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From the Field

Field Chemical Immobilization of Andean and Pampas Cats in the High-Altitude Andes

CINTIA G. TELLAECHE,[1,2,3] *GECM (Mammal Behavioural Ecology Group), Laboratorio de Fisiología Animal, Departamento de Biología, Bioquímica y Farmacia, Universidad Nacional del Sur, San Juan 670, Bahía Blanca, Argentina*

JUAN I. REPPUCCI,[3,4] *GECM (Mammal Behavioural Ecology Group), Laboratorio de Fisiología Animal, Departamento de Biología, Bioquímica y Farmacia, Universidad Nacional del Sur, San Juan 670, Bahía Blanca, Argentina*

ESTELA M. LUENGOS VIDAL, *GECM (Mammal Behavioural Ecology Group), Laboratorio de Fisiología Animal, Instituto de Ciencias Biológicas y Biomédicas del Sur (INBIOSUR), Departamento de Biología, Bioquímica y Farmacia, Universidad Nacional del Sur, San Juan 670, Bahía Blanca, Argentina*

DEANA L. CLIFFORD, *Wildlife Investigations Lab, California Department of Fish and Wildlife, 1701 Nimbus Road, Rancho Cordova, California, USA; and Department of Medicine and Epidemiology, School of Veterinary Medicine, University of California, Davis, CA 95695, USA*

MAURO LUCHERINI,[3] *GECM (Mammal Behavioural Ecology Group), Laboratorio de Fisiología Animal, Instituto de Ciencias Biológicas y Biomédicas del Sur (INBIOSUR), Departamento de Biología, Bioquímica y Farmacia, Universidad Nacional del Sur, San Juan 670, Bahía Blanca, Argentina*

ABSTRACT Three protocols (Ketamine–Medetomidine, Ketamine–Xylazine and Ketamine–Medetomidine–Midazolam) were used to immobilize 2 sympatric wild cat species, the critically endangered Andean cat (*Leopardus jacobita*), and the relatively more common Pampas cat (*L. colocolo*), in the high Andes Mountains of Argentina between September 2011 and May 2016. Based on 8 Andean cat capture events and 9 Pampas cat capture events, we determined that the ketamine–medetomidine combination safely induced 45 minutes of anesthesia at a dosage range of ketamine: 6–9 mg/kg, medetomidine: 0.05–0.08 mg/kg for field immobilization. Heart rate, respiratory rate, and oxygen saturation remained within acceptable limits during all captures, but we had cases of hyperthermia in animals captured during the day. There was no evidence of a decline in the health condition of any animals recaptured 148–1,290 days post–initial capture. © 2020 The Wildlife Society.

KEY WORDS Argentina, Carnivora, immobilization, ketamine, *Leopardus jacobita*, *Leopardus colocolo*, Mammalia, medetomidine.

The Andean cat (*Leopardus jacobita*) is considered one of the rarest felids in South America and classified as Endangered by the International Union for the Conservation of Nature and Natural Resources (Nowell and Jackson 1996, AGA 2011, Villalba et al. 2016). Its distribution is restricted to arid regions of the High Andes Mountains of Argentina, Bolivia, Chile, Peru, and a portion of the Patagonian steppe in Argentina, South America. The Andean cat appears to be morphologically adapted to the extreme environment (high elevation, low temperature, very dry and extremely windy climates) where it occurs by having thick fur and a long thick tail. These features have been reported to provide insulation from cold for the face and paws of snow leopards (*Panthera uncia*) when resting at low temperatures (Kitchener et al. 2010). However, little is known about the physiologic adaptations to altitude in carnivores in general and there is no information for the Andean cat. The Andean cat shares its entire distribution range with the Pampas cat (*L. colocolo*), a more common and widespread felid that inhabits a variety of habitats. A high degree of competition between these 2 felids is inferred because of their similar size and morphological characteristics; no segregation in niche dimension between these 2 species has been found. Additionally, the Andean cat has a narrower niche (in all studied dimensions) in comparison with the Pampas cat, which makes the former apparently more specialized to the environment where they live but also more vulnerable to changes than the generalist Pampas cat (Lucherini et al. 2009; Reppucci et al. 2011). Andean cat populations face numerous conservation threats including habitat loss and degradation, prey depletion, and illegal hunting from local communities (Villalba et al. 2016).

There is an urgent need to understand the demography, habitat use, and population health of Andean cats in particular,

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[1]*E-mail: cintiatellaeche@gmail.com*
[2]*Current affiliation: CETAS (Centro de Estudios Territoriales, Ambientales y Sociales), Facultad de Ciencias Agrarias, Universidad Nacional de Jujuy, Alberdi 47, San Salvador de Jujuy, Argentina*
[3]*Andean Cat Alliance*
[4]*Current affiliation: CONICET (Consejo Nacional de Investigaciones Científicas y Técnicas)/APN-DRNOA (Delegación Regional Noroeste, Administración de Parques Nacionales), Santa Fe 23, Salta, Argentina*

which often requires capture and immobilization of live animals. This is typically the case for carnivores, given their cryptic habits and low densities (Boitani and Fuller 2000, Crooks et al. 2001, Soisalo and Cavalcanti 2006). Prior to this study, to the best of our knowledge, only one wild Andean cat had been immobilized in the field. Field immobilization of Pampas cats has occurred several times, although little has been published on this topic for this species (Delgado et al. 2004, Silveira et al. 2005, Beltrán et al. 2009).

