THE PHENOMENON OF GAME MIGRATION IN THE KALAHARI-GEMSBOK NATIONAL PARK WITH A DISCUSSION OF VARIOUS MARKING METHODS TO FACILITATE A STUDY OF THE ROUTES FOLLOWED

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When the first explorers tried to describe the vast herds of antelopes they had seen in Southern Africa, nobody believed them and their accounts were considered 'Travellers' tales'. Some experienced hunters would not even attempt estimating numbers, instead they used descriptive phrases such as "gigantic herds", "countless thousands" and "myriads of antelopes stretching as far as the eye can see". Cattrick (1959) claims that definite evidence points to the fact that at one time some 500 million springbok graced the area comprising the Karoo and the Kalahari Desert. Reliable witnesses have testified to having encountered herds of ten million and one hundred million animals. In one instance a herd stretching for 138 miles over a front of 13 miles was reported, another over a distance of 47 miles, and extended to the left and right as far as the eye could see.

Other equally unbelievable stories were told by settlers. Stories about riding for four or five days on end, and seeing valley after valley covered by springbok. Dongas, gulleys and river beds were literally filled with dead bodies over which the others streamed across. Among the springbok hundreds of eland, kudu and red hartebeest were observed.

An account of a springbok trek by W. C. Scully, one-time magistrate at O'Kiep, is quoted by Cattrick (1959). Millions of springbok are reported to have crossed the Kamaggas mountains and rushed into the Atlantic Ocean. There they drank the salt water and died, their bodies lying in a continuous pile along the shore for over 30 miles. The stench which ensued, forced the Trekboers who camped near the coast, to retreat far inland.

Other antelopes were, of course, outnumbered by springbok, but nevertheless thousands of eland, blesbok and others were also reported. The trekbokke were mercilessly slaughtered, because they trampled down everything, including fences, sheep and even herd boys. Where they had passed, not a single blade of grass remained.

These great "treks" of game were observed as early as 1840 and continued until 1896. After the latter date lesser herds have been observed on the move, but the herds of millions or even thousands have disappeared.

Only in isolated spots in the Kalahari and Bechuanaland are springbok seen today in herds of hundreds, and very seldom in herds approaching four figures. Other antelope stocks have also dwindled at an alarming rate, the most tragic case being that of the magnificent eland whose ranks have been depleted to such an extent that there is some anxiety over the question of its survival as a species.

One shudders to think what the position would have been today had not the Kalahari Gemsbok National Park been proclaimed in 1931. It became the sanctuary of the last remaining eland and herds of springbok and gemsbok. Outside the Park these antelopes are continually being hunted and practically exterminated.

The proclamation of the Park by no means guaranteed the existence of the eland, gemsbok, red hartebeest and other antelopes common to the Kalahari. It only provided an area where they could be protected. The Department of Nature Conservation of the National Parks Board then had to cope with the problem of keeping the antelopes in the Park. Those which ventured out did not survive for long. Boreholes were sunk in the dry beds of the Auob and Nossob rivers, windmills erected and drinking troughs built, to provide water for the animals. Although this had the effect that some herds, especially blue wildebeest, took to permanently grazing in an area around a windmill, other herds kept on moving around. Obviously it is of the utmost importance to ascertain which factor or factors are responsible for the trekking of the antelopes. Preventative measures may then be taken in the form of altering conditions, if possible, to suit the animals.

Since the great "treks" were first recorded, hunters and naturalists have speculated on their causes. Some ascribed it to mere drought and lack of food which drove the animals out and back towards the grasslands. Others claimed it was some hereditary instinct which caused them to flock together and to start marching. However, since the great "treks" now belong to the past, there is no way in which we can hope to ascertain, beyond doubt, the cause or causes of these mass game migrations. The only place left in South Africa where the remnants of these great herds may be studied is the Kalahari Gemsbok National Park. Here a certain degree of trekking still occurs and if the causes thereof could be determined, it may be possible to shed some light on the underlying causes of the great "treks".

WHAT IS MIGRATION?

