

# studying predators

Brian C.R. Bertram

A series of handbooks on techniques in African Wildlife ecology,  
produced by the African Wildlife Foundation



Handbook number 3

second edition





STUDYING PREDATORS

by

Brian C.R. Bertram

Revised second edition

Handbook No.3

in a series of Handbooks on techniques  
currently used in African Wildlife ecology

Edited by J.J.R. Grimsdell

African Wildlife Foundation

P. O. Box 48177

Nairobi

Kenya

September 1979

Cover photograph by David Bygott

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### Acknowledgement

Mr. Karl van Orsdol kindly commented on an earlier draft of this handbook.



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## SECTION 1 INTRODUCTION

### 1.1 Predators, and their study

A predator is an animal which catches and eats other animals. There is an enormous number of predatory species of invertebrates, fish, birds and mammals. This handbook naturally cannot deal with all these. The best known, and most highly developed, predators are the Order of mammals known as the *Carnivora*, and it is with the larger East African *Carnivora* that this handbook will be concerned. The term "predator" is used for short in this handbook to cover the following : lions, leopards, cheetahs, hyaenas, wild dogs and jackals. Of course the principles involved in the study of them may be applicable to other species; it is hoped so.

This handbook gives a guide to some of the techniques used in studying predators. It is intended that many of the routine observations described will be carried out by Park Wardens or Game Wardens in the course of their normal duties. Some of the methods described will be more applicable to those concerned with a more detailed predator study.

Why one needs to know about predators is discussed in general terms, and the problems involved in studying them are outlined. At the end of this section 1, we consider the sort of information needed, and consider why it is needed. The remaining five sections (2 to 6) describe how to obtain such information.

### 1.2 Why one needs to know about predators

There are five main reasons :

1) Because it is important to know what effect they have on other species. Supposing an ungulate species were



increasing or declining rapidly in numbers, it would be important to know whether predation was responsible, and to predict what would happen.<sup>19</sup> For example, would more lions mean fewer zebra? Or fewer buffalo? Or fewer wildebeest? Or fewer wildebeest and therefore more buffalo? Or no change in prey populations? Or fewer hyaenas? Or fewer hyaenas and therefore more cheetahs? Or fewer cheetahs? There are endless possible interactions, which one needs to know about in order to predict changes, to understand the causes of changes, and to decide whether and what management actions are needed to accelerate or slow down those changes.

ii) Because predators are a major tourist attraction in National Parks, and a large source of revenue more directly from professional hunting in other areas. Knowledge of those predators is needed to ensure that they remain available in numbers for tourists to see, and similarly in hunting areas it is important to determine how large shooting quotas should be.

iii) Because some predator species (such as cheetahs<sup>28</sup>) are scarce and becoming more so, management action may be needed for their conservation. The wrong action, taken in ignorance, would be both costly and futile, and possibly damaging. Suppose, for example, that the cheetah population in an area appeared to be declining fast. One would need to know first whether it were really true, and not simply a change in their use of the area. If it were true, one would obviously need very different conservation measures depending on whether this decline was caused by decrease in their prey species, by increase in other predator species competing for food, by a change in vegetation making their hunting more difficult, by an increase in numbers of species which prey on new-born cheetahs, by disease, or by harassment of adults by visitors or other predators. Again the position could be very complex, but needs to be understood.



iv) Because in areas where predators kill domestic stock the situation needs to be properly understood in order that appropriate solutions to the problem can be worked out.<sup>40</sup>

v) Because we have an obligation to future generations to leave them as much as we can. Human pressure may eventually make us unable to prevent the disappearance of many wildlife areas and wildlife species, but we can and must leave for our successors detailed descriptions of those areas and those species, of their form, their ecology and their behaviour. They will have a use for such information, even if we do not at present. It is striking, for example, how much better conservationists we would be now if only we knew what was the ecology of our wildlife areas and species a century or two ago.

### 1.3 General problems involved in studying predators, and how they are overcome

Problems arising are due to five main causes :

i) Predators are relatively scarce. Needing to eat a large number of prey animals each year, predators naturally cannot be nearly as abundant as those prey animals. This scarcity means that observations will be made on a relatively small number of individuals; therefore one needs to know which individuals they are. Recognition of individuals (section 2) in turn provides much extra information. The relative scarcity of predators also makes all information on them worth having, even that collected in a non-systematic way. But great care is obviously needed in analysing such information.

ii) Predators are often difficult to find. They need to be invisible to prey species, and therefore are often well camouflaged and tend to remain hidden. Practice makes for improved spotting, helped by knowledge of where to look and of the behaviour of other species when they have detected



predators.

iii) Predators are often nocturnal. Most of their activity occurs at night when it is difficult to observe them. Nocturnal species are usually also active for a while after dawn and before dusk, so they can and should be observed then. Instruments for night vision have been developed but are expensive.

iv) Predators' hunting is liable to be disturbed by the observer. Most predators rely on their prey being unalerted, and the observer nearby makes those prey more wary and therefore much more difficult to catch. Great care is needed.

v) Predators can be dangerous. They must therefore be studied with caution and with intelligent knowledge of their behaviour.

#### 1.4 What one needs to know about predators, and why

i) Their population size - how many there are. This enables one to know the magnitude of their effect on other species, and to detect any changes in numbers of predators. Methods of determining predator population sizes are described in section 2.

ii) Their population dynamics - what their population structure is (i.e. age and sex structure), and what their rates of reproduction, mortality and migration are. Such knowledge is necessary for predicting changes in their population size, to determine how the predator population would be likely to respond to changed conditions. Section 3 outlines methods of study of predator population dynamics.

iii) Feeding - what numbers of what species of prey they are eating. This enables one to determine their effect qualitatively and quantitatively on the different prey



species, and to be able to predict the effects on the predator of changes in the numbers of prey species. Methods of studying predator feeding are described in section 4.

iv) Movements and habitat preference - how far the predators move, how they use their range, and what determines how much they move.<sup>45</sup> The movements of predators may or may not influence or be influenced by the movement of their prey species; knowledge of predator movements is necessary for understanding their interactions with their prey species. Methods of study of predator movements, especially by radio-tracking, are described in section 5.

v) Handling - how to capture and immobilize predators. Marking and radio-collaring are necessary for some aspects of a predator study; both require a restrained animal. Methods of restraining it are described in section 6.

vi) Social organisation - how individual groups are organised and how they relate to neighbouring groups. Such knowledge will be useful in explaining aspects of population dynamics, hunting ability, inter-group spacing, and will be relevant to any management actions taken on the predators themselves. Methods are not explained here as they are based on straightforward observation of both individuals and groups.



## SECTION 2 POPULATION SIZE

Predators are difficult to census. There are a number of possible methods; each has its drawbacks, and different methods are more applicable for different species or situations. They are not alternatives : a combination of methods may provide the most reliable answers.

### 2.1 Aerial counts

Method : Fly, and count all predators seen. Methods of carrying out aerial censuses have been described in Handbook No. 1.<sup>29</sup>

Pros and cons : The main advantage of such a method is that a large area is covered in a short time.

