Chemical immobilization, physical restraint and stomach lavaging of fur seals at Marion Island

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The Antarctic and Sub-Antarctic fur seals co-exist at Marion Island. We investigated the suitability of stomach lavaging as a method to determine the diet of these two species. Intramuscular injections of ketamine hydrochloride and xylazine hydrochloride through an unbarbed Telinject-dart resulted in variable degrees of immobilization. Stomach lavaging following immobilization and physical restraint produced low retrieval of stomach contents (7 out of 29 seals). We conclude that the use of these methods to determine otariid diets is limited.

Keywords: *Arctocephalus*, food, field-technique

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Introduction

Knowledge of the diet of pinnipeds has been based principally on stomach contents of culled specimens (Fiscus & Baines 1966; Fitch & Brownell 1968; Hall 1977; Bester & Laycock 1985), the collection of identifiable remains of prey species through the analyses of scats and spewings (Brown & Mate 1983; North, Croxall & Doidge 1983; Green, Williams & Burton 1991), the use of emetics (Gales & Burton 1988) and a relatively limited amount of stomach lavaging (Hall 1977; Antonelis, Lowry, DeMaster & Fiscus 1987; Green & Burton 1993; Slip 1995).

Present day environmental awareness, as well as the increasingly ethical approach of researchers, advocate against the culling of individuals for investigations into their diet. Furthermore, non-lethal methods have become the most appropriate alternative method and result in a limited amount of disturbance to individuals and populations (Gales & Burton 1988). The analyses of scats and spewings, the use of emetics and stomach lavaging, therefore, remain as the most acceptable methods in dietary studies of pinnipeds.

A variety of pinnipeds lend themselves to restraint without chemical assistance, but very often an entirely inert animal is required. Chemical immobilization followed by stomach lavaging (Antonelis *et al.* 1987; Rodhouse, Arnbom, Fedak, Yeatman & Murray 1992; Slip 1995) or the use of emetics (Gales & Burton 1988) have been reported for a number of seals. In this paper we investigate the chemical immobilization, physical restraint and stomach lavaging of two co-occurring fur seals (*Arctocephalus tropicalis* and *A. gazella*) at Marion Island. We discuss the ethical use of this method and problems associated with fur seal immobilization and stomach lavaging.

Materials and Methods

Fieldwork took place during April 1990, and February and April 1991 at Marion Island (46°53'S and 37°52'E). Of the two fur seal species which breed on the island, *A. tropicalis* was more abundant (Wilkinson & Bester 1990). At the time of the study, Rook's Bay on the south-western coast was the only beach utilized by both *A. tropicalis* and *A. gazella* and was consequently chosen as the study site.

Seals were given intramuscular injections of ketamine hydrochloride (Ketalar, Parke Davis Laboratories (Pty) Ltd, Isando) and xylazine hydrochloride (Rompun, Bayer Pharmaceuticals (SA) (Pty) Ltd, Johannesburg) at an approximate ratio of 3 units ketamine: 1 unit xylazine during April 1990 and 4 units ketamine: 3 units xylazine during February and April 1991 (ketamine: 100 $mg.ml^{-1}$ solution and xylazine: 20 $mg.ml^{-1}$ solution). The desired dosage was 5 mg ketamine.kg^{-1} body mass and 1 mg xylazine.kg^{-1} body mass, which was considered appropriate to induce immobilization to a level (level 2 & 3; see below) at which physical restraint and intubation of the animals could be done (see Bester 1988).

The identified individual, which was usually resting, was approached from downwind with as little disturbance as possible to other seals. An unbarbed Telinject-dart containing the drug dose based on an estimate of the individual's weight, was fired from approximately 5-10 metres range using a CO_2 -pressurized Telinject dart gun. The dart was aimed to enter the lumbar muscles, but following some trials the majority of seals were darted in the lower neck and shoulders using 18 gauge, 38mm needles. Seals were weighed using a 50kg Salter spring balance following successful immobilization, and the actual dosage was calculated.

