (Themalon)	100	Transported 475 miles to Free State Game Park
28	F	2,800	725	3·5 (Themalon)	100	Transported 12 miles to boma in crate
29	M	2,700	725	4·0 (Themalon)	125	Transported 475 miles to Free State Game Park
30	F	2,900	725	4 (Themalon)	125	Transported 475 miles to Free State Game Park

* Nos. 1–12 are not detailed here.
† 'Boma' is a holding enclosure.

TABLE III

DOSES OF NARCOTIC DRUG MIXTURE* FOR THE CAPTURE OF GIRAFFES

No.	*Sex*	*Estimated body wt.* (*lb.*)	*Dose of Largactil* (*mg.*)	*Dose of Morphine* (*mg.*)	*Dose of Hyoscine* (*mg.*)	*Time before Immobilization* (*min.*)	*Method of capture*	*Behaviour*	*Dose of Lethidrone* (*mg.*)
1	M	1,200	250	250	50	80	Rope round neck	Running slowly	None
2	M	1,500	250	250	50	60	Rope round hind leg	Walking	None
3	M	1,200	250	250	75	75	Caught by the tail	Walking	None
4	M	1,600	375	375	75	90	—	Down	375
5	M	1,500	250	250	75	150	Rope round hind leg	Standing	None
6	M	1,200	200	350	75	180	Driven into rope held by two men	Running slowly	None

* More recently it has been found that the addition of 100 mg. phencyclidine to the mixture shown (using the smaller morphine dosage) makes it possible to handle the animal sooner and tends to make it stand still.

sufficient quantity to allow the animal to be caught. This time interval would preclude its use on any other animal, but did not prove a grave difficulty with giraffes, which remain in the area and are easy to see. In fact, an injected animal can be left to be watched by a scout while another is injected. Another disadvantage is that a giraffe which is very nearly immobilized is still too fast to catch by hand and is still able to deal an effective kick with fore or hind leg (Fig. 1).

The advantages, however, outweigh the disadvantages. If just enough morphine is given to bring it down, a quick-release collar may be put round the animal's neck; it can then easily be brought to its feet with an intravenous injection of Lethidrone and subsequently led the mile or two to the holding enclosure (Fig. 2).

The quick-release collar was made on the principle of the heavy casting hobble, and with a "D" on each side for attachment of ropes. Once on its feet the animal is easily led by a light rope on each side.

This method had the following advantages:

(a) Far greater safety;

(b) Reduced trauma, as the ride on a lorry while lying down and tied is done away with;

(c) Reduced expense, as a lorry no longer has to follow the catching team through the bush.

The giraffe-catching exercise is still being carried out and only a small series of animals have been caught in this way. Dosages are as in Table III. Several giraffes did not become sufficiently narcotized to be caught and these were left to be caught on a subsequent occasion.

Other animals

Besides those mentioned, other species have been captured with the same mixtures, but only in small numbers. Their behaviour differs in no particular way from that already described, and so detailed description is not needed. Elephants (*Loxodonta africana*) up to 1,500 lb. weight have been caught using the phencyclidine/Themalon/hyoscine mixture and respond in a similar way to rhinoceroses; however, they are somewhat more resistant as they remain standing and fairly active. Hippopotamuses (*Hippopotamus amphibious*) also react similarly to rhinoceroses. They have no superficial veins suitable for injection of antidote.

Buffaloes (*Syncerus caffer*) and wildebeest (*Connochaetes taurinus*) take a long time for the mixture to take effect and about half to three-quarters of an hour will elapse before capture is possible. The method is therefore suitable only for young buffaloes captured for relocation and for antelopes if they are found on a wide plain on which a vehicle can move sufficiently easily to "shepherd" them during the interval between injection and incapacitation. The six wildebeests injected in this way showed some individual variation, some going down and others remaining difficult to catch. Unlike the giraffe, whose eyesight appears to remain acute, the wildebeest, while walking, would not react to a stationary man or vehicle until it was only a foot or two away; the animal would then stop and ponder, during which time it could readily be seized by the horns. The

hearing remains acute and the animal will gallop for 20 to 30 yards at the sound of a footstep. The wildebeest depicted in Fig. 3 almost bumped into the photographer and was caught a minute later with no trouble.

A limited number of experiments indicate that the large antelopes may be caught with a mixture of 0·5 mg. Largactil/lb. body weight and 1 mg. phencyclidine/lb., with hyoscine (0·05mg./lb). If hyoscine is not available atropine can be used at a rate of about 0·07 mg./lb. The use of phencyclidine without either hyoscine or atropine is inadvisable. Trouble is experienced with the animal when it is in a state of near-anaesthesia, and it is necessary to ensure that it remains on its brisket and that a probang or similar instrument to release ruminal gases is at hand. The mixture has no reversible component, but the safety margin is large, so that with practice it may be usefully employed for moving the larger antelope.

For lions (*Felis leo*) the mixture of Largactil, phencyclidine and hyoscine is satisfactory, as there is no real indication that a reversible mixture is needed for the cat family.

DISCUSSION

The method of immobilizing animals with narcotics would seem to be of considerable use for the capture of animals in the field. It appears to be particularly suitable for the capture of large animals for relocation or for study purposes.

It is considerably safer than methods employing paralysing drugs and no deaths from overdosage have been suffered among the 80 or so animals narcotized by this method, in spite of the fact that most of them were caught by personnel without special knowledge of science.

The method probably has greater application to the capture of free-ranging animals, when a short excitement period is no real disadvantage, as compared to those in enclosures. It has a very real value for the treatment of injured animals and those caught in snares, as the wide safety margin renders it suitable for use by game wardens and others who have no extensive practice in the technique of drug administration.