Disadvantages are :

a) High cost.

b) Except in extremely open country, most predators are not visible from the air. By day, they tend to be concealed in thickets (lion, leopard) or underground (hyaenas); even if not, they can be very easily overlooked if in the shade or inactive.

Applicability : Little. For diurnal predators in completely open country, aerial censuses would be feasible, but in few other circumstances. However, it is certainly worth noting down predators seen in the course of aerial censuses of other species; this information tells you little about predator numbers, but it could be useful in detecting gross increases in population size over a period of years, or in showing large-scale movements of predators' ranges.

### 2.2 Ground counts

Method : Again, methods of carrying out ground counts have been described in a previous handbook and elsewhere.<sup>29,30</sup>



Ground counts for predators must be carried out from a vehicle.

Pros and cons : Advantages : probably fewer animals are missed than with aerial counts, since the observer is travelling more slowly and can stop to investigate any suspicious objects or movements.

Disadvantages :

a) Nonetheless, most animals are still missed if the vegetation is at all thick, for example many predators stay in stream-side vegetation. In long grass they may be invisible from the ground but could be seen from the air.

b) Very time-consuming, because in most types of country one's reliable visibility range is less than about two hundred metres; it therefore takes a long time, driving slowly, to cover a large area.

Applicability : Usually little. It is, however, suitable for determining numbers of fairly abundant and well dispersed diurnal predators in an area of open country, such as the Serengeti plains.<sup>29</sup> But this situation rarely arises.

### 2.3 Counts of calls, faeces, or footprints

Method : Basically one is searching not for the predator itself but for things associated with it : its noises,<sup>38</sup> its droppings, or its footprints.<sup>30</sup>

Pros and cons : Advantages : Some very shy predators which conceal themselves make no attempt to conceal these signs of themselves.

Disadvantages : One does not obtain an absolute value for population size, but a minimum figure. Not all animals call, not all droppings nor footprints are found, and the methods need to be calibrated first in areas of known populations. This has not yet been done.



Applicability : Call counts are naturally unsuitable for the silent species; others may call too variably. Faeces counts are probably suitable only for spotted hyaenas whose white droppings are very visible.<sup>22</sup> Footprints are suitable for counting in some habitats. But none of these methods has been calibrated yet, nor do they give direct information on population size, though they may indicate changes in population size.

#### 2.4 Capture - Mark - Release - Recapture

Method : The principle of this method<sup>29</sup> (which has been widely used with insects) is as follows. You capture a number of, say, flies, mark them in some way recognisable to you, release them into the population again, allow enough time for them to have scattered themselves among the other members of the fly population, and then capture flies again. A proportion of those you now catch will be your marked ones. You assume that this proportion is the same as the proportion of marked flies in the wild population, and knowing how many marked flies you released, you can calculate how big the wild population is. This is the principle of the method; there are some modifications<sup>22,30</sup> possible in the calculations to allow for death or emigration of marked animals, and for some non-randomness in the capture and recapture methods.

Catching methods are described in section 5. The most successful marking method so far used with large predators is to cut notches in the ears.<sup>22</sup> Ear tags may work their way out rather quickly,<sup>42</sup> but not necessarily.<sup>31,46</sup> Freeze-marking,<sup>14</sup> causing a small permanent patch of white hair, is another effective method and has been used on lions and on mongooses.<sup>36</sup> In the case of most large predators, there is no need to recapture - the mark can be seen on the free-living animal, which is a great advantage in saving time and money.

Pros and cons : Advantages : This method can give a reliable figure for population size provided that the animals



move and intermingle a reasonable amount, and provided that the sightings or recaptures are done randomly with respect to their movements.

Disadvantages :

a) Many predators are extremely difficult and time-consuming to capture; some individuals or sexes are much more difficult than others.<sup>15</sup>

b) Many predators are resident within a small area, not mingling with neighbours; in these circumstances it is almost impossible to recapture or re-sight randomly with respect to the marked animals.

Applicability : This method has been used successfully with hyaenas in Ngorongoro,<sup>22</sup> and with nomadic lions on the plains of Serengeti.<sup>42</sup> It is suitable for populations where a large number of animals use the same area (e.g. hyaenas); it is not suitable for solitary resident species. Capturing and marking almost all the members of the population is a development of this method, intermediate between the mark-release-recapture method and the individual recognition method. It has been used successfully with lions in the Kruger National Park.<sup>46</sup>

## 2.5 Individual recognition

Method : The most accurate way of determining population size is obviously to recognize all the animals in the population individually, if this is practicable. All animals differ from one another; the problem is simply whether the observer can detect, record, and recognize these differences, from the distances he usually is from the animals.

Lions can be recognized individually by tears in the ears<sup>42</sup> (which may change somewhat over long periods); by scars on the face; by missing teeth; by the arrangement of whisker spots;<sup>32</sup> by the size and colour of the mane, if any; and by other obvious features such as the tail tuft



missing, or a blind eye.

Leopards and cheetahs can be recognized individually by the pattern of spots on their coats. The spots on the head are smaller, but they have reference points (such as the eye) nearby, and they do not change their position as the animal moves and so stretches its skin.

Wild dogs have very clear patterns of black, white, and brownish patches on both sides of the body, and all dogs are different.<sup>13</sup>

For hyaenas and jackals it is almost impossible to recognize many wild individuals reliably from their natural markings.<sup>22</sup> For all species where individual recognition is attempted, it is worth maintaining a photographic record of each individual so that later observers can also recognize the same individuals.<sup>4</sup>

Pros and cons : Advantages : If applicable, this method gives the most accurate figure for population size, in most cases.

Disadvantages :

a) Very time-consuming; it may take a very long time before every individual has been seen and recognized.

b) Many animals are too timid for the observer to get close enough to observe their individual markings.

The method of determining predator population size by recognizing all the individuals present has been used successfully with lions,<sup>16</sup> leopards and cheetahs. It is generally unsuitable for hyaenas and jackals, and for areas where most individuals of the other species are very unapproachable. Unsuitable for very large populations, unless a keying system can be devised; but predator populations are rarely that large. Note that in a population containing a proportion of individually recognized animals, a Recognise -



Re-recognize method can be applied whose principle is the same as for the Mark - Recapture method already described.



### SECTION 3   POPULATION DYNAMICS

The previous section described how to go about determining the size of predator populations. However, one generally wants to know not only how many predators there are, but also other questions concerning population dynamics : What is their population structure? What are their reproductive and mortality rates? What influences these rates? Methods of answering these questions are discussed below.

#### 3.1   Population structure

##### i) Routine observations

For each predator, or group of predators seen, it is suggested that the following should be done as a routine minimum :

a) If any animals in the group are known individually, identify them. Learn to recognize others if required and if practicable.

b) Note the size of the group encountered.

c) Classify each animal in the group into an age and sex category as described below.

d) Make a note of the time and place.

e) Wait quietly and watch the animal(s) for a while. It will often be found that extra timid animals (such as small young) reappear, or that useful observations will be made on behaviour connected with population dynamics.

f) Note the occurrence of any such behaviour; record for example, any oestrous or mating behaviour; suckling; feeding;<sup>5</sup> any sick or dying animals. And note, of course, from which individuals such behaviour is seen.