After successful administration of the drug, seals were prevented from entering the water using a wooden choker pole (Gentry & Holt 1982). Usually the positioning of an observer between the seal and the water was sufficient to stop movement. The choker pole was used to further restrain the seal once induction had been achieved, and to transfer the animal to the restraining board. The restraining board was employed

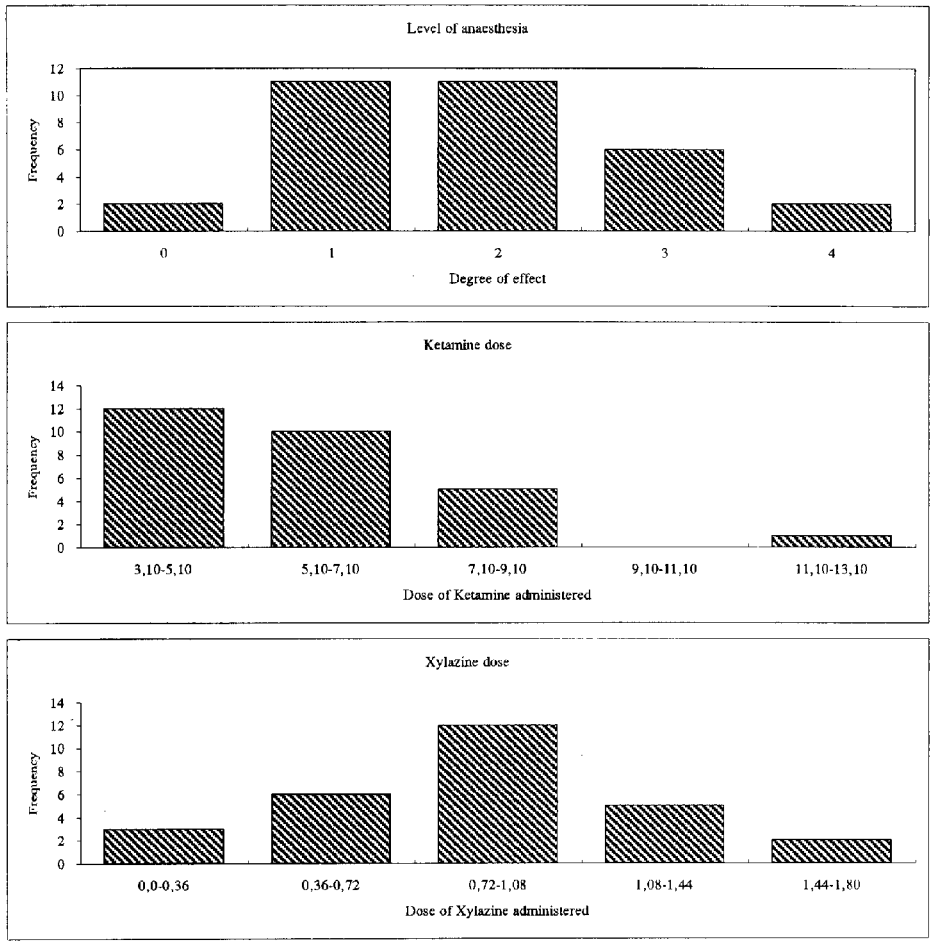

Figure 1 The level of anaesthesia recorded (levels 0-4) during ketamine and xylazine injection, and the frequency distribution of recalculated ketamine and xylazine dose rates ($mg.kg^{-1}$) applied to *Arctocephalus* spp. at Marion Island.

in view of the unpredictable response to chemical immobilization reported for fur seals (see Erickson & Bester 1993). The plane of anaesthesia was recorded on an arbitrary scale from 0 (low) to 4 (high) (Briggs, Hendrickson & Le Boeuf 1975; Trillmich 1983; Bester 1988). Induction time was measured from the time of injection to the first observable signs of immobility or inability to resist handling (Geraci 1973; Bester 1988). Duration of immobilization was taken to be the time from induction until the seals were capable of coordinated locomotion.