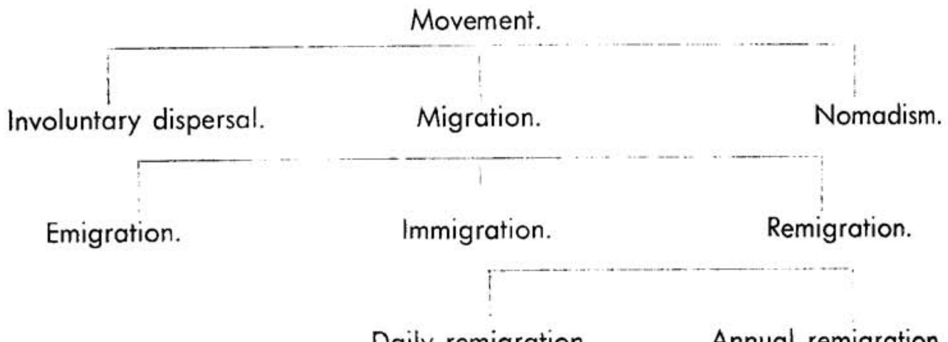
It is pointed out by Eloff (1959, a) that the movements of the antelopes in the Kalahari, do not seem to be regular anymore, nor for that matter do they seem to be between two distinct areas. He therefore considers it incorrect to describe these movements as "migration".

For this reason it is essential to decide what exactly the term migration conveys; Cahn (1925) was the first to define migration as: "A periodic passing from one place to another". To this definition Thomson (1926) added that the animal's movements need not necessarily have great geographical amplitude, to qualify to be termed migration. It must, however, involve a definite change of locality and "there must be return movements to the original area". This view is shared by Eloff (1959, a) who maintains that the term migration has been used by biologists to describe certain movements of animals, indicating a periodic departure and return.

Williams (1930) takes exception to the above definition, on account of the requirement that: "there must be return movement to the original area". He reasons that this would prevent the use of the word migration for the well-known movements of lemmings and locusts. He concluded that: "the definition of migration that appears to suit best the conditions as found in mammals, birds and insects is as follows: Migration is a periodic, more or less unidirectional, continued movement, assisted by the efforts of the animal, and in a direction over which it exerts a control, which results in the animal passing away from its previous daily field of operations".

Heape (1931) suggested that the type of movement common to many species of animals should be placed in four categories, namely: Emigration, Immigration, Migration and Nomadism. This he explained by stating that if a population moves from point A to point B, they emigrate from point A and immigrate into point B. If the population moves from point A to point B and back again to point A, it is migration, and if the population moves in random fashion from one locality to another, the movement is termed Nomadism.

Urquhart (1958) approves of Heape's definitions, but adds some modifications to explain every known trekking habit of animals. His classification is illustrated by the following diagram:



Urquhart (1958) then explains his classification as follows: Movement, as far, as a living organism is concerned, is the action or process of moving. Involuntary dispersal is the term used to describe the distribution or scattering of living organisms in all directions from a source, the organisms being unable to control it.

Nomadism refers to the state of living a wandering life, hence it describes a random type of movement which is controlled by the organism.

Migration describes the movement of an organism in one direction, as a more or less continuous action, under the control of the organism, resulting in the organism passing away from its previous field of operation.

Emigration describes the movement of an organism in one direction out of a given area, as a more or less continuous action, under the control of the organism, resulting in the organism passing away from its previous field of operation with no return. This definition also applies to describe the term Immigration, the only difference being, that the organism moves into the given area.

Remigration describes the periodic movement of an organism in one direction, as a more or less continuous action, under the control of the organism, resulting in the organism passing away from one field of operation to another with a return to the original field of operation.

As can be seen, Urquhart's classification may be compared to a phylogenetic system of classification for living organisms. The phylum (Movement) is divided into three orders, of which one (Migration) is in turn divided into three families. Urquhart expresses the belief that future study will disclose more orders, or that the study of one family may disclose a variety of distinct movements which may lead to the splitting of the family into smaller units. In the latter case, he suggests that descriptive adjectives should be used to define more clearly a particular type of movement. This could result in the acceptance of terms such as 'daily remigration', 'annual remigration', 'reproductive emigration' etc.

To me the classification suggested by Urquhart seems most acceptable, since it may be regarded as the logical development and refinement of the term Migration to suit every circumstance.

POSSIBLE CAUSES OF GAME MIGRATION.

Much has been written about the possible causes of game migration and since Brynard (1956) dealt with the matter so thoroughly it would suffice to mention the various theories briefly.

(a) *Instinct* :

It seems unlikely that instinct could be the cause of game migration, since it does not occur regularly, nor do the animals for that matter, move in the same direction every time (Cronwright-Schreiner, 1925). The fact that not all the antelopes ever join in such a big trek — there are always those that remain behind — induces Brynard (1956) to discard instinct as a cause of game migration.

