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Field immobilization of lions using disassociative anaesthetics in combination with sedatives

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Summary

Zoletil (CI-744) proved to be a useful drug combination for lions during 64 immobilizations. The duration of Zoletil immobilizations were dosage dependent, but the onset of immobilization was similar for both low and high dosages. These characteristics were pragmatic in that low dosages of Zoletil were used for the initial dose, which was delivered by dart-syringe. This practice facilitated either a short duration of immobility, or the possibility of adding an additional dose by hand, which prevented the loss of large amounts of Zoletil in the case of a dart failure. Ketamine and xylazine were used on 120 lions at dosages of 7·5 and 3·5 mg kg^{-1}, respectively, and antagonized with 3·9 mg kg^{-1} Tolazoline. Disadvantages of the ketamine/xylazine combination were the inability to use lower dosages for short periods of immobilization and the large volumes required. Midazolam served as a practical drug for the capture of retiring and unapproachable lions, and significantly increased trapping success. Additional notes are presented on the use of Ro 15-3505 as an antagonist for Zoletil immobilization in lions.

Key words: Chemical, immobilization, lion, wildlife management, carnivore

Résumé

Au cours de 64 immobilisations, le Zoletil (CI-744) s'est révélé être une combinaison médicamenteuse très utile pour les lions. La durée de l'immobilisation par le Zoletil dépend du dosage, mais le début de l'immobilisation est aussi rapide, que le dosage soit fort ou faible. Ces caractéristiques sont pratiques en ceci qu'une faible dose est administrée au début au moyen d'une seringue projetée à distance. Ce système permet, soit que l'immobilisation dure peu, soit qu'elle soit prolongée par une dose supplémentaire administrée à la main, ce qui évite la perte de grandes quantités de Zoletil au cas où le tir aurait échoué.

On a employé de la kétamine et de la xylazine sur 120 lions, aux dosages de 7,5 et 3,5 mg/kg respectivement, et l'antidote était la Tolazoline, à raison de 3,9 mg/kg. Les inconvénients de la combinaison kétamine-xylazine étaient qu'on ne peut en

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employer de faibles doses pour de courtes durées d'immobilisation et qu'il en faut de grands volumes. On a employé le Midazolam pour la capture de lions dissimulés et inapprochables, et cela a considérablement augmenté le succès des captures. On présente aussi quelques notes sur l'usage du Ro 15-3505 comme antidote lors de l'immobilisation de lions au Zoletil.

Introduction

The immobilization of large carnivores formed an integral part of extensive studies and management of these species in Etosha National Park, Namibia (Orford, Perrin & Berry, 1988; Stander, 1990; Stander, 1991). Lions (*Panthera leo*, Linnaeus) in particular were immobilized for permanent marking by means of a hot brand (Orford *et al.*, 1988), and for the attachment of collars equipped with radio transmitters.

The aim of this paper is to present data and comment on the results of the chemical immobilization of lions under the southern African field conditions of Etosha National Park. The endeavour of our experiments in the application of chemical drugs was to accomplish the following goals: (a) the safe immobilization of a large number of lions, with rapid induction and quick recovery; (b) the use of drugs that are stable under semi-arid field conditions; (c) the means to capture lions that were retiring and notoriously unapproachable, hereafter referred to as 'wild'. These 'wild' lions, often those responsible for the raiding of domestic livestock along the boundaries of Etosha National Park, provided a particular management problem. The need to immobilize them was often crucial to alleviate the problem of stock-raiding (Stander, 1990).

Initially a ketamine hydrochloride (Ketalar, Park-Davis) and xylazine hydrochloride (Rompun, Bayer) combination (Van Wyk & Berry, 1986) was used for all immobilizations. Ketamine, a cyclohexylamine with dissociative anaesthetic properties (Glen, 1973; Pryor & Bush, 1973; Kraynack *et al.*, 1980) has been widely used in combination with xylazine on carnivores (Herbst, Packer & Seal, 1985; Logan *et al.*, 1986; Kreeger & Seal, 1986). Xylazine is an $alpha_2$ adrenergic agonist and has good muscle relaxant sedative and analgesic properties (Hsu, 1981; Renecker & Olsen, 1985). Tolazoline hydrochloride (Priscoline, Weimer Pharmaceuticals, Rastat), an $alpha_2$ adrenergic antagonist (Martindale, 1982) known to reverse the effects of xylazine (Hartsfield, Thurmon & Benson, 1986) was used, and significantly reduced the time to mobility (Van Wyk & Berry, 1986).