The 1.67x0.58m restraining board was fitted with four handles to facilitate using it as a stretcher. The seal's neck was clamped in a restrainer, described in Gentry & Holt (1982), which was fitted to the one end of the restraining board. Restraint on the seal's head could be controlled through five settings of the neck clamp. Two motor vehicle seat belts were fitted through slots in the board, which restrained the seal's body when fastened, and facilitated easy release when required. Rectal temperatures of some of the seals were monitored using a KM2002 digital thermometer (Kane-May Instrumentation) connected to a thermocouple (Bester 1988), but was discontinued after initial results illustrated no substantial variation.

Following immobilization and restraint, seals were stomach lavaged. A Grey's stainless steel gag was placed in the seal's mouth to keep the jaws apart, and a transparent, flexible PVC tube (18 mm outside diameter, 2 mm wall thickness) with a rectangular suction port (45 mm x 10 mm) cut 20 mm from the tip, was guided down the oesophagus until the tube reached the stomach. A coat of surgical lubricant facilitated passage of the tube. Fresh water (1-2 *l*) was pumped into the seal's stomach using a manually operated suction pump to generate a slurry (Hall 1977; Antonelis *et al.* 1987). Negative pressure was created in the aluminium collection container

Table 1 Summary of data collected for two *Arctocephalus* spp. at Marion Island during April 1990, February and April 1991

Sample	Date	Species	Sex	Age	Mass	Ket	Xyl	DKet	DXyl	Ind	Imm	MEF	Temp	Con	Remarks
MFS1	900413	*A. tropicalis*	M	SA	24.0	1.5	1.0	6.25	0.83	6	-	4	35.5	N	Xylazine dose: 0.6ml initially followed by 0.4ml 10 minutes later. Died possibly due to manhandling. Following dissection found 1 stone and 2 squid beaks in stomach, 2 squid beaks in small intestine and caecum and otoliths.
MFS2	900413	*A. tropicalis*	U	SA	-	-	-	-	-	-	-	-	-	-	Dosage not delivered following correct darting.
MFS3	900413	*A. tropicalis*	M	SA	25.0	1.0	0.5	4.00	0.40	-	50	3	-	N	
MFS4	900413	*A. tropicalis*	M	SA	21.0	1.0	0.5	4.76	0.48	7	51	4	36.0	Y	
MFS5	900413	*A. tropicalis*	F	A	30.0	1.5	0.5	5.00	0.33	13	55	2	36.0	N	
MFS6	900413	*A. tropicalis*	F	A	-	1.0	0.5	-	-	-	-	0	-	-	Could not restrain and do stomach lavaging.
MFS7	900413	*A. tropicalis*	F	A	-	1.5	0.8	-	-	-	-	1	-	-	Ketamine dose: 1.0ml initially followed by 0.5ml 22 minutes later. Xylazine dose: 0.5ml initially followed by 0.25ml 22 minutes later. Abandoned 21 minutes after second dose.
MFS8	900413	*A. tropicalis*	F	A	-	1.5	0.5	-	-	-	-	0	-	-	Abandoned after 30 minutes.
MFS9	900415	*A. tropicalis*	F	A	-	1.5	0.5	-	-	6	32	1	37.0	Y	
MFS10	900417	*A. tropicalis*	M	SA	-	-	-	-	-	-	-	-	-	-	Dosage not delivered. At impact needle base and syringe tip bent leading to leakage onto fur.
MFS11	900417	*A. tropicalis*	M	SA	-	-	-	-	-	-	-	-	-	-	Dart at angle into lower chest, anterior of flipper insertion. Syringe snapped in half. Abandoned after 30 minutes.
MFS12	900417	*A. tropicalis*	M	SA	30.0	1.5	1.0	5.00	0.67	5	55	3	36.0	Y	Ketamine dose: 1.0ml initially followed by 0.5ml 25 minutes later, Xylazine dose: 0.5ml initially followed by 0.5ml 25 minutes later.
MFS13	900417	*A. tropicalis*	U	SA	-	-	-	-	-	-	-	-	-	-	Dosage not delivered following dart touching ground before entering, separating needle from syringe.
MFS14	900417	*A. tropicalis*	M	SA	32.0	1.0	0.5	3.13	0.31	10	64	2	37.0	N	
MFS15	900425	*A. tropicalis*	M	SA	23.0	1.5	0.5	6.52	0.43	6	36	2	35.5	Y	
MFS16	900425	*A. tropicalis*	M	SA	30.0	1.5	0.5	5.00	0.33	6	36	2	36.5	N	
MFS18	900426	*A. tropicalis*	F	A	-	1.5	1.0	-	-	15	33	1	-	-	Was very active involving lot of chasing by observers. Abandoned after 33 minutes.
MFS19	900426	*A. tropicalis*	M	SA	21.0	1.5	1.0	7.14	0.95	7	44	1	-	Y	
MFS20	900426	*A. tropicalis*	M	SA	22.5	1.5	1.0	6.67	0.89	8	75	3	-	-	Not stomach lavaged.