(b) *Lack of Water :*

The theory that want of water is the main cause of game migration has also had numerous supporters. It is, however, a well-known fact that game in the Kalahari can go without water for an unbelievable period and when "Tsamma" *(Colocynthis citrullus),* "Gemsbokkomkommer" *(Colocynthis naudiniana), and* "Wildekomkommer" *(Cucumis hookeri)* are available, quite indefinitely. Furthermore the animals still migrate in the Gemsbok Park despite the water that has been provided in the river beds of the Nossob and Auob. Brynard (1956) concludes that lack of water may under certain conditions induce game to migrate, but it can certainly not be considered a primary cause.

(c) *Grazing conditions :*

One of the most popular reasons given as the main cause of game migration certainly is, lack of grazing. It appears, however, that only the more localised migration takes place as a result of the immediate needs of the animals. Long-distance migration seems to be caused by a much stronger incentive, since, according to the report of witnesses, the antelopes seem to be absolutely obsessed, creating the impression that the instinctive urge to migrate is perhaps based on the need for some form of natural population control. Brynard (1956) expresses the belief that no single factor can be held responsible for game migration, but rather a combination of factors. During certain years all the complementary factors are favourable for migration, or unfavourable for the game to remain, with the result that they start trekking. During other years one or more of the inciting factors may not be present or favourable with the result that the game do not migrate. What all these factors are and to what extent and in what manner they influence one another is not yet clear, and much research is still necessary before a satisfactory explanation may be given for this phenomenon.

MARKING OF ANTELOPES.

As may be expected ornithologists followed by ichthyologists were first to mark individual animals for later identification, but many years passed before mammalogists followed this example. In South Africa, however, nothing has yet been done in this direction. Eloff (1959, a & b) in every report on his observations on the migration and habits of the antelopes of the Kalahari Gemsbok Park, stressed the necessity for marking animals in such a manner that they can easily be recognised, to provide direct information regarding their movements, and Bigalke (1959) remarks that: "observation on daily and seasonal range, herd composition and other aspects of the animals' life, are made very much easier, and in many cases only become possible, when some individuals, at least, can be positively identified". This is the case in the Gemsbok Park, especially if migratory movements of antelopes are to be studied.

Owing to the vast distances covered by herds of springbok, gemsbok, red hartebeest and eland, it is imperative that these animals be marked in such a manner that they can easily be identified. Also, sufficient numbers should be marked, otherwise future spotting would be too uncertain.

Besides marking animals in the Park, it will be necessary to obtain the co-operation of other authorities, such as the Bechuanaland Protectorate officials and the wardens and personnel in the various South West African game reserves. The whole marking operation would very much depend upon accurate reports from these sources.

In the event of its taking the initiative as regards the marking of animals, the National Parks Board could perhaps induce the above-mentioned organisations to follow suit, marking animals in their respective areas. In this event it is quite possible to foresee remarkable results, as far as definite observations are concerned regarding distances covered by migrating antelopes and the routes followed.

THE VARIOUS MARKING METHODS.

The methods used for capturing wild animals, could be divided into two classes; those whereby the animals need not be captured, and those whereby the animals have to be captured.

(a) *Without capturing the animal.*

It is obvious that the methods falling in this category, being dependent on some kind of marking device or other, do not offer as many alternatives as when the animals are captured first.

The Ontario and Wyoming marking devices, developed by Taber, de Vos & Altman (1956) for marking moose (*Alces americanus*), are two well-known apparatuses. Basically the two are the same, consisting of a tripcord set across a game trail. When it is set off, paint or dye is deposited on the animal. A rat trap is used as the trigger mechanism in the Ontario marking device. The trap is fastened to a board above a trail, where it passes between two trees. The trip wire is attached to the trap from where it leads down along the trunk of the tree and across the trail at the height of the animal's shoulder. A razor blade is brazed to the striking-arm of the rat trap, and a plastic bag full of colouring matter suspended from the board in such a position that when the trap is sprung, the blade severes the plastic bag, showering the colouring matter over the animal below.

The Wyoming marking device also has to be set along a game trail. It consists of an arm about four feet long which pivots from a vertical post next to the trail. The arm is arranged to reach slightly over the middle of the trail when it is in the horizontal position, at the approximate shoulder-height of the animal to be marked. The arm is held in a slightly backward inclined postion by the trip wire which is attached to the lower end of the arm, passed through a screw eye behind the arm and from there it is stretched across the trail where the other end of the trip wire is secured to a tree or another post. A container with dye is attached to the upper end of the arm (the authors used a hollow rubber ball with a section removed). When a passing animal exerts tension on the trip wire the arm is swung over and the dye is released on the back and shoulders of the animal.