The use of narcotic mixtures has less use for antelopes as they are not readily caught with the mixture as now used, and because of the expense and the number of injections that go wide of their mark when small and lively animals are being followed. A further difficulty is the problem of predators who are likely to devour those antelopes caught for marking or examination and promptly released. Antelopes which have been caught by paralysing drugs are also more susceptible than normal animals to subsequent predation, and it has yet to be shown whether the mortality likely to be suffered by narcotized animals from this cause exceeds the mortality that can be suffered from capture by other methods.

SUMMARY

The capture of various animals by the method of drug immobilization is described.

The drug mixtures used were Largactil and phencyclidine, with Themalon or

PLATE I

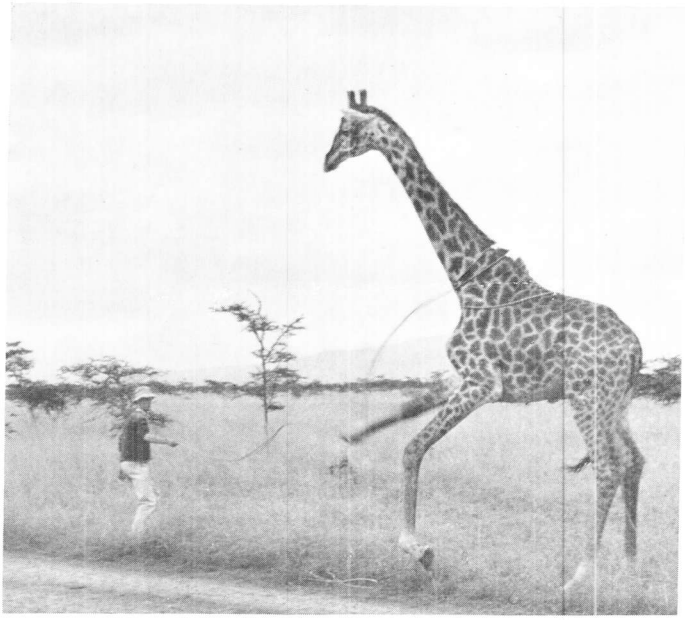

Fig. 1. The giraffe may be sufficiently narcotized to prevent it running away, but still able to show aggressive reaction while a rope is placed round the neck.

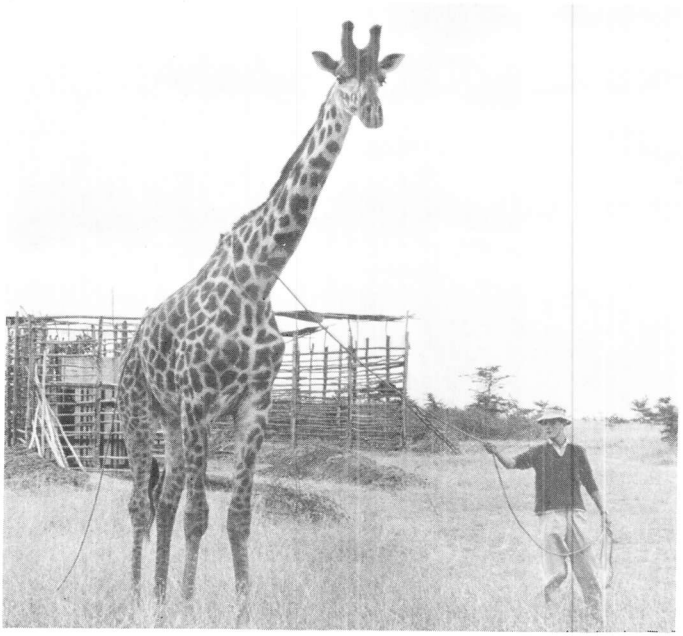

Fig. 2. The narcotized giraffe may be approached and a rope thrown round its neck, or put on to its hind foot. Subsequently, it can be led for a mile or two to the holding enclosure.

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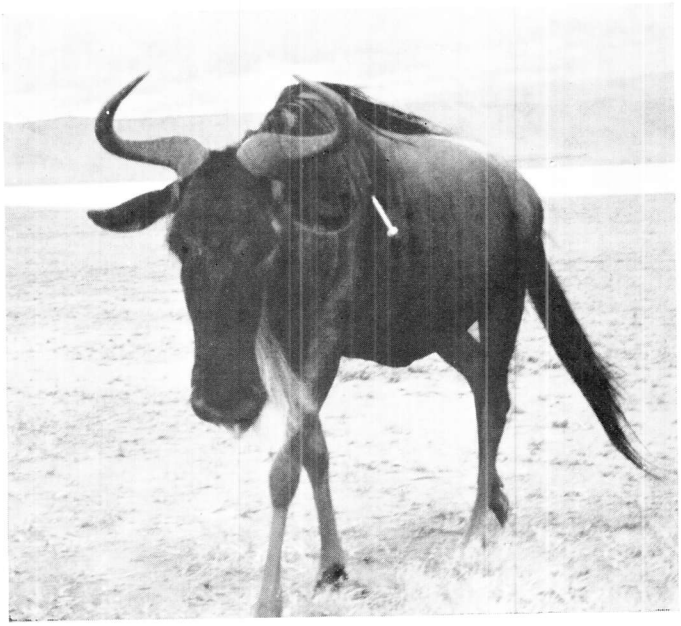

Fig. 3. Wildebeest may go down with the narcotic mixture or be caught while walking. The one depicted here was caught a minute later when the horn was seized as the animal walked by.

morphine and hyoscine. On capture, the narcotic is reversed with Lethidrone.

This method has reduced mortality as a result of the injection of drugs to zero, and greatly facilitated the subsequent handling of the animals caught.

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