##### ii) Sex classification

Except in very young animals, predators are generally easy to sex - males have conspicuous testicles. In situations where these cannot be observed, there are often other indicators of sex. The mane on male lions is usually



conspicuous on adults; young or maneless males generally have slight tufts around the neck, visible with careful observation. Male leopards are considerably larger than females, with much heavier, thicker necks. Male cheetahs are somewhat larger and heavier in build than females. Hyenas are difficult to sex, for the females have a genital apparatus very similar to that of the males;<sup>35</sup> in mature adult animals the presence or absence of large nipples indicates the sex, but immature animals cannot be sexed in the field.<sup>22</sup>

### iii) Age classification

Free-living predators naturally cannot be aged precisely in the wild. However, they can be classified into various age categories based first on size and then (for adults) on tooth wear. This classification based on size is likely to be somewhat arbitrary. A universal classification system is needed which can be used by different people, for different predator species, and in different areas. The following system is suggested, based on size in relation to adult size.<sup>50</sup> Each worker may of course need to subdivide these groups further, especially Class I.

a) Class I : Small cubs. These would include all young up to  $1/3$  of the weight of an adult female. In lions, this would correspond to an age of about 10-12 months,<sup>50</sup> being just before the set of milk teeth are replaced by the permanent ones.<sup>42</sup> (The equivalent stage in other species would correspond very roughly to ages of : leopard 5 months, cheetah 5 months, hyaena 6 months, wild dogs 4 months; but these ages are very tentative and need confirmation.) This class could be subdivided into 2 equal parts : Class Ia less than (and Class Ib more than) half the weight of a full-sized Class I cub (i.e.  $1/2$  of  $1/3 = 1/6$  of adult weight).

b) Class II : Large cubs. These would include all young between  $1/3$  and  $2/3$  of the weight of an adult of the same sex. (Very rough ages at which animals would leave this age class would be : lion 2 years, leopard 10 months, cheetah 10 months, hyaena 12 months, wild dog 8 months.)



c) Class III : Subadults. This class would contain all animals more than  $\frac{2}{3}$  of adult weight, but noticeably still young and of more slender build. (Rough ages at which animals would cease to be subadults and be considered adults would be :lion 3 years, leopard 2 years, cheetah 2 years, hyaena 2 years, wild dog  $1\frac{1}{2}$  years.)

d) Class IV : Adults. All animals of full weight. Signs of aging adults are more difficult to quantify in free-living predators. As it gets past its prime, the animal shows signs of age, such as a more haggard appearance, more deeply sunk eyes, and more angular and less rounded body. Tooth changes with age can be seen in the incisors and canines of live animals. Young adults have long, sharp, creamy-white canine teeth; with age these become gradually yellow then orange or toffee-coloured. They also become worn blunt and thus become shorter, or they may get broken off, leaving only a smooth stump. Also with age, the small incisor teeth progressively drop out. It is worth describing the front teeth of each predator, as it gives an indication of its age, but it is not yet possible to express this in terms of an accurate number of years. Live adults can provisionally be divided into two sub-classes :

IVa : Medium adults. Adults with white to yellowish canines, showing less wear than for old adults.

IVb : Old adults. Adults with canine teeth orange or toffee-coloured, both being worn down to at least 20% shorter than young adults' canines.

This is a subdivision which is likely to be more useful for lions and possibly hyaenas than for the other species, which do not usually show so much tooth wear.

For hyaenas,<sup>22</sup> the spotting on the coat changes, which is a useful indication of the age of the animal. Young hyaenas, less than about 4 years old, have very clear black spots all over the body; medium age animals (about 4 to 10 years) have few or indistinct spots on the body; old animals (more than about 10 years) have no spots except on the legs.



### 3.2 Factors which can change the population size

There are obviously three such factors : reproduction, migration in or out, and mortality.

#### i) Reproduction

Predators in general have short gestation periods, and give birth to small young. Their stomach size also varies greatly according to how recently and how much they have eaten. For these reasons, pregnancy is often difficult to detect in wild predators until a relatively late stage. An enlarged abdomen and swollen mammary glands not yet being suckled are signs of a late stage of pregnancy.

After the birth of young, suckling by cubs produces dark stains round the nipples, which is a clear indication that the animal is suckling young. The mammary glands may be full or empty, depending on how large the young are and when they last suckled from their mother.

It is worth recording, for every predator seen, whether it is pregnant, lactating, or being suckled from.

#### ii) Emigration and immigration

Knowledge of individuals helps one in estimating the importance of immigration or emigration. If they occur frequently, sudden arrivals of new unknown individuals, or disappearances of healthy adults would suggest a fairly high level of immigration into and emigration out of the study area. Radio-tracking of individuals could answer the question of where known animals emigrated to.

#### iii) Mortality

Any dead predators should be examined to try to determine the cause of death. However, care must be taken in the case of apparently healthy, undamaged animals as they may have died from anthrax.<sup>27</sup> If possible such examination should be done by a veterinarian. Failing that, the dead animal



should be examined<sup>9</sup> in the same way as described for kills (in section 4). Signs of injury should be looked for on the fur, and also by skinning the animal and inspecting both skin and carcass. Pieces of tissue should be collected for later microscopic examination. The general appearance, condition, age and amount of fat present should be noted. The stomach contents should be inspected. Any signs of violence in the vicinity should be looked for, such as scattered fur. It ought to be possible to decide whether the animal died as a result of fighting with a conspecific, violence from another species (including other predators), old age, disease, starvation, or a combination of these causes.

Because predators are scarce and so little is known about them, it is worth collecting skulls whenever they are found. They can be given relative ages in two ways :

a) From the amount of wear of the canines, as described above for live animals.

b) From the amount of wear on the second premolar tooth in the upper jaw. This starts out conical in young animals, but gradually gets worn down; the diameter of the wear surface should be measured, as it gives a relative indication of age - the greater this diameter, the older the animal.<sup>22,42</sup>

For lions, the order and extent of tooth replacement and tooth wear have been worked out in detail for known-age animals from small cubs to old adults.<sup>50</sup> Leopard, cheetah, hyaena, wild dog and jackal skulls can be assigned a relative age in the same way, but there has not yet been calibration using known-age animals.

One must remember that there are biases in any skull collection; for example the skulls of cubs, being smaller and weaker, are much more likely to be broken up by hyaenas and therefore never found. But among adults, such biases probably do not occur so much.



### 3.3 Long-term records

Given that it is possible to recognize individual predators, the building up of long-term records of their life histories and reproductive performance of those individuals provides much extra information. Observations made routinely as indicated above, will, when analysed, provide information on such things as : litter sizes, and how these depend on individuals and on other factors; cub survival, and what factors influence this; birth rate and interval between litters, and what factors (such as cub survival) influence these.