Clover (1954) was responsible for the development of two devices for marking deer in California. The one apparatus consist of a six-inch length of shotgun barrel, or three-fourths inch pipe, fitted horizontally through a wooden post which is driven into the ground alongside a deer-trail. The rear end of the piece of barrel protrudes on the outside of the wooden post, where an ordinary rat-trap is nailed to the post in such a position, that when the trap is set off, the striking arm strikes the firing pin of the gun. A large-head nail may be employed to serve as firing pin. An empty, primed shotgun shell, loaded with a very small charge of powder is thereupon carefully sealed, to prevent the dye from seeping through to the powder. The loaded shell is then placed into the firing chamber, and the rest of the barrel three-quarters filled with dye. Waxed paper is then pulled over the muzzle and sealed around the edges by means of adhesive tape. The apparatus is set next to a deer trail, with the muzzle approximately 25 inches from the ground. A nylon trip-cord is run over the trail, 10 inches off the ground and attached to the mouse trap. When a deer sets the trap off through the tension exerted on the trip wire by the forelegs, the striking arm strikes the firing pin, causing the shell to detonate and the dye to be ejected from the barrel onto the passing animal.

In areas with high concentrations of deer Clover (1954) used an automatic marking device to mark deer. It consisted of a tank containing dye under pressure, a spray nozzle and a release treadle. The apparatus is once again set next to a deer trail with the release treadle in the trail, camouflaged by soil or any suitable material. When a passing animal puts a foot down on the treadle a push-rod opens the release valve and an amount of dye is squirted through the nozzle, over the animal. The apparatus requires no re-setting, and is ready to mark the very next animal passing by. The apparatus used by Clover could be set off approximately 100 times before the dye and the pressure in the tank is exhausted.

It is doubtful whether these marking devices could be of value in the Kalahari Gemsbok Park where owing to the sparseness of the vegetation very few definite game trails exist. It would also be practically impossible to camouflage the apparatus or to erect it in such a manner that game would not be frightened into avoiding it altogether.

The Palmer chemical equipment Co. (1958) has developed a container which may be filled with liquid colouring-matter for marking animals. The container is fired by means of the firm's now well-known "Cap-Chur gun", and it is claimed to be accurate over a distance of forty-five yards. The container has a rubber nose, which sprays the dye over the animal on impact.

In the Gemsbok Park animals are rarely encountered at a distance of 45 yards or less, which renders the use of this method rather dubious. Furthermore it has been found that the rifle is not accurate at that distance and that temperature affects its elevation considerably. This is probably due to the fact that the compressed carbon dioxide is under greater stress at a relative high temperature.

Although the manufacturers claim that the rifle causes a hardly audible report, it is loud enough to frighten game away. This means that only one animal may be marked at a time, because it is unlikely that the herd will remain stationary after a shot has been fired.

Another drawback is that the dye container is of such expensive construction that it would have to be recovered for repeated use. This is not only troublesome, but could also prove rather costly since the container could very easily be lost.

Robertson (1960) reports that he has given thought to developing a capsule which could be loaded with colouring matter and shot at the animal that is to be marked. Upon striking the animal the capsule should be shattered to leave an easily visible stain on the animal. The main problem lies in that a dye containing projectile has to be constructed, possessing the following qualities :

(1) it should be sufficiently strong not to break when the cartridge is detonated or upon passing through the barrel of the rifle;

(2) it should be shattered upon striking the animal; and

(3) it should not be such that it would cause injury to the animal.

However a pressure of approximately one and a half ton develops in the barrel of an ordinary .303 rifle when a shot is fired. It is therefore virtually impossible to construct a container capable of withstanding such a high pressure, that will not cause injury to the animal shot at. When a lesser charge is used the trajectory would not be as flat, and the degree of accuracy will consequently be less. Experiments done with glass capsules, fired from a shotgun were abandoned, since this proved to be insufficiently accurate and furthermore, the glass splinters injured the animal (Robertson, 1960).

In addition to these disadvantages experiments done by Imperial Chemical Industries proved that an animal marked with dye or any colouring matter, somehow becomes aware of the stain on him, and will roll in the dust and rub himself against any object until all traces of colouring matter have disappeared (Streicher, 1960).