As part of a project to study the ecology of Andean and Pampas cats, we aimed to determine safe and effective doses for chemical immobilization of these 2 poorly understood felids. We also provide recommendations regarding capture procedures when working in extreme environments such as those found in high-altitude areas.

STUDY AREA

Our study was conducted in the western part of Jujuy Province, northwestern Argentina (22°30′S 66°30′W; Fig. 1). This area forms part of the High Andes Mountains ecoregion that encompasses a mosaic of mountain ranges, volcanoes, salt flats, lagoons, and high-altitude plateaus. Vegetation was sparse and formed by a mixture of grasslands (mostly *Stipa* and *Festuca*) and scrublands dominated by *Parastrephia* spp. and *Fabiana* spp. (Cabrera 1976). Elevation of the study area ranged from 3,500 to 6,000 m with an average of 4,200 m. The temperature can vary widely because of this high altitude, from 30° C (86° F) during the day to −20° C (−4° F) at night. Annual rainfall varied from 100 to 200 mm and concentrated in summer (Jan–Feb; Cabrera 1976).

METHODS

We captured Andean and Pampas cats between September 2011 and May 2016. Capture and handling procedures followed the guidelines of the American Society of Mammalogists (Sikes et al. 2011, 2016), with appropriate permissions from the Dirección Provincial de Biodiversidad, Jujuy Province government. A veterinarian was present during all captures.

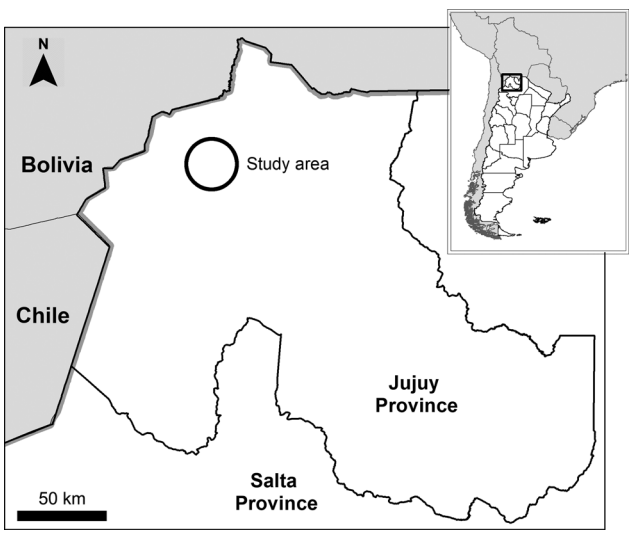

Figure 1. Location of the study area where chemical immobilization levels of small Felids were tested between September 2011 and May 2016 in the western part of Jujuy Province, northwestern Argentina.

We used padded foot-hold and box traps to capture cats: 1) Victor Soft Catch 1.5 (Oneida Victor, Euclid, OH, USA) foot-hold traps modified by wrapping each jaw in an additional rubber layer were anchored with a 30-cm iron stake driven into the ground, no bait was placed; and 2) iron mesh custom-built box traps ($40 \times 40 \times 120$ cm, width, height, and length, respectively). We placed traps in areas where we had species detections using camera traps and deployed on trails or places that seemed likely transit paths for small felids. We stopped using box traps after 2012 because of a lack of success. To minimize the time between capture and immobilization, we attached very-high-frequency transmitters that emitted a signal when the trap was disturbed. We monitored the trap transmitter signals every 30 minutes throughout the day and night and conducted a physical check of all traps daily.

Cats captured in foot-hold traps were briefly physically restrained using a "Y" shaped pole to inject drugs for chemical immobilization. We delivered 1 of 3 drug combinations under evaluation in this study via hand-injection into the muscle of the lateral thigh and recorded the time of injection. We decided initial drug doses based on visual estimation of body mass. After immobilization, we measured actual body mass using a 10-kg Pesola® balance (Pesola AG, Schindellegi, Switzerland), with 100-g precision. We monitored respiratory rate (respirations/min) visually, heart rate (beats/min) using a stethoscope, oxygen saturation (percent O_2) using a pulse oximeter, and rectal temperature using a digital thermometer; we took these measurements every 15 minutes whenever possible. We applied ophthalmic ointment to the eyes to prevent desiccation, and covered the eyes to minimize visual stimulus and protect them from dust and light. We also placed earplugs (cotton) to reduce stress from auditory stimulus. We fitted cats with Global Positioning System radiocollars and, after collar placement, collected blood, fecal, and ectoparasite samples and recorded morphometric measurements. To account for the presence of rocks and cliff hazards, after the antagonist injection, we placed cats in a cage, monitored them every 15 minutes, and released them from the cage when completely recovered. To minimize thermoregulation issues, we processed cats inside of a sun shade shelter to protect the animal from sun, dust, and wind, and used hot water bottles and a blanket during the night to keep them warm. We considered that an animal was suffering hypothermia when its rectal temperature was <36° C (96.8° F) and hyperthermia when it was >39° C (102.2° F; Luengos Vidal 2003, Luengos Vidal et al. 2014, West et al. 2014). Depending on the severity and duration of signs, we treated animals exhibiting hyperthermia with ≥1 of the following: ethyl alcohol applied to the groin area and foot pads, ice packs, cold water applied to the body surface and groin area, and cool water enema.