For relatively scarce and long-lived animals, a great deal of such extra information can be gained from the keeping and analysing of long-term records of individual predators.<sup>3,4,13,16</sup>



#### SECTION 4 FEEDING

For understanding the impact of predators on prey species, it is obviously necessary to know about their feeding : What prey species are they killing? What proportion of them do they take? What age, sex, and condition are these prey? And how do they compare in number and age-sex distribution with the live prey population?

It must be remembered that most predators are extremely flexible in what they eat. Their diet certainly varies from place to place, depending partly, of course, on what prey species are present in different areas. For the same reason, the diet may vary with season as the prey species present change. Even if the numbers of different prey species in an area do not alter, there may be differences in their catchability, due to changes in cover or in social behaviour of the prey. It is extremely difficult to say what proportion of prey animals are truly "available" to the predators. And there are certainly differences between individual predators in the prey animals they take. Conclusions from a predator feeding study may therefore be valid only for the time and place where the study was done.<sup>2,10,11,22,23,24,31,33,37,39,47</sup>

Methods of studying predator feeding are the following :

##### 4.1 Finding killed animals<sup>10,22,24,33,39,42</sup>

Kills may be found in a variety of ways :

i) By finding the predator (at its kill) by some other means such as radio-tracking (see below).

ii) By watching vultures. Seeing vultures scattered in the branches of trees often indicates that there is nearby a kill to which the vultures are unable to get access, often because a predator is present and keeping them away. To see



several vultures coming down from the sky in a straight line usually indicates food down below. Many vultures getting up from the ground at the same place is often an indication that there has been a carcass nearby. A column of vultures circling is little guide - it simply means that they are wanting to rise and have found a good thermal, and these thermals can move fast and may be a long way away from where the vultures took off.

iii) Occasionally by smell.

iv) For leopard kills, by looking up in suitable trees, where the remains of their prey may stay for weeks, draped over a branch.

v) For hyaena and lions, by hearing the noises of these predators squabbling with one another over the kill.<sup>22</sup>

#### 4.2 Examination of kills

Kills can be examined by waiting until the predator has finished feeding, or if this is impossible (e.g. because of lack of time, or because a small prey animal is likely to be totally consumed) by temporarily driving it from its kill. Predators can usually be made to withdraw by driving slowly towards them and separating them from their kill which can then be observed from close range. Although most predators will flee from a human on foot, this method disturbs them considerably, and they may not then return to their kill.

i) Cause of death.<sup>22,42</sup> Almost any predator scavenges if it can; therefore the presence of a predator feeding at a carcass does not necessarily mean that it killed the animal itself. The cause of death needs to be determined. Indicators of death due to predators rather than to natural causes are :

a) Haemorrhages, especially in the region of the throat or muzzle; it is in these regions that a cat predator holds



its prey. Its teeth cause the breakage of minute blood vessels there, resulting in a haemorrhage - a reddish patch clearly visible on the inside of the skin. A haemorrhage is proof that the animal was alive when the wound was caused.

b) Chewed grass in the mouth of the dead animal. An animal which dies of natural causes (disease, old age) is unlikely to be in the middle of a mouthful at the time. An animal caught by a predator is likely to regurgitate a portion of the contents of its stomach. Grass in the mouth indicates a violent death.

c) Footprints<sup>10,11</sup> and/or hoof marks in the ground can sometimes clearly indicate how the kill was made. A blood patch on the ground suggests a kill.

d) Good condition, absence of disease, and the location of the dead animal can also be suggestive.

Counter-indications, suggesting a natural death, are signs of vultures having been feeding at the carcass (e.g. the eye removed; a small hole in the groin region, with much meat gone; or white vulture droppings on top of the carcass).

Having established that death was caused by a predator, there is still the problem of which species of predator killed it, for the large ones will, if they can, take kills from the smaller. Thus lions will rob all other species, although a pack of hyaenas can sometimes drive a single lioness from her kill.<sup>22</sup> An indication that a kill was made by hyaenas is if the legs are much bitten and scratched - lions topple their prey (often inflicting scratches on the shoulders or rump) and hold its throat or nose;<sup>42</sup> hyaenas bite at its legs until it falls.<sup>22</sup> Throat haemorrhages indicate a large cat predator. Lions very rarely carry away parts of their prey, whereas hyaenas frequently do; so if a limb bone of, for example, a zebra, is missing, it is an indication that hyaenas have been at the kill. Leopards pluck some of the fur from their prey; therefore to find tufts of plucked hair of the prey is an indication of a leopard kill only. It is always worth looking for signs of other predator species in the



neighbourhood of a kill, and for traces of blood around their mouths, which indicate recent feeding.

ii) Prey animal.<sup>9,22,42</sup> The kill should be examined and its age and sex determined.<sup>22,42</sup> For those which cannot be aged etc. in the field, it is worth taking a lower jaw for later tooth sectioning.<sup>44</sup> The condition of the animal should be determined from inspection of the femur fat.<sup>43</sup> Specimens of tissue (liver, lung, heart, blood) should be taken if there is someone available and competent to inspect these for disease.

#### 4.3 Examination of faeces<sup>2,22,23,25,32,37</sup>

Especially as a way of detecting kills of small quickly-consumed species, it is advisable to examine predator droppings; these should be collected when practicable. Depending on the type of dropping, the amorphous matter can be removed through a seive, either wet or dry, and the remainder examined. Apart from hair, there may well be items eaten which can be identified, such as small bones, tortoise shell pieces, scales of reptiles or birds, feathers, claws or hoofs, fruit seeds, grass, or pieces of insect. This variety of items is more likely to be found in the droppings of those predators which do more scavenging.

Many predator droppings contain large amounts of hair. The prey species to which this belonged can be determined with practice by examining these hairs under a microscope : each species has characteristic features of the shape, length, or colouring of its hair which enables identification. For this it is necessary to have a labelled reference collection of the hairs of all species which the predators might eat, to compare their structure with those found in the droppings. Such a reference collection can be built up by taking hair from dead or killed animals whenever they are encountered in the course of field work, or from museum specimens.



Remember that a few leopard hairs (for example) found in a leopard dropping does not mean that the animal has been eating other leopards - only that it has been grooming itself.

#### 4.4 Observation of hunting<sup>12,22,26,31,41,42</sup>

The predators may be observable when hunting and an appreciable amount of information obtained in that way; this is true particularly of the diurnal species (cheetah, wild dog) which outrun their prey. For the nocturnal ambushing species (lion, leopard) this is more difficult. Radio-tracking (see below) makes it possible to find and follow them at night, but not to observe them. It is very difficult at night to observe an ambushing species hunting, because if you are close enough to observe the predator, you are very likely to alert the prey or to make it avoid you and therefore the predator also. Most lion hunts fail anyway, and your presence will increase that proportion, and probably give a distorted picture of what they are catching.