Table 1 (Continued)

Sample	Date	Species	Sex	Age	Mass	Ket	Xyl	DKet	DXyl	Ind	Imm	MEF	Temp	Con	Remarks
MFS21	900426	*A. tropicalis*	M	SA	21.0	1.5	1.0	7.14	0.95	7	28	1	-	Y	
MFS22	910219	*A. tropicalis*	M	SA	25.0	1.5	1.0	6.00	0.80	4	60	3	-	N	
MFS23	910219	*A. tropicalis*	M	SA	24.0	1.5	1.0	6.25	0.83	6	60	3	-	N	
MFS24	910219	*A. tropicalis*	F	A	29.0	1.5	1.0	5.17	0.69	6	-	4	-	Y	Died two hours after injection.
MFS25	910220	*A. tropicalis*	M	SA	23.0	1.5	1.0	6.52	0.87	7	-	4	-	N	Died two hours after injection.
MFS26	910220	*A. tropicalis*	F	A	22.0	1.5	1.0	6.82	0.91	3	40	2	-	N	
MFS28	910221	*A. tropicalis*	F	A	40.0	1.5	1.5	3.75	0.75	7	60	2	-	N	
MFS29	910221	*A. tropicalis*	M	SA	27.0	1.0	1.5	3.70	1.11	10	30	2	-	N	
MFS30	910221	*A. tropicalis*	M	SA	22.0	1.0	1.5	4.55	1.36	10	60	2	-	N	
MFS31	910222	*A. tropicalis*	M	SA	27..0	1.0	1.5	3.70	1.11	4	26	2	-	N	
MFS32	910222	*A. tropicalis*	M	SA	20.0	1.0	1.5	5.00	1.50	10	60	2	-	N	
MFS38	910417	*A. tropicalis*	M	SA	35.5	2.5	3.0	7.04	1.69	15	120	1	-	N	
MFS39	910428	*A. tropicalis*	F	A	35.0	4.0	1.5	11.43	0.86	-	-	-	-	-	Died 4 hours after first injection. Ketamine dose: 2.5ml followed by 1.0ml 15 minutes later followed by 0.5ml 25 minutes later. Xylazine dose: 0.86ml followed by 1.0ml 15 minutes later followed by 0.5ml 25 minutes later.
MFS17	900426	*A. gazella*	F	A	32.0	2.5	2.0	7.81	1.25	7	174	3	36.8	N	Ketamine dose: 1.5ml initially followed by 1.0ml 24 minutes later. Xylazine dose: 1.0ml initially followed by 1.0ml 24 minutes later.
MFS27	910220	*A. gazella*	F	U	-	1.0	1.0	-	-	8	30	1	-	N	
MFS33	910222	*A. gazella*	F	A	40.0	1.5	1.0	3.75	0.50	7	45	2	-	N	
MFS34	910416	*A. gazella*	F	U	-	1.8	1.0	-	-	15	60	1	-	N	
MFS35	910416	*A. gazella*	F	A	27.	1.5	1.0	5.56	0.74	15	50	1	-	N	
MFS36	910417	*A. gazella*	F	A	28.0	2.0	1.5	7.14	1.07	15	60	1	-	N	
MFS37	910417	*A. gazella*	F	A	35.0	2.5	2.0	7.14	1.14	15	60	1	-	N	