When Zoletil (CI-744: Virbac) became available we used it in place of the ketamine/xylazine combination for reasons discussed below. CI-744 has proved useful in the immobilization of various carnivores (Bertram & King, 1976; Boever, Holden & Kane, 1977; King, Bertram & Hamilton, 1977; Bush *et al.* 1978; Van Jaarsveld, 1988). It consists of a 1:1 combination (by weight) of the dissociative anaesthetic tiletamine hydrochloride and the sedative zolazepam hydrochloride. Tiletamine (CI-634) is a cyclohexylamine related to ketamine and phencyclidine. It has been used on some members of the Felidea (Bennet, Zydeck & Wilson, 1971; Calderwood *et al.*, 1971), in which convulsive seizures and clonic or tonic muscular reactions were recorded (Calderwood *et al.*, 1971). Zolazepam (CI-716) a pyrozolodiazepinone reacting with the benzodiazepine reactors has

anticonvulsant properties and therefore when combined with tiletamine, eliminates the side effects (Boever *et al.*, 1977). Laboratory tests (Anon, Undated) show that in the domestic cat (*Felis catus*, Linnaeus) the elimination half-life of tiletamine is shorter than that of zolazepam.

Materials and methods

Darting and field techniques

Drug mixtures were delivered using Fauncap 1 and 3 cc (Fauncap (Pty.) Ltd., Box 70, Klaserie, 1381, R.S.A) and Cap-Chur 1–4 cc dart-syringes propelled by a 32-gauge rifle fitted with a .22 adaptor (Extra Long Range Projector; Palmer Chemicals and Equipment Co., Georgia, USA). Cap-Chur darts were occasionally used with a plastic tail flight modification (Simmons equipment, Nebraska, USA). Reflective fabrics were attached to all darts with tail flights (McKenzie, 1989) to increase recovery rates at night. Darts were fired from varying distances between about 10 and 60 metres. The use of a fresh and partly skinned carcase of either gemsbok (*Oryx gazella*, Linnaeus) or springbok (*Antidorcas marsupialis*, Zimmerman) dragged behind a vehicle or tied to a tree was essential to attract most lions. When dealing with 'wild' lion prides, tape recordings of lion vocalizations were played back via an amplifier to attract them to the carcase, which is a procedure similar to that described by Smuts, Whyte & Dearlove (1977). The efficiency of capturing lions is measured by dividing the number of days or nights that lions were darted by the number of days or nights that attempts were made to dart them, and presented as the percentage 'trapping success'.

During all immobilizations excess disturbance to lions was avoided before and especially after a dart was fired. In the case of 'wild' lions, where 95% of dartings were performed at night, as lions were more approachable when feeding in the dark, all lights were switched off and total silence was maintained for 15 minutes after a dart was fired successfully. Thereafter the immobilized lion could be attended or further dartings resumed. Most immobilized animals were weighed. When weighing was not possible the animal's mass was estimated from body measurements. These estimates proved to be accurate within 10 kg. Care was taken to protect immobilized animals against exposure (i.e. heat, cold, and dust or sand in unprotected eyes). When immobilized lions revived too soon, consecutive doses, of the same drug combination initially used, were applied. During translocations, individuals were transported in the back of a pick-up truck and the animals covered and padded with protective materials. These translocations required prolonged immobilization which was maintained by adding small doses of the drug used when the animals showed signs of recovery. Most lions were observed until fully recovered and sometimes for several days following the immobilization.

Statistical computations of the interdependent variables, dosage and induction or duration thereof, were carried out with the product-moment correlation coefficient (Sokal & Rolhf, 1969). Data that were not normal were analysed with non-parametric statistics (Siegel, 1956).