Field experiments on the addition of dyes to salt licks were done on a limited scale by Kindel (1960). The aim was to trace the movements of elk in relation to salting by locating their coloured droppings. Four dyes were found to impart a vivid stain to the faeces, namely methylene blue, crystal violet, basic fuchsin and aniline blue. The dye appeared in the faeces approximately 24 hours after ingestion and continued to appear for 2 to 4 days. It is obvious, however, that this method cannot be employed to determine the movements of game over long distances and long periods.

(b) *Animal captured by mechanical means.*

When these methods are considered, the oldest method of capturing wild animals is called to mind, namely the use of various types of traps. Sugden (1956) captured bighorn sheep *(Ovis canadensis)* in a reasonably large enclosure, having two entrances over which gates were suspended. Electrical detonating caps were used to close the two gates at the correct time. The caps were attached to the ropes from which the gates were suspended. A blasting machine was used to explode the caps, causing the ropes to snap and the gates to close. The explosion of the caps causes the animals which are standing in the gateways to jump clear, either into the enclosure or out of it, thus eliminating any chance of the closing gates being jammed.

Ritcey & Edwards (1956) trapped moose in an enclosure constructed with aspen poles and cedar posts. The trap is essentially a pen with two gates which is erected across a game trail. The trap is camouflaged with evergreen boughs and when set, the gates at both ends are open. When the trip-string inside the trap is disturbed by an animal, both doors are released and the animal is trapped inside.

A very similar trap is described by Webb (1943), who reports having had success in using a No. 1 steel trap to release the gates of the trap.

The objection raised previously also holds in this case, namely that the vegetation is so sparse in the Gemsbok Park that a trap or a catching pen could not be erected or concealed in such a manner that it will not be noticed by the animals. Such a method must therefore be rejected.

(c) *Animal captured by means of a drug.*

Owing to the widespread use that has been made of the "drugged dart" or "immobilising rifle" lately, and also on account of recent developments in this field, this method must occupy a prominent position in any discussion on the capture of game animals.

This method originated in 1953 when Hall, Taft, Baker & Aub captured large numbers of deer in order to study antler-growth. The animals were captured by driving them into a chute, from where they were dragged and wrestled to the ground. It proved to be an undesirable and dangerous method, since the animals often sustained injuries from which they died, while antlers were often broken.

The pressing need for a method whereby animals could be easily and safely anaesthetised resulted in the development of the "drugged dart." A .22 Crossman rifle, powered by compressed carbon dioxide, contained in a cylinder, was used to fire a dart at the animal to be captured. The dart was constructed so that the central portion fitted tightly into the barrel of the rifle. The rear part consisted of bristles, and the foremost part of a pointed shaft with circular grooves. The grooves were filled with the anaesthetic in the form of a paste.

The drugs used by Hall *et al.* (1953) were paraldehyde, Curare (d-tubo-curarine Hydrochloride pentahydrate) and Flaxedil (tridiethylaminoethoxy) benzene triethyliodide). Paraldehyde and Curare were, however, soon discarded because of the very narrow margin between an effective and a lethal dose. In the case of the latter various antidotes were also tried on the immobilised animals, without much success, however. It was therefore concluded that Flaxedil was the most desirable drug, since the margin of safety was not so narrow, and in addition it was found that Tensilon (3-hydroxyphenyl dimethylethyl ammonium chloride) is an excellent antidote for Flaxedil.

In 1957, however, Crockford, Hayes, Jenkins & Feurt, proclaimed Flaxedil unsuitable for capturing deer, after having carried out extensive trials with curare alkaloids and synthetic curare-like compounds. Strychnine salts were then used and although 21 animals were captured, the mortality rate was so high that the use of these compounds was also abandoned.

Crockford *et al.*, (1957) concluded that the ideal drug for these purposes must possess the following characteristics:

(a) The effective dose may not exceed the quantity that can be carried on an appropriate-sized dart.

(b) It must be a stable compound.

(c) It must be absorbed into the system rapidly.

(d) The onset of the reaction must be rapid, immobilising the subject sufficiently.

(e) It must have a wide margin of safety. (3 times the minimum dose should still not be lethal).

(f) No antidote should be required.

(g) It must be such that it will be rapidly eliminated from the system.

(h) It must have no drastic effect on gestation.

(i) It must do no permanent damage to an animal.

After experimenting with numerous compounds, Crockford *et al.,* (1957) eventually decided that nicotine salicylate had the least undesirable characteristics, and that it was the drug that came closest to conforming to the required properties. Although they immobilised goats in more than a hundred trials and in some cases one individual as many as six times, not a single fatality occurred and no adverse effects were noted during lengthy observation after the experiments.