In very open country, it is sometimes possible to observe predators hunting on moonlit nights. Two expensive instruments have recently been developed for night vision, which may be useful for the observation of predators hunting at night; they are the image intensifier system, and infra-red binoculars. With these, one can see clearly at fairly long range even without any moonlight.

By observing hunting, one should be able to understand better the different hunting methods employed, and the causes of different success rates when hunting different species. It should also be possible to determine the relative importance of scavenging, either by robbing other predator species or by finding naturally dead animals.



#### 4.5 Determination of feeding rates<sup>10,12,22,41,42</sup>

One must know not only what species of prey are taken, but also how many of them. To do this it is necessary to find out how many prey animals are killed per predator per week. It should be remembered that not all the animals killed are always eaten, as the kill may be stolen by another predator. The only reliable way of measuring feeding rates is to follow individuals continuously for long periods in order to determine the total weight of food killed or eaten during that time.<sup>12,41</sup> Radio-tracking provides the means by which one can follow individuals in this way. It is necessary to estimate the approximate weight of each prey animal killed, as well as the weight of the remains when the predator leaves. If the predator is obtaining small amounts of food at many different kills it may be impossible to determine its feeding rate. Figures on feeding rates in zoos are available; feeding rates in the wild are likely to be somewhat higher than these figures because wild predators are more active and usually have to support a parasite load as well.

These continuous observations also enable one to compensate for biases arising from the fact that large kills take much longer to be eaten, so you are much more likely to find them. By recording the time taken to consume kills of different sizes, one can correct the figures for the numbers of kills of different sizes that were found.

#### 4.6 Determining the effect on the prey species<sup>22,33,42</sup>

We assume that (using lions as an example) the average amount of food eaten per lion per day has been found (as above). Not all of a carcass can be consumed, and some of the food eaten has been scavenged not killed, so the weight of food killed per day per lion is different from this figure, but we can calculate it from the data we have obtained. We have determined the lion population size by one of the methods in section 2. Therefore the total weight of the



animals killed by the lion population per year can be calculated. We have found the relative numbers of each species killed, corrected for size, and knowing the average weights of adult animals of each prey species, we can determine the number of each species killed. We have also aged and sexed the kills we have found, so we can calculate how many of each age and sex class of each species is killed by our lion population per year.

We then want to know how significant this is in relation to the live prey population. For this purpose, it is necessary to conduct regular (e.g. monthly) counts of prey species within the study area (or areas) where the predator population is being observed. The regular counts can be used to calculate mean numbers of prey species over the study period and will also show how prey numbers fluctuate according to season, the season of lowest prey availability presumably setting the limit for predator numbers. Total or sample counts can be used depending on the size of the area and the prey species being counted. The sex and age structure of the prey populations should also be determined. Methods of estimating numbers and population structure can be found in other handbooks.<sup>29,44</sup>

From these figures, and from data on mortality in these prey species, we can determine for each age and sex class what proportion of those which die do so as a result of predation by lions. Thus we can determine the effect of lion predation on that species in the study area.



## SECTION 5   MOVEMENTS

There are three main methods by which the movements and ranges of predators can be determined : by plotting the positions of known or marked animals whenever they are found; by continuous following of individual animals; and by radio-tracking them so that they can be found at intervals decided by the observer. All have relative advantages and disadvantages, and again the different methods are not alternatives.

### 5.1 Plotting the positions of individuals whenever found<sup>16,22,31,42,51</sup>

This is always worth doing, for it gives information on ranges of large numbers of animals at no cost. The main problem with such non-systematic observations is that where and whether the animals are found depends on where the observer looks. If you do not find an animal after looking in its normal range, you do not know if it is there but unseen, or if it is outside its normal range. If it is possible to arrange one's searching effort either randomly or fairly systematically over the whole study area, one can obtain information useful in plotting ranges of individuals; usually it is either not possible or not productive to do so, and so the ranges obtained will be minimum ranges only. Since on most days an individual predator will often not be found, the data obtained in this way cannot be used to determine, for example, an average rate of movement per day, because the individual may be more likely to be found if it is close to where it was yesterday. Nonetheless, non-systematic observations are of use, but it must be remembered in analysis of them that they have been obtained in this non-systematic way.

### 5.2 Continuous following of individuals<sup>31,41</sup>

If it is possible to keep track of a single individual,



following it wherever it goes, such methods can give the type of information needed above, for example on feeding rate, and home range. One of the best methods of keeping track of an animal continuously is by radio-tracking it, as discussed below. In most cases it can be a very difficult problem to follow a predator continuously wherever it goes, except for animals which are diurnal and in open country. If you are too close, you may disturb the animal and its potential prey. If you are too far behind, you risk losing sight of it and not being able to find it again. Continuous observations must be continuous to be of much value - it is no use being able to follow an animal only when it is moving slowly or very little.

Continuous observations are needed for calibrating one's intermittent observations - to be able to say, for example, that an animal which is found 4 km from where it was found yesterday is likely on average to have actually travelled a distance of, say,  $5\frac{1}{2}$  km. They are needed for discovering activity patterns, rates of feeding, defaecating, calling, drinking, fighting, and so on. But continuous observations have their limitations, in that the observer gets information on only a single animal in the course of the day. If such detailed information is needed, continuous observation is a good way of obtaining it. But often, more general information on a large number of animals may be more valuable.

### 5.3 Radio-tracking<sup>1,8,15</sup>

Radio-tracking provides a method whereby particular animals can be found wherever they are, whenever you want to find them. This is done by having a small radio-transmitter attached to the animal, usually in a collar round its neck. This transmitter produces a continuous "bleeping" radio-signal which is, of course, inaudible but which can be detected by means of a radio receiver and aerial. You can find the direction from which the signal is coming, and therefore can find the animal.



i) The advantages and disadvantages of radio-tracking :

Many predator studies are likely to benefit from the use of radio-tracking, for the following reasons :

a) It greatly increases the efficiency of the study in enabling you to find more animals per day.

b) It enables you to find individuals reliably, and so to discover rapidly the ranges and movements of those animals, and to discover when they go outside their normal ranges.

c) It enables you to follow individuals continuously, even at night and in difficult country. You can stay much further behind, because it does not matter if you lose sight of the animal, since you can always find it again; therefore you cause less disturbance to the animal and to its hunting.

d) It enables you to carry out regular intermittent observations, such as every two or three hours, or every day, or every week; observations at intervals such as these will often enable you to answer the questions arising in the study more efficiently than continuous observations would do, because you can observe several different animals intermittently over the same period.

e) It enables some forms of automatic recording to be used, such as recording when an animal is at a particular place.

The disadvantages of radio-tracking are :

a) That the cost of equipment is rather high, though not excessive.

b) That some disturbance to the animals is involved in immobilizing and collaring them, although such disturbance should not be very great. Methods of immobilizing predators are described in section 6.

c) That in practice there are often problems with the equipment which cause delays and interruptions of the observations planned. In use, the equipment rarely works as well as the manufacturers claim it should.