Ketamine and xylazine

Ketamine powder was mixed with isotonic saline and made up to a standard concentration of 210 mg ml^{-1}. Xylazine was obtained in a lyophilized powder form. Five ml of ketamine was added to a 500 mg vial of xylazine to give a concentration of 210 mg ketamine and 100 mg xylazine per ml. Based on estimated body mass before darting, lions received 5 ml of the concentration for adult males, 4 ml for adult females and subadult males, 3 ml for sub-adult females and 2 ml for smaller lions, as the initial dose (Van Wyk & Berry, 1986).

Zoletil

Zoletil was found to be highly soluble. As a result, small darts (1 and 2 ml) could be used, so increasing darting range and accuracy. Solution strengths varied from 50 mg ml^{-1} to 500 mg ml^{-1} depending on the desired requirement. The dosage strength also varied with the desired effect, and ranged from 0·6 to 8·3 mg kg^{-1}. When needed, fairly low dosages of Zoletil were fired by dart-syringes. These were intended to render the animal sufficiently immobile so that an additional dose of Zoletil for a deeper immobilization could be administered by hand. The advantage of this practice is discussed below.

Oral sedatives

Many lions in the remote parts of Etosha National Park and those responsible for stock raiding, were extremely 'wild'. This created a particular problem as it was difficult or nearly impossible to approach them closely enough to fire a dart-syringe; hence, drugs were administered in a bait. Two benzodiazepines, midazolam (Dormicum, Roche) an effective anticonvulsant, amnesic and anxiolytic agonist (Reves *et al.*, 1985) and triazolam (Halcion, Upjohn), were used as oral premedications. This served as an attempt to partly sedate individuals, which allowed a closer approach and the successful firing of a dart-syringe. A large carcase was tied to a tree to which the lions were attracted. Between 10 and 30 midazolam (15 mg per tablet) or triazolam (0·5 mg per tablet) tablets were placed inside the carcase. To improve the changes of one lion consuming the entire dose, all the tablets were inserted in a kidney or heart through a small slit.

Antagonists

First signs of recovery after immobilization with ketamine/xylazine were characterized by ear flicking, licking, and eye reflexes for lions. Pain perception was noticeable during this period. The assumption was then made that most of the ketamine had been metabolized (Van Wyk & Berry, 1986) and 4 mg kg^{-1} of Tolazoline was administered intramuscularly to antagonize the remaining xylazine effect.

Ro 15-3505 (Roche, Switzerland), a specific benzodiazepine antagonist developed for use in animals and applied in horses (Rehm & Schatzmann, 1984), was tested on 7 lions immobilized with Zoletil in an attempt to shorten the down time. Zoletil-immobilized lions showed the first signs of recovery with head movements, licking and reaction to noise and pain stimuli. Ro 15-3505 was then administered intravenously at dosages ranging from 0·04 to 0·1 of the total zolazepam /midazolam dose.

Table 1. Dosages, immobilization and recovery times for lions injected with a solution of 210 mg ketamine and 100 mg xylazine per ml, antagonized with Tolazoline

	Ketamine dosage (mg kg^{-1})	Xylazine dosage (mg kg^{-1})	Tractable (min)	Tolazoline dosage (mg kg^{-1})	Recovery (min)
n	120	120	48	119	73
Mean	7·6	3·5	10·1	3·9	154
SD	2·1	1·0	3·1	0·7	31
Range	4·2–15·8	2–7·5	6–20	2–5·8	120–235

Results

Ketamine and xylazine

A total of 120 lions were immobilized with a combination of 210 mg ml^{-1} ketamine and 100 mg ml^{-1} xylazine, and antagonized with Tolazoline (Table 1). The majority of lions received consecutive doses and the results were combined with the few that received single doses. Average dosages of 7·6 mg kg^{-1} ketamine and 3·5 mg kg^{-1} xylazine were used. Lions were, on average, tractable within 10 min (range 6–20 min) after darting and showed first signs of recovery at an average time of 102 minutes ($n = 102$; SD = 6·8 min; range 75–175 minutes). At this point the antagonist, Tolazoline, was administered intramuscularly at an average dosage of 3·9 mg kg^{-1}. Low dosages (<4·2 mg kg^{-1} ketamine and 2 mg kg^{-1} xylazine) were generally insufficient to immobilize lions for shorter periods and the animal had to be re-darted or consecutive doses added. On average lions had recovered and were walking normally in 154 ± 31 minutes after darting. One lion died during a ketamine/xylazine immobilization. This lion was severely stressed during stock raiding activities on farmland outside of Etosha National Park prior to immobilization and the stress precipitated fatal capture myopathy (Joubert & Stander, 1990).