Crockford *et al.,* (1957) administered the nicotine salicylate in the same manner as Hall *et al.,* (1953), did the Flaxedil, namely by mixing purified honey with the powdered nicotine salicylate to form an adhesive paste. This they applied to the grooved shaft of the dart, which was then placed in a tube containing calcium chloride to dehydrate and partially harden the paste. Upon exposure to air, however, it is soon converted back into a readily absorbable state, on account of the hygroscopic nature of the nicotine alkaloid.

The Palmer Company then started with the production of the "Cap-Chur gun" and soon replaced the grooved dart with a syringe dart in order that the drug could be administered in fluid form, which is much more practical than the paste. The use of this rifle for capturing wild animals seemed promising but Boch (1959) Brynard & Pienaar (1960), van der Walt (1959) and Lamprey (1960) all complain about the limited range and the inaccuracy of the "Cap-Chur gun".

Because of the limitations of the "Cap-Chur gun" various research workers have experimented with other means of propelling a "drugged dart". The cross-bow with a great number of modifications was tried out and Marais (1960) and van Rooyen (1960) each produced a model that appears to be very effective. It has been reported that both these instruments are capable of shooting quite accurately up to a distance of 100 yards.

Not only the instrument to propel the dart, but also the drug to be used produced some problems. Marais (1960) concluded after extensive trials that the nicotine compounds are too dangerous. He considers flaxedil still the best drug for this purpose because of the fact that there is an antidote for it. It is, however, not as quick-acting but if bovine hyaluronidase is added the desired effect is produced in a much shorter time.

"Midarine" (Succinylcholine chloride) was used very successfully by Harthoorn, Lock & Beuchner (1959) to immobilise game animals. It is well-known, however, that different species react differently to most drugs and Lamprey (1960), Harthoorn *et. al.,* (1959) and Sandeman (1959) all report that "Midarine" should not be used on any animal. Blue wildebeest for instance seem to succumb very easily under the effect of this drug. Harthoorn (1960) also found that it is most important to administer atropine to certain animals, after they have been immobilised.

The dose is calculated according to the body weight of the animal to be immobilised, but the requirements differ from specie to specie. Sandeman (1959) reports, for instance, that only 1/10th of the dose, per pound body weight, used on Uganda Cob, is required for Rhino.

This method of capturing animals certainly has possibilities, however, it also has disadvantages which weigh up heavily against its use in the Gemsbok Park. The animals are normally encountered at quite long distances, and are bound to prove difficult targets. It is unpredictable what the reaction of an antelope will be upon being struck by the dart. It may flee and cause the rest of the herd to stampede. On the other hand the herd may continue grazing and only the animal that has been hit may run some distance until the drug takes effect. Should this be the case, the obvious procedure would be to shoot a number of antelopes at a time and then mark them.

As indicated above, the whole process of capturing and marking antelopes in this manner, is bound to prove time-consuming. In addition a faultless drug has yet to be discovered, since most of the drugs known are too dangerous or too slow-acting — both very serious disadvantages. Therefore, one must conclude that this "drugged dart" method may prove difficult to employ with success in the Kalahari Gemsbok Park.

The fact that difficulties are encountered with the "drugged dart" method, does not necessarily rule out the use of drugs. These may also be employed for capturing animals by being added to drinking water. This can, of course be done only at artificial watering places, for the exact volume of water must be known, in order to prepare the correct concentration of the drug, and it is essential that the watering place should be drained once the work has been completed. Fortunately conditions in the Kalahari Gemsbok Park are in accordance with these requirements, since no natural watering-places exist. Furthermore the underground water that is pumped into troughs for animal consumption, has a very high salt content which is excellent for screening the taste of the drug which is added.

Chloral hydrate, a well-known drug, is admirably suited for this purpose, since it dissolves easily in water and is relatively quick-acting, inducing a deep sleep within 10 to 20 minutes after being taken. Its main disadvantages are that it gives a somewhat biting-bitter taste to the water, and its safety margin is not very wide. Marlow (1956) used it for capturing Euro *(Macropus robustus cervinus)* in Western Australia, under very arid conditions.

Various species of game were captured in South West Africa by Port (1959), also using chloral hydrate. He reports that all animals unhesitatingly drank of the water and were sleeping soundly within 20 minutes. Since the conditions under which the experiment was conducted are very much the same as in the Kalahari Gemsbok Park, it may be assumed with reasonable safety that the animals in the Park will drink of the "drugged" water.