The collar obviously should interfere with the animal's normal life as little as possible. As a rough guide it should not



ii) Equipment<sup>1,8</sup>

Radio-tracking equipment is produced by a number of firms. Unless you have a skilled radio-technician at hand, it is worth buying equipment ready-made from one of those firms, which will have already tested it in the field.

The standard radio-tracking equipment purchasable operates at a high frequency, around 150 MHz, although some may be obtained at around 30 MHz. Higher frequencies have the advantages of greater directional accuracy with smaller more compact receiving aerials, and of being more efficient (i.e. greater range for weight) in unobstructed country. On the other hand, if the country is extremely broken and thickly vegetated, lower frequency signals will provide longer range, but it is more difficult to determine their direction. But reliability is the most important point, and probably the higher frequency transmitters are generally the more reliable because they have been tested in the field more.

The range from which signals can be detected is dealt with under tracking methods below. A transmitter is connected to batteries which have a limited capacity. A transmitter giving longer range requires more power, and therefore empties the batteries quicker; long range transmitters therefore last less long than short range ones. If the weight of the collar is not important, more batteries can be put in, so that one can get both long range and long life; but with the smaller predators one must avoid too much weight, and a compromise between range and life must be reached.

The type of collar used will vary according to the species, situation, and requirements of the project. A collared animal should be observed carefully, especially during the first two weeks, so that, if necessary, modifications can be made to the collar design in the light of these observations. The collar obviously should interfere with the animal's normal life as little as possible. As a rough guide it should not



weigh more than, say, 3% of the animal's own weight, and should be less if possible. It should not be too tight. It should have no rough parts which can cause sores on the animal's neck. It should be made as much as possible the same colour as the animal itself. It must be constructed in such a way that it cannot be destroyed by the animal wearing it, or by its companions which may well chew at it. And it should be made in such a way that it can be put on or taken off the animal as quickly as possible. A suggested design which meets these requirements is shown in Figure 1.

The collar is put on when the predator has been immobilized; the methods of immobilizing it are described in section 6.

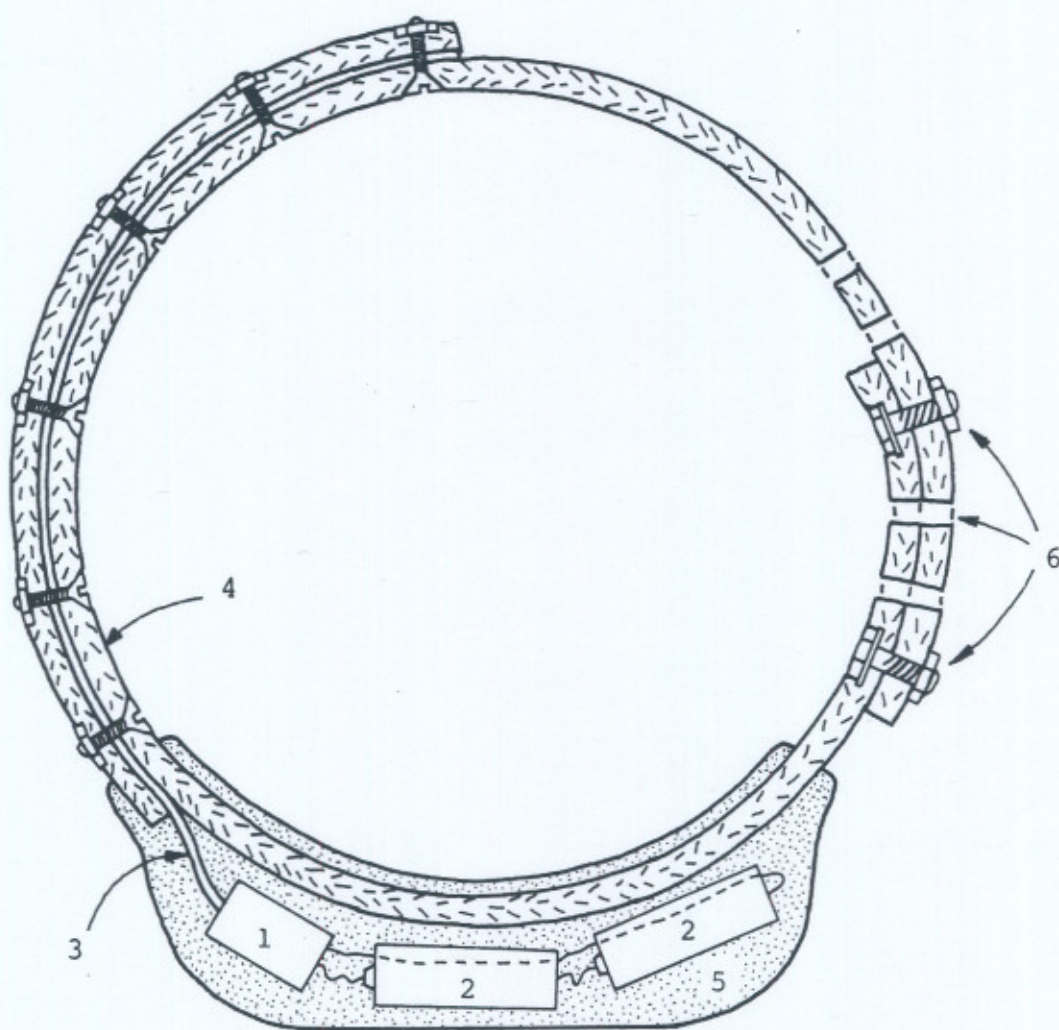
### iii) Tracking methods<sup>1,8,15</sup>

Radio-collared animals can be tracked from the ground or from the air. In general, the greater the height above the ground of both the transmitter and the receiving aerial, the longer will be the range from which the signal can be detected. For average equipment, in fairly flat and open country, a standing predator should be detectable from about 2-3 km away from an observer holding an aerial on a car roof; the range from an aeroplane in flight would be about 5 times as far. The range would increase a great deal if the animal went up a tree, and would decrease if the predator went into a ditch. Larger aerials, or combinations of aerials, can be constructed which will give greater range and directionality, but they then become less portable.

The direction of the signal can be determined, but not its distance. In general, nearby transmitters give louder signals than distant ones, but this is not precise because of obstructions, different heights above the ground, and so on. To find the animal, one can either drive straight towards the signal until one finds it, or drive at an angle to the signal direction for a while, and then obtain a new signal direction; plotting these directions on a map will then give



Fig. 1 Cross section of a radio collar



1. Transmitter
2. Mallory ZM-12 Mercury batteries providing 2.8 volts connected in series
3. Wire aerial bolted to collar, the length of the aerial depending on the frequency of the transmitter
4. Machine belt collar
5. Dental acrylic material surrounding and waterproofing the transmitter and batteries
6. Room for adjustment of the collar diameter, the collar finally being secured with recessed bolts.



the location of the animal. The two different methods are helpful in different circumstances. How often you should obtain a fix or find the animal obviously depends on the questions you are wanting to ask through radio-tracking.