Zoletil

Zoletil was used on 64 lions with no mortalities. Total dosages varied from 0·6 to 15 mg kg^{-1} with the mode at 2·13 mg kg^{-1}. There was a positive linear relationship between dosage (mg kg^{-1}) and the total immobilization time (Fig. 1). This was the case for both lions that received single doses ($r = 0·605$, $P < 0·05$), and those who received two or more doses ($r = 0·702$, $P < 0·001$). Following a single dose, lions appeared to experience good muscle relaxation and a smooth immobilization. Single doses also had a longer anaesthetic effect than consecutive doses (Fig. 1). Lions that received consecutive doses responded sooner to pain stimuli than individuals that received a single dose. Although recovery after two or more doses was extended, it was probably due to the difference in the rates of metabolism of the two components, tiletamine and zolazepam. Tiletamine appears to have a shorter elimination half-life than zolazepam in lions, as is true with domestic cats (Anon., n.d.).

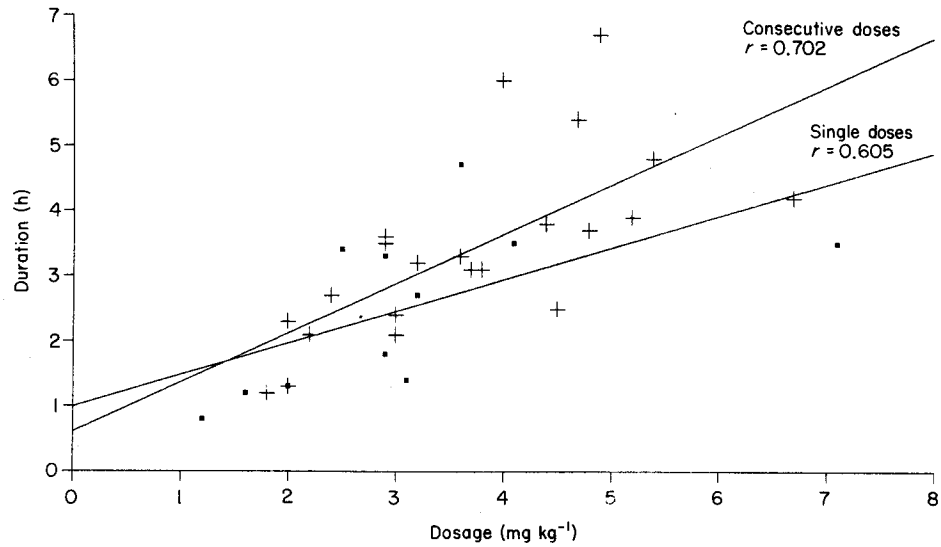

Fig. 1. The immobilization periods resulting from different Zoletil dosages administered to lions. Consecutive dosages are indicated by + and single dosages by ■.

Table 2. The response of lions to Zoletil immobilization

	Ataxia (min)	Recumbent (min)	Tractable (min)	Respiration rate/min*	Heart rate/min*
n	48	40	49	14	11
Mean	2·8	6·6	11·4	17	103
SD	1·1	3·3	4·9	6·9	15·8
Range	1–5	2–20	5–27	12–39	72–126
r	−0·22	−0·29	−0·12		
P<	0·20	0·10	0·20		

* Respiration and heart rate measured approximately 30 minutes after animals became tractable.

There was no correlation between dosage (mg kg^{-1}) and the onset of immobilization (Table 2). After the initial drug dose was administered via dart-syringe, ataxia, on average, was evident at 2·8 minutes, recumbency after 6·6 minutes and the lions were tractable after a mean of 11·4 minutes. This appeared irrespective of the initial dosage. Respiration and heart rate were measured at approximately 30 minutes after the animals became tractable and, although variable, were satisfactory at a mean of seventeen breaths per minute and a heart rate of 103 per minute (Table 2).