It has emerged, from work done at Onderstepoort, that ruminants drink approximately one gallon of water for every 75 lbs. of body weight. It is therefore immaterial whether a very big or a very small animal drinks of the "drugged" water. As long as the concentration is correct, the amount of the drug taken by the animal will be in proportion to its weight and the animal will not receive an overdose. On the assumption that the above figure holds for game animals, van der Walt (1960) recommends a concentration of 6 grm. of chloral hydrate per gallon of water, which is approximately $\frac{1}{4}$ oz. per gallon of water. When the bontbok were transferred from Bredasdorp to Swellendam, however, it was found that each animal only drinks approximately half a pint of water per 75 lbs. of body weight, with the result that the concentration chloral hydrate was much too low. This could also be the case with the antelopes in the Gemsbok Park, for that would explain why Port (1958) used a much stronger concentration of chloral hydrate.

Other drugs, especially some of the barbiturates, have a much wider safety margin than chloral hydrate. Sodium pheno barbitone for instance has a safety factor of 45, i.e. forty-five times the effective dose may be administered before harmful effects will result. It is furthermore odourless and tasteless in water, in other words, a drug excellently suited for our purpose, but for one characteristic: four hours elapse before the reaction sets in after it has been taken. This, of course, rules Pheno barbitone out for use in the Kalahari Gemsbok Park, because in the four hours before an animal falls asleep it may cover a long distance and may not even be found to be marked. It can then easily fall victim to animals of prey.

As yet very little research has been done on the use of barbiturates for this purpose. It is therefore impossible to recommend any of these drugs as being superior to chloral hydrate. It is of great importance however, that every drug that can possibly be used be tried and evaluated, in an attempt to ascertain which drug is best suited for the purpose of capturing game.

In the discussion on the marking methods whereby the animals have to be captured, attention has so far only been given to the various means of capturing animals. Nothing has been said about the actual marking of the animals, because once the animals are captured they may be marked in any manner.

Various types of paint and dyes have been used in America for marking deer and other animals. Hay (1958) reports that the spraying of the pelage of beavers with bright enamel paint proved a failure, because these animals have a habit of constantly combing themselves, with the result that all traces of paint are removed after two days. An attempt to bleach portions of the pelage by means of hydrogen peroxide also failed on account of the oily nature of the fur.

The use of paint for marking purposes was also abandoned by Neal

(1959). He experimented with various marking methods on the collared peccary *(Pecari tajacu)*, and found that a paint mark lasted only for a month.

Various commercial fur dyes and paints have been used for marking deer. Webb (1943) even used picric acid crystals dissolved in alcohol or formalin, and Clover (1954) used a little nitric acid. Both turn the hair bright yellow. However, the use of any colouring matter is limited in the case of deer, on account of the animals shedding their coats. A dye or paint mark is therefore only effective for a maximum period of six months.

The hides of the antelopes in the Kalahari are not as oily as that of beavers and they have, of course, no combing habits. Therefore the problem encountered by Hay (1958), working on beavers, will not be present. The findings of Streicher (1960) regarding the use of paint are so conclusive, however, that we need not even consider marking animals on any part of the body with paint. The application of paint to the horns of an antelope could perhaps prove to be more effective. It is of utmost importance that the paint should be quick-drying, and not likely to peel or splinter off. A polyacrilic paint is recommended by Robertson (1960) for this purpose, since it does not splinter up like an enamel or plastic paint and dries within a few minutes. The colours are furthermore claimed to be very stable and will not fade.

Neal (1959) also tried chemical branding, ear-notching and ear-tagging for marking peccary, and concluded that ear-tagging, using an aluminium cattle ear-tag with a plastic disc, is the most reliable method. The chemical brand, he found, was obscured within a month or two by new bristles growing out. A notch in the ear proved both effective and permanent, but it was too small to be easily detected under field conditions.

Bigalke (1959) recommends the use of coloured plastic ear tags for marking game. These tags are used for farm stock and are available in various colours. He claims that marked animals can be recognised quite easily at 150 yards with a pair of 10X binoculars. In the Kalahari where antelopes are seen in large herds and often at great distances, I do not think such an ear-tag will be conspicuous enough for immediate spotting, or big enough to be seen at a great distance.