Mass is given in kilograms. Age refers to age-classes with SA - sub-adult and A - adult. Ket - Ketamine (100 mg ml^{-1} solution) administered in millilitres, Xyl - Xylazine (20 mg ml^{-1} solution) administered in millilitres, DKet - Ketamine dose expressed as mg kg^{-1}, DXyl - Xylazine dose expressed as mg kg^{-1}, Ind - induction time, Imm - total time that seal was immobilized, MEF - maximum degree of effect where 0 = no visible effect, 1 = incapable of locomotion but able to resist handling, 2 = capable of movement of head and hindquarters, 3 = incapable of coordinated movement and 4 = incapable of movement. Temp - body temperature, Con - stomach contents retrieved or not.

Table 2 Species-specific Spearman rank correlation coefficients (r_s) between each induction time, immobilization time and maximum degree of effect and ketamine and xylazine doses administered to *A. tropicalis* and *A. gazella* breeding on Marion Island. *n* represents the sample size and *p* the significance level

Arctocephalus tropicalis				
		Induction time	Immobilization time	Levels of anaesthesia
Ketamine dose	r_s	-0.94	-0.30	0.27
	n	21	21	21
	p	0.0001	0.2126	0.25
Xylazine dose	r_s	-0.54	-0.02	0.05
	n	21	21	21
	p	0.0151	0.9397	0.8181
Arctocephalus gazella				
		Induction time	Immobilization time	Maximum degree of effect
Ketamine dose	r_s	-0.87	0.36	0.89
	n	5	5	5
	p	0.0833	0.4726	0.0736
Xylazine dose	r_s	-0.87	0.36	0.89
	n	5	5	5
	p	0.0833	0.4726	0.0736

through a one way intake valve and the use of a bicycle pump with its one-way valve inverted. This system caused the slurry of irrigation fluid and undigested food parts to be suctioned from the stomach into the collection container. This procedure was repeated more than once for each restrained seal, upon completion of which each one was released from the restraining board. The seals were monitored until they were capable of coordinated movement spontaneously, or were prompted to move away if capable. The slurry was then filtered through cotton cloth and food remains were transferred to and stored in 70% ethanol for later analysis (see Klages & Bester 1998).

Results and discussion

Induction occurred within 4-15 minutes for *A. tropicalis* and 7-15 minutes for *A. gazella* following the injection of ketamine and xylazine. Immobilization time ranged from 28-120 minutes for *A. tropicalis* and from 30-174 minutes for *A. gazella*. Second and third levels of anaesthesia was observed in 11 and 6 cases respectively for both species combined. Complete immobilization (level 4) was achieved in only one instance out of 34 cases where the drugs were successfully delivered. Three animals died after complete immobilization was achieved. One animal (MFS39) died four hours after the first injection. No degree of effect was recorded for this animal (Table 1).

Recalculation of the dose rates showed that, for *A. tropicalis* the most desirable effect, which conceivably would allow easy handling and fast recovery (levels 2 & 3), was attained in 53.1% of cases (Figure 1a). Most of the animals (76.6%) were exposed to ketamine dose rates of between 3.1-7.1 mg.kg^{-1} (Figure 1b) while for the majority (42.9%) the xylazine dose rates varied between 0.7-1.1 mg.kg^{-1} (Figure 1c). The higher range of ketamine dose rates (> 7.0 mg.kg^{-1}) generally failed to produce a response beyond level 1 in both species, the exceptions being one *A. gazella* female (MFS17) for which the combined dosage was delivered on two separate occasions 24 min apart, and an *A. tropicalis* female (MFS39) which died. No side effects such as muscle tremors and salivation, noted in a study of *A. gazella* by Bester (1988), were evident. Two *A. tropicalis* individuals (MFS6, MFS8) showed little sign of being affected by the drugs, remained active, and could not be restrained. These individuals were excluded from the correlation analyses.