Zoletil immobilization was characterized by lions lying on their sides with open eyes and pupils dilated. The palpebral and pinnal reflexes were strong. Occasionally salivation and urination occurred and once defaecation, none of which was

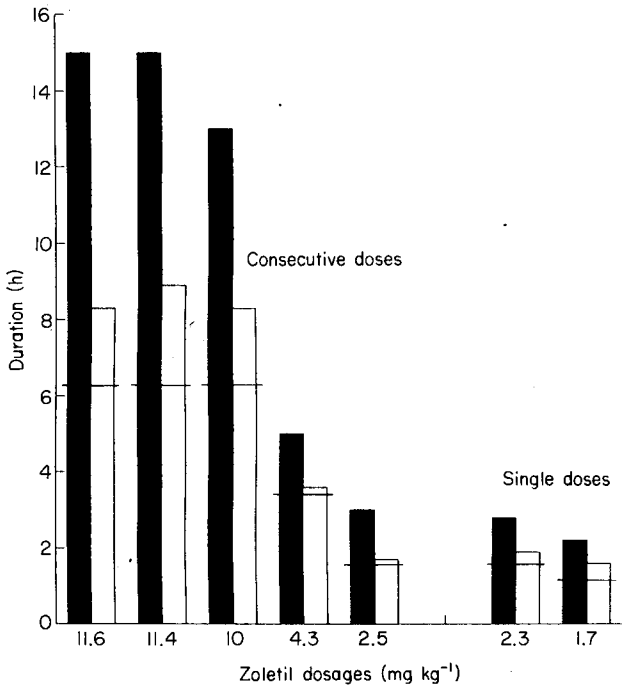

Fig. 2. The duration of immobilization of seven lions treated with the benzodiazepine antagonist, Ro 15-3505 (open bar) compared to the projected time of immobilization (solid bar) derived from 57 lions previously immobilized with Zoletil, but not treated with an antagonist. Ro 15-3505 was administered at the first signs of recovery, indicated by the horizontal lines across both bars.

excessive. During emergence from immobilization, jaw movements and licking were the first signs, growling and whirling of the tail occurred in disturbed animals. During attempts to rise, head movements and extension of the neck were noticeable and the front quarters regaining coordination first.

The benzodiazepine antagonist, Ro 15-3505 was administered after the first signs of recovery in seven lions immobilized with Zoletil (Fig. 2). The projected immobilization time was extrapolated from the 57 lions previously immobilized with Zoletil, based on the total dosage. During the seven cases, Ro 15-3505 had a mean reduction value of 0·38 per hour of immobilization time (SD = 0·052).

Translocations

To relieve stock raiding problems on border farms, six lions were translocated using Zoletil (Table 3). The first individual (an adult lioness weighing 130 kg) received 1940 mg Zoletil over a period of 9·5 hours in 14 consecutive doses ($\bar{x}$ = 126·2 mg) at approximately one half hour intervals. Although the lioness had recovered to the point of feeding and walking after 24 hours, she showed signs of slight tranquillization which only disappeared after 33 hours. The following two lions also received consecutive doses at 30 minute intervals and showed slight sedative effects after recovery. The last three lions (Table 4) received high initial doses and fewer additional doses. This proved advantageous as the lions were clearly under a deeper level of anaesthesia during transportation. Their time to mobility was quick and smooth. They then received a benzodiazepine antagonist which further reduced the recovery time.

Table 3. The translocation of six lions under prolonged immobilization with Zoletil

Mass (kg)	Darting dose (mg)	Additional doses (mg)		Total dose (mg)	Mobility (h)	Recovery (h)
		n	mean			
130	300	13	126	14·9	17·8	24
160	500	4	163	7·2	9·5	12·5
110	300	3	100	5·5	5·0	7·6
60	500	1	200	11·7	6·3	8·3*
80	500	2	150	10·0	6·3	8·3*
60	500	1	300	13·3	6·3	8·9*

* Antagonist Ro 15-3505 administered.