If the radio-collared animals remain within a relatively small area, e.g. only a few kilometres across, then it may be possible to establish permanent tracking stations; these can be large, and constructed on hilltops or high points so as to detect signals from far away. They can be made accurately directional, so that if an animal fitted with a transmitter can be detected from two of these points the direction from each can be determined, and the location of the animal fixed by triangulation.

Receivers are capable of picking up signals from any transmitters in their frequency range. To avoid confusion, a receiver has several different fine frequency channels, and it can be arranged that each transmitter used is on a different one of these channels. But even if they are on exactly the same channel, signals from different transmitters can be distinguished by their "bleep" rate : some make a large number of "bleeps" per minute, and some only a few so one can tell which transmitter one is hearing by how fast it is "bleeping".

It should be stressed that practice makes you improve enormously with time at detecting radio-signals. Partly your ear gets trained to listen for very faint "bleeps", and partly you learn the best high points or times of day for detecting signals. The signal strength varies according to the relative positions and orientations of the transmitting and receiving aerials, so an animal which is moving and therefore changing its position and orientation can generally be detected from further away than a motionless beast. With practice you learn when and where to listen for signals.



## SECTION 6 CAPTURE AND IMMOBILIZATION METHODS

### 6.1 Reasons for capture

There are probably 5 main reasons why you may want to capture or immobilize a wild predator :

- i) To attach a radio-collar to it;
- ii) To mark it individually in some way;
- iii) To take a sample (e.g. of blood, parasites, etc.) from it;
- iv) To treat it for injury or disease;
- v) To transport it to somewhere else.

Before carrying out an immobilization, you should satisfy yourself that it is worth doing. Will the information gained be worth the cost of the operation and the risk to the animal's life which attends every immobilization? Is your treatment or transportation ecologically justifiable?

### 6.2 Methods of capture<sup>1,18</sup>

If an immobilization is justified, you must then select a method of carrying it out. The requirements of any method of immobilization are : that the risk to the life of the animal should be small; that there should be minimal disturbance or injury to the animal; and that the time and cost of the operation should be as small as possible consistent with the above.

There are basically three possible methods of capturing a wild predator : trapping; netting or roping; and darting.

i) Trapping<sup>52</sup> in fixed traps is more suitable for the smaller or more timid species, and at night. Trapping, with baited traps incorporating drop doors, can be a very time-consuming business, and it is also extremely difficult, if not impossible, to capture particular individuals or sexes in this



way. In addition, the animal usually needs to be restrained chemically after capture; if it is to be drugged eventually, it saves time to dart it straight away, if possible. Trapping is thus generally a method to be used when darting is impossible. It has the further disadvantage of causing some disturbance to the animal, and possibly slight injuries. Such problems can be avoided if care is taken.

ii) Netting or roping of a free moving predator is rarely possible or advisable. For the larger predators it is impossible without unacceptable disturbance and injury to the animals and risk to humans. It is suitable, where possible, for young animals which can be captured quickly and easily by netting from a car. With nets, assistance, and tarpaulin, a lion cub up to about 6 months can be captured relatively easily in this way.

iii) Darting<sup>6,17,18,20,49,53,54</sup> provides the best method of capturing predators where practicable. Dart guns at present have reliable ranges only up to about 30 metres, so animals to be darted must be reasonably approachable to start with, and must be approached very carefully so they will allow you within this range. Advantages of this method are : the operation can be done quickly, quietly, and alone; very little disturbance is caused to the animal; you can select and capture the particular animal you want; and there are safe drugs suitable for predators which are reasonably cheap and fairly easily available.

Darting is thus preferable where possible. As already mentioned, it is not likely to be possible with timid animals which will not allow you within range; with small animals where the inaccuracies of dart guns make misses or injury likely; and in the night operations, since a darted animal may run off into the darkness, and you lose sight of it before the drug has taken effect.



### 6.3 Darting methods

i) The methods of approach are important. To get within 30 metres of a predator is often very difficult. A very slow and careful approach is usually likely to be the most successful method. Suggestions are :

- Drive slowly;
- Do not drive straight towards the animal, but at an angle towards it;
- Keep completely silent all the time;
- Stop the car and switch off the engine as soon as the animal shows signs of timidity or of leaving its resting place;
- Wait until it relaxes again before you continue;
- Do not stick the gun barrel out of the window suddenly, and preferably do it when the car is still far away from the predator.

It may take over an hour to get within the necessary 30 metres of the animal. It may often be impossible.

Some species may be approachable enough only at certain situations, for example, at a kill; it may be possible to attract them to a carcass.<sup>49</sup> A successful method with timid hyaenas was to dart them when they were resting in culverts under a road during the day. In some situations it may be necessary and possible to dart the animal from a fast-moving vehicle.

ii) Darting precautions. There are several different types of darting equipment.<sup>20</sup> Suggestions for their use are : Practise repeatedly beforehand with the gun to be used until you can be certain of hitting the animal, with the accuracy required, at different ranges. Practise beforehand with the darts to be used. Use a standard size of dart, always filled full, so as to get a consistent and straight flight. Grease all moving parts of the dart shortly beforehand, and check that they move freely. Check that the needle is a suitable



length (c. 1 cm), that it has a small barb on it, and that its hole is not blocked. Check that the internal charge is from a reliable batch. Smooth the tail, and comb it if of a woolen tuft type, to ensure a straight flight.

iii) Darting. In general, don't fire unless you are sure of hitting the right spot. If you miss, or mishit, it will be extremely difficult to get close to the animal again, for it will have been disturbed by the first attempt.

Aim at a muscle block which is at right angles to the direction of travel of the dart. It must be at right angles for the internal charge to be detonated and to avoid the dart glancing off. Suitable blocks of muscle are the shoulder and the rump. The shoulder is often preferable, for in this area there is usually a slightly bigger target at right angles, and the animal when darted is less able to pull out the dart but wastes time turning in circles trying to reach it.

After firing, keep the animal in view, but do not talk, and do not move except to follow it if it is likely to get out of sight. The animal should only go a short distance and will start attempting to pull out the dart, instead of running away from you. Undisturbed animals go down much more easily.

After the drug has taken effect, any other individuals can be driven away carefully by driving the car straight towards them.

Do not disturb the animal before it is properly immobilized. Test, by poking gently at its rear end, that the predator is properly immobilized before you get out of the car.

iv) Care of the immobilized animal. When it is immobilized, carry or drag it into the shade, or provide shade for it.



Immobilized cats are liable to become overheated. Cover its eyes with a cloth so that it cannot see you.

Do whatever operations are to be done quietly and quickly; the noise of you will tend to stimulate it, and make it struggle and try to get up sooner.

Measure, and if possible weigh<sup>5</sup> the immobilized animal, so as to know exactly what dose rate of drug it received, so that this can be modified in the light of experience.

Get back in the car and drive a little way away when the animal raises its head. It is not dangerous at that stage, but is liable to be badly disturbed by the sight of you nearby.