No clear pattern emerged to suggest a relationship between dose rates and induction time, immobilization time and the maximum degree of effect recorded for either of the species (Table 2). Three *A. tropicalis* which died had received dosages of ketamine (< 6.5mg.kg^{-1}) and xylazine (< 0.8mg.kg^{-1}) which were below that which induced immobilization and subsequent recovery in conspecifics, while a fourth (MFS 39) succumed after receiving a total dosage of 11.4 mg.kg^{-1} ketamine and 0.9 mg.kg^{-1} xylazine. Similarly, Boyd, Lunn, Duck & Barton (1990) found that one of the three adult male *A. gazella* which died following the administration of ketamine with xylazine resulted from an accidental overdose (11.5 mg.kg^{-1} ketamine), while the others were within the normal range (6.9-7,7 mg.kg^{-1}) used in their study. Dosages between 7.9-10.8 mg.kg^{-1} ketamine also resulted in the death of two yearling *A. gazella* (Bester 1988). This suggests that, in combination with xylazine, the upper limit for ketamine dosages for these fur seals is approximately 7.8 mg/kg^{-1}. David,

Hofmeyr, Best, Meyer & Shaughnessy (1988) also lost two of seven South African (Cape) fur seal, *A. pusillus pusillus*, bulls during attempted immobilization with ketamine dosages as low as 4.2-5.2 $mg.kg^{-1}$ in combination with xylazine. The unpredictable response of the two fur seal species to the ketamine/xylazine combination (Bester 1988; Boyd *et al.* 1990; present study), and the relatively high mortality rate suffered (i.e. 14.3% & 6.7% for *A. gazella* - Bester 1988; Boyd *et al.* 1990, and 14.3% for *A. tropicalis* - present study) suggest that its use should be limited. The generally low levels of immobilization achieved put the animals at considerable risk when choker poles and restraining boards are employed. Unanticipated strikes at the equipment may result in damage to teeth, and here the hoopnet, modified by David, Meyer & Best (1990) from the prototype developed by Gentry & Holt (1982) is far superior (David *et al.* 1990, pers obs). Twenty-nine fur seals (22 *A. tropicalis* and 7 *A. gazella*) were stomach lavaged following immobilization, but food items were retrieved from only seven *A. tropicalis*. The diameter of the lavage tube, the size of the suction port, the degree of negative pressure achieved, the volume of irrigation fluid, and the time that had elapsed since the seal's last meal, conceivably determined the outcome of the lavaging. The contents consisted primarily of small squid beaks and small quantities of fish remains. In all but one of the seals that died, the stomachs were found to be empty upon dissection. It is, therefore, unknown whether all the contents, if present, would have been evacuated with the irrigation fluid. Suction was adequate to remove smaller sized stones from stomachs, but it is doubtful whether small squid beaks within the rugae of a stomach would have been flushed out. Food items too large to fit in the lavage tube would remain in the stomach. Physically and ethically there is an upper limit to the diameter of lavage tubes and the number of repeated flushings to which fur seals can be subjected. Despite the biases that are introduced (Gales & Cheale 1992; Klages & Bester 1998) fur seal diets can be investigated from scat analyses (Green, Burton & Williams 1989; Green, Williams & Burton 1991; Daneri 1996; North 1996; Klages & Bester 1998). Considering the low returns from stomach lavaging, and the danger to the animal from physical and chemical restraint, the determination of the diets of otariids using the methods described here has been discontinued.

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