Table 4. The use of midazolam to orally sedate 'wild' (retiring and unapproachable) lions

Age	Sex	Number of tablets	Dosage (mg kg^{-1})	Effect at one hour after oral intake
Adult	♂	10	0·8	Drowsy
Adult	♀	40	3·3	Recumbent
Adult	♀	20	2·5	Drowsy
Adult	♀	20	2·2	Recumbent
Sub-adult	♂	7	1·3	Drowsy
Sub-adult	♂	15	2·8	Drowsy
Sub-adult	♂	15	2·8	Drowsy
Sub-adult	♀	10	1·9	Drowsy
Sub-adult	♀	9	2·3	Drowsy
Sub-adult	♀	8	2·0	Drowsy

Oral sedatives

Midazolam was used on ten lions with dosage strengths ranging from 0·8 to 3·3 mg kg^{-1} (Table 4). The effect of midazolam administered orally was rapid. Within one hour after intake, all lions were affected. Induction was smooth and the effect was characterized by recumbence with the two larger doses, and by drowsiness, stumbling, and a lack of fear and wariness with the rest. All these lions were then immobilized with normal dosages of Zoletil. One adult lioness was orally treated with triazolam (25 tables, dosage = 0·1 mg kg^{-1}) and induction appeared relatively long as the lioness showed no effect at one hour after intake, but was recumbent after five hours.

Zoletil immobilization of midazolam-treated lions appeared similar to untreated lions in most respects, except respiration. Thirty minutes after Zoletil immobilization, midazolam-treated lions had a significantly higher respiration rate per minute (Mann-Whitney *U*-test, $P < 0{\cdot}01$) than untreated lions. Their respiration rate per minute ranged from 14 to 77 ($n = 10$; $\bar{x} = 38$; SD = 21·2).

Lions that were classed under the behavioural category 'wild' were notoriously difficult to capture, as revealed by the reduced trapping success; 39% ($n=147$), as opposed to 98% ($n=59$) for non-'wild' lions. Midazolam proved a useful drug in the immobilization of 'wild' lions, and significantly increased the trapping success from 35% ($n=137$; without midazolam) to 90% ($n=10$; $\chi^2=3{\cdot}93$; $P<0{\cdot}05$). The significance of midazolam is illustrated in an example where attempts to capture some members of a particular 'wild' pride, prior to the use of midazolam, were fruitless after 34 trapping nights, despite a great urgency to replace a decaying radio-collar and to resolve stock-raiding problems. Midazolam was then introduced and a total of four lions in this pride were immobilized during only three trapping nights.

General

On 115 of 206 trapping days or nights (56% trapping success) a total number of 184 lions were immobilized. On the 57 successful trapping nights of 'wild' lions, an average of 1·9 lions was immobilized ($n=95$; SD = 1·58; range 1–8). In contrast, lions that were not 'wild' could be captured during the day. On 58 successful trapping days 89 lions were immobilized ($\bar{x}=1{\cdot}6$, SD = 0·9; range 1–5). During all immobilizations, excess disturbance to lions was a crucial factor and was minimized before and after firing a successful dart. Under these conditions lions (including the darted individual) never ran further than 20 metres after a dart has been fired. When lions were disturbed during the darting activities, induction was prolonged, they appeared to hallucinate and in the case of low dosages, would not become tractable.

Although the ketamine/xylazine combination and Tolazoline were light-sensitive, both they, Zoletil and Ro 15-3505 appeared reasonably stable at high ambient temperatures and were kept in a vehicle for up to three months at temperatures ranging from 0 to 45°C. Dissolved solutions of Zoletil were kept in similar conditions for up to one month without apparent loss of potency, although the manufacturer recommends that once dissolved, Zoletil should be kept at 4°C and used within 24 hours.

Discussion

Ketamine and xylazine

Ketamine/xylazine antagonized with Tolazoline proved a useful drug combination for lions. Our immobilizations were based on the methods described by Van Wyk & Berry (1986), but differ by a slightly lower average ketamine dosage (7·6 mg kg^{-1} as opposed to 8·5 mg kg^{-1}) although the xylazine dosage was similar. This difference was the result of a lower strength ketamine mixture of 210 mg ml^{-1} which solved the problem of crystallization that occurred with the 250 mg ml^{-1} concentration (Van Wyk & Berry, 1986). In all other regards our results supported data presented by Van Wyk & Berry (1986).

The only disadvantages with the ketamine/xylazine mixture were (a) the large volumes required (e.g. the average total dose for an adult male of 200 kg is 1520 mg kg^{-1} ketamine and 700 mg kg^{-1} xylazine: at the present solution strength, this dose would amount to a volume of 7 ml and (b) the inability to apply lower dosages for shorter immobilizations.