Aldous & Craighead (1958), whilst conducting field studies on the Nelson bighorn sheep *(Ovis canadensis nelsoni)*, had to adopt a method whereby each animal could be marked as a distinct individual. This they did by branding numbers into the horns of the sheep. Rams were branded with a 2-inch iron and ewes with a $\frac{7}{8}$-inch iron. Numbers were branded at the base, on the outside of both horns. In order to facilitate the spotting of marked sheep a plastic streamer was tied with a knot through a slit in the animal's ear. In addition an ear-tag was secured to the animal's other ear for further identification.

The branding of a number on the horns of antelopes in the Gemsbok Park would, to my mind, be unpractical, since it would be most time-consuming and would not even show up well. The use of a plastic streamer and an ear-tag, could prove quite successful in the Kalahari, provided the plastic streamer is not torn from the animal's ear by thorny shrubs, such as the swart-haak *(Acacia detinens)*.

Whilst studying the movements of white-tailed deer *(Odocoileus virginianus)* in Missouri, Progulske (1957) used a conspiciously coloured collar for marking these antelopes. He rejected other marking techniques such as the use of plastic ear-tags, as being recognisable at short distances only, and the use of dyes, because these are seldom colour-fast for a very long period. When bells are used, records may be obtained for animals out of sight although only a small number of animals may be marked in this manner.

The collar Progulske (1957) used, was made of belt leather and various designs cut from red, yellow, green, black and white upholstery plastic were cemented to the rough side of the leather collar, by means of a rubber solution. Deer wearing these collars could be identified at great distances, and different designs were easily discernable at 350 yards with the aid of a 7X pair of binoculars. However, the collar was found to be unsuitable for young animals, because if it was buckled on loosely enough to permit growth, it would slip over the animal's head.

A similar collar, only in this case being made wholly of polyvinyl chloride, a plastic material, was used by Ealy & Dunnet (1956) for marking euro, *(Macropus robustus cervinus)* and quokka *(Setonix brachyurus)*. In order to identify these animals by night as well as by day, various patterns of red "Scotchlite" reflective tape were cut and glued to the collar. Of the various colours of polyvinyl obtainable, yellow was chosen on account of the striking contrast it formed with the red "Scotchlite". The polyvinyl, it was found, became less pliable after some time though no serious deterioration took place. After nine months the reflective tape showed a number of cracks, but the designs were still easily distinguishable.

Such a collar is undoubtedly very effective, since it enables one to distinguish between marked animals by using various colours and designs. However, it is bound to prove rather expensive in the Kalahari where the marking is to be done on such an extensive scale. Reflecting tape is, of course, unnecessary since the animals need not be identified at night.

A method which is worth some consideration, is to fit polyvinyl chloride tubing over the horns of the antelopes. The tubing is obtainable in various colours and sizes. The $1\frac{1}{2}$ inch fits tightly over the horn of a Gemsbok and the 1 inch over the horn of a Springbok ram. The material is approximately 1/16th inch thick, and reasonably flexible; when a 4-inch length is pushed over the horn as tightly as possible, it fits reasonably well around the horn despite the fact that the horn is tapered. Such a 4-inch piece can be seen distinctly at a distance of 200 yards. With the aid of a 10X pair of binoculars the marked animals should be identified anywhere within sight.

Polyvinyl chloride adhesive tape is equally suitable, and perhaps a little more practical than the tubing, of which different sizes are required. The cost attached to either is approximately the same. How well the tubing or the tape will stand up to rubbing against trees cannot be forecast. An animal may succeed after some time in rubbing the tubing off and the tape may be lost even more easily if one of the ends becomes unstuck.

CONCLUSION.

It has emerged from the preceding discussion how necessary it is to commence with the marking of antelopes in the Kalahari Gemsbok National Park. The various methods were then evaluated and one must conclude that the best method appears to be to incapacitate the animals by adding chloral hydrate to the drinking water, and then to apply various colours and colour combinations of polyacrilic paint to their horns. In addition numbered ear tags may also be used for later exact identification. Should the chloral hydrate prove unsuccessful it would be necessary to resort to immobilising the antelopes by means of a drug shot with one of the specially designed rifles. It may even be necessary to use this method on some of the antelopes in any event, for instance when antelopes are to be marked in the dune veld where there is no water, or for marking eland which drink very rarely.

When deciding upon a method for marking animals, it is essential to ascertain that the animal's natural behaviour should not be disturbed by it. In this respect both the proposed methods are ideal, for the animal will be under the influence of a drug when being marked and will therefore know nothing about it. It will be necessary, however, to ascertain how the rest of the herd will react when the marked individuals join them. If they are avoided or driven out, the results will obviously be worthless and the animals will then have to be marked in some other way.

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