Watch the animal, from the car at a distance which will not disturb it, until it has recovered. Other predators, as well as buffaloes and elephants, may attack a groggy semi-drugged predator. You should keep it under observation to protect it from these until it can walk and you feel that it is capable of looking after itself.

#### 6.4 Drugs<sup>18</sup>

There are 4 drugs which have proved suitable for darting predators : Succinylcholine, Sernylan, Ketamine, and CI-744. The characteristics, applicability, and dose rates for each are given below.

##### 1) Succinylcholine chloride<sup>17,22,42,52</sup>

This is a drug which blocks the nerve-muscle junctions of the darted animal. The animal is thus fully conscious, but paralysed and incapable of moving.

It is quick acting. The animal is unable to move away after 4-5 minutes, recovering enough to retreat after 15-30 minutes, and being completely normal within an hour.



The drug has the following advantages :

- It is cheap, and easily available;
- It is easily soluble, and dart systems have been devised which inject it as a powder;
- It is quick to immobilize the animal, which also recovers quickly.

It has the following disadvantages :

- It has a narrow safety margin. A slight underdose does not capture the animal but only makes it stumble occasionally, while a slight overdose can kill it. An overdose kills it by paralysing the respiratory muscles as well as the other body muscles; this is not always fatal, because artificial respiration can sometimes be given successfully if breathing stops;
- The animal is conscious throughout the operation and therefore is likely to be more timid later;
- The time of immobilization is not long enough, reliably, for some operations such as fitting collars, etc. to be done, and the obtaining of maximum amounts of information from the animal.

Succinylcholine is useful for animals where only short operations are called for, where the animal need not be fully immobilized, where it does not matter if the animal is more timid later, where it does not matter if the animal fails to go down at all, and where it is not disastrous if the animal dies. For almost all purposes, better drugs are now available.

Approximate dose rates can be given which have been used successfully.

Lion<sup>42</sup> : 67 mg for an average adult female weighing about 125 kg (i.e. about 0.54 mg/kg). 82 mg for an average adult male of about 170 kg weight (i.e. about 0.48 mg/kg).

Hyaenas<sup>22</sup> : 22-24 mg for an adult hyaena (i.e. approximately 0.45 mg/kg).



It would not be advisable to try it on the other species, on which it has not been used.

ii) Sernylan (phencyclidine hydrochloride<sup>6,17,18,34,49</sup>),

This drug acts on the central nervous system. The animal is unconscious and unable to feel anything.

The drug is relatively slow acting. The first effects (unsteadiness, and waving of the head from side to side) are seen after about 5-10 minutes, and it takes about 12-25 minutes before the animal is fully immobilized and unable to raise its head. It then remains immobilized for a long but variable period, usually between 1 and 4 hours, before it can raise its head again. It is usually at least 5 hours after darting before the animal is able to walk, and it is probably not fully normal for about a day.

Sernylan has the following advantages :

- It is cheap and often easily available;
- It has a wide safety range. An overdose does not kill the animal, and a recovering or under-dosed animal can safely be given more to immobilize it again.

It has the following disadvantages :

- It is very slow acting, which wastes much of the worker's time, and means that the animal is vulnerable for a very long period;
- It is liable, by upsetting the animal's temperature control mechanism, to make it overheat in hot climates. This must be guarded against, for it can prove fatal. The immobilized animal should be in the shade, its rectal temperature being measured at intervals. It should be doused with cold water if its temperature goes above 40°C;
- Animals drugged with Sernylan are prone to violent muscular convulsions, the whole animal shaking rigidly. These convulsions are often triggered by stimulation, including overheating. They are generally not harmful, and most animals undergo at least one convulsion while immobilized. Convulsions



are reduced by adding a tranquiliser, Acetyl Promazine, to the initial Sernylan dose.

Sernylan is almost always preferable to succinylcholine except in the few cases already outlined. Its slowness is its main drawback; it has no advantages over either of the next two drugs.

Recommended dose rates are :

Lion<sup>6</sup> : 1.0 mg/kg of Sernylan, with 0.3 mg/kg of Acetyl Promazine up to 40 mg total dose.

Other species<sup>32</sup> : about 1.5 mg/kg of Sernylan, with 0.3 mg/kg of Acetyl Promazine.

### iii) Ketalar (Ketamine)<sup>48,49</sup>

Ketamine, like Sernylan, is centrally acting; the animal is both unconscious and anaesthetized.

The drug is relatively quick acting. The animal is usually immobilized after about 12 minutes, and is able to walk again about 2½ hours later.

Ketamine has the following advantages :

- It is quick acting, thus avoiding wastage of the worker's time, and avoiding risks due to the long-acting effects of Sernylan (such as over-heating);
- It is safe : overdoses are not fatal, and top-up doses can be given as necessary;
- The animal is relaxed, and convulsions are much less likely than with Sernylan.

Its disadvantage is that it is not very soluble, so a rather bulky dose needs to be given. With the larger predators this is a serious problem, as even at maximum concentration not enough drug can be put into a single dart to immobilize a lion.



If obtainable in sufficiently concentrated form, it is preferable to Sernylan in all cases, and almost always to be preferred over succinylcholine.

Recommended dose rates would be :  
Lion<sup>48</sup> : about 12 mg/kg.

For other species, on which it has scarcely been used, one would suggest experimentally starting with a dose rate of about 8 mg/kg, giving more if this proves insufficient.

iv) CI-744 (Parke-Davis)<sup>7,21</sup>

This drug is very similar to ketamine, and again is centrally acting, producing an unconscious and non-feeling animal. It is a mixture of anaesthetic (Tiletamine) and tranquilizer (Zolazepam).

It is a rapidly acting drug. The first signs of drug action are detectable within 2 to 5 minutes, and the animal is unable to raise its head after about 8 to 12 minutes. It remains thus immobilized for 20 to 50 minutes, and is generally just able to walk after about 2 hours more.

The advantages of CI-744 are :

- As with ketamine, it has the advantages of quick action and quick recovery;
- It is safe, with the result that overdoses are not fatal and under-dosed animals can be given more. Animals recovering too early can be immobilized again by a second dose.
- the animal is completely relaxed, and there are no convulsions or heating problems;
- It is extremely potent and soluble, with the result that sufficient drug to immobilize even an adult male lion can be fitted into a 3 ml dart syringe.

Its only disadvantage is that it is not yet freely available. If obtainable, it is preferable to each of the



three alternative drugs already described.

Recommended dose rates<sup>7,21</sup> are :

Lion : male 2.8 mg/kg; female 3.8 mg/kg.

Leopard : male 3.6 mg/kg; female 4.8 mg/kg.

For other species, suitable dose rates are not yet known. One would suggest experimentally starting at a dose rate of about 4 mg/kg.

Animals recovering in the dark are liable to become alarmed and to struggle violently. This can be prevented by giving 0.15 mg/kg of the tranquilizer Azaparone to the immobilized animal when it begins to come round.



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