Zoletil

Zoletil dosage rates for lions were suggested by Bush *et al.* (1978) as 3·76 mg kg^{-1}, and 5·0 mg kg^{-1} (Boever *et al.*, 1977). King *et al.* (1977) and Bertram & King (1976) found that 'the anaesthetic period for each category was markedly dose dependent'. Both studies also found a sex difference in response to dosage strength (males were immobile longer than females). We found no sex difference but emphasize the strong correlation between dosage and total time of immobilization.

As there is no correlation between dosage strength and the induction thereof, Zoletil dosages as low as 0·6 mg kg^{-1} were adequate to render a lion sufficiently immobile to add an additional dose by hand. This was extremely useful financially, in situations where dart failure was a risk. These situations occurred frequently, especially when dealing with members of 'wild' prides at night. However, despite the financial advantage in using low initial dosages, a single dose is preferred when possible. In this situation the quality of immobilization will be improved and will have a slightly longer anaesthetic effect, as well as being more predictable. The prolonged recovery of lions after consecutive doses of Zoletil can be attributed to the sedative effect of zolazepam. The discrepancy between tiletamine and the sedative effect of zolazepam towards the end of immobilization is exacerbated if consecutive doses of Zoletil have been administered. This phenomenon was also described for the domestic cat (Anon., 1987).

Zoletil was the preferred combination over ketamine/xylazine. The high solubility of Zoletil resulted in the use of small darts, for example a large adult male lion of 250 kg could be immobilized using 750 mg of Zoletil in a 1·5 ml dart. If preferred, a low initial dosage of 150–200 mg Zoletil for the same lion would immobilize it sufficiently for the application of a second dose, an attractive alternative when risking the loss of 750 mg Zoletil due to a dart failure.

We feel that Ro 15-3505 was a successful antagonist for lions immobilized with Zoletil. Although the sample size is small and complete reversal of Zoletil was not always achieved, Ro 15-3505 markedly reduced the time from first signs of recovery to full coordination.

Oral sedatives

Midazolam, known to cause a state of deep hypnosis in many animals (Klein & Klide, 1989), proved greatly advantageous when dealing with 'wild' lions and significantly increased capture efficiency. Oral absorption of the drug was rapid and the effect astonishing, even the most unapproachable lion allowed a close approach and a good opportunity to deliver a Zoletil filled dart-syringe.

Conclusions

Both ketamine/xylazine and Zoletil resulted in the reliable immobilization of lions. Only one death occurred during 120 ketamine/xylazine (0·8%), and none during 64 Zoletil immobilizations. The induction of both drug combinations was similar and lions were tractable in approximately 10 minutes. Recovery after a ketamine/xylazine immobilization antagonized with Tolazoline, followed after an average time of 2 hours and 34 minutes. Small dosages of ketamine/xylazine did not result in a reduced immobilization time and were mostly not sufficient to immobilize a lion. In contrast, the durations of Zoletil immobilizations were markedly dose-

dependent. Low dosages of Zoletil resulted in shorter immobilizations. Zoletil was the preferred drug combination and had the following advantages over ketamine/xylazine; (a) high solubility which allowed the use of smaller darts, thus increased darting accuracy and range, (b) the ability to use low dosages for shorter immobilizations and (c) the ability to add a second dose by hand to prevent losing a large dose due to dart failure when a long period of immobilization was required.

All drugs were stable for several months under semi-arid field conditions. In contrast to manufacturer's recommendations, dissolved Zoletil remained effective for periods of up to one month stored in a vehicle with ambient temperatures ranging from 0 to 45°C.

The use of midazolam significantly increased the trapping success of 'wild' (retiring and unapproachable) lions. Although the sample size is small ($n = 10$), the results were nonetheless effective.

The antagonist, Ro 15-3505, showed powerful abilities to reduce the down time in seven lions immobilized with Zoletil. The more extensive use and evaluation of Ro 15-3505 may lead to the description of a valuable counterpart to Zoletil which may further its usefulness.

Zoletil additionally proved a functional drug for the prolonged immobilization of lions required during translocations.

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