We evaluated 3 different drug combinations because not all drugs were available for use at each capture event. For the first protocol (KM) we used a combination of ketamine 100 mg/mL (Ketonal; Richmond Vet Pharma, Grand

Bourg, Buenos Aires, Argentina), and medetomidine 1 mg/mL (Wedgewood Pharmacy, Swedesboro, NJ, USA) to achieve immobilization, and administered atipamezole 5 mg/mL (Antisedan; Zoetis Inc., Kalamazoo, MI, USA) or yohimbine 2 mg/mL (Vet Úp; Richmond Vet Pharma, Grand Bourg, Buenos Aires, Argentina) as antagonist for medetomidine. For the second protocol (KX), we used a combination of ketamine and xylazine 10 mg/mL (Rompun; Mobay Corp., Animal Health Division, Shawnee, KS, USA) without antagonist. For the third protocol (KMM), we used a combination of ketamine, medetomidine, and midazolam 5 mg/mL (Richmond Vet Pharma Grand Bourg), and administered atipamezole as antagonist. Based on literature for similar species we utilized an initial target dose range of ketamine: 5–10 mg/kg, medetomidine: 0.05–0.07 mg/kg for KM; ketamine: 7–15 mg/kg, xylazine: 0.7–2 mg/kg for KX; and ketamine: 4–6 mg/kg, medetomidine: 0.02–0.05, midazolam: 0.2–0.4 mg/kg for KMM. Dosages at the higher end of the target range were used at the discretion of the veterinarian based upon the animal's behavior and apparent stress level in the trap. We considered a dose to be effective when cardiac and respiratory rates were within acceptable ranges and the anesthesia was sufficiently deep to allow safe and comfortable handling for ≥45 minutes, which we considered sufficient time to record morphological and physiological measurements, take blood samples, and attach a radiocollar based on our previous experience. We considered a dose ineffective when the initial dose was not enough to reach an appropriate anesthetic plane or when the duration of adequate anesthesia did not last 45 minutes.

We measured the duration of 4 periods (induction, immobilization, re-dosage, and recovery time). We defined Induction time (IT) as the time from the initial drug injection until complete sedation; Immobilization time (ImmT) as the time from the initial drug injection until the antagonist injection (in one case we did not use antagonist and ImmT was the time from the initial drug injection until the first nonstimulated head movement); Re-dosage time (RedT) as the time from the initial drug injection until the second drug injection, when needed; and Recovery time (RecT) as the time from the antagonist injection, or first nonstimulated head movement, to the release of the animal.

RESULTS

We captured 5 unique Andean and 6 unique Pampas cats in 180 days of trapping. We monitored these cats after the capture procedure and after a period of <12 hours of restricted movements, they started traveling long distances, and their movements appeared normal. Four individuals (3 Andean, 1 Pampas cat) were recaptured once and 1 Pampas cat was recaptured twice. Time between recaptures varied from 148 to 1,290 days. Recaptured animals exhibited no evidence that would suggest a decline in health condition post–initial capture (e.g., no loss of mass, no changes in expected behavior, and no apparent trap wounds).

For Andean cats, KM was used on 7 occasions and KMM was used once (Table 1). The mean effective dose using KM for Andean cats was ketamine: 6.35 ± 1.56 mg/kg, and medetomidine: 0.05 ± 0.01 mg/kg. The mean effective dose using KMM was ketamine: 4.78 mg/kg, medetomidine: 0.03 mg/kg, and midazolam: 0.24 mg/kg. For Pampas cat, KM was used 6 times, KX once, and KMM twice. The mean effective dose using KM was ketamine: 8.75 ± 2.88 mg/kg, and medetomidine: 0.07 ± 0.01 mg/kg. For the single Pampas cat immobilized with KX, the effective dose was ketamine: 7.65 mg/kg and xylazine: 0.74 mg/kg. With KMM, the only effective dose was ketamine: 4.55 mg/kg, medetomidine: 0.03 mg/kg, and midazolam: 0.23 mg/kg (Table 1).

For both species, mean IT was longer than 10 minutes (11 ± 1.73 min) when immobilized with KMM. Andean cats immobilized with effective KM and KMM doses showed similar RecT (93.1 ± 28.6 min); one individual that needed a supplemental dose had a longer RecT (150 min). Pampas cats immobilized with an effective KM dose tended to take longer to fully recover (140.5 ± 12.0 min) than Andean cats (92.8 ± 31.9 min; Table 1). Using KM, effective doses were achieved after initial injection in 6 of 7 Andean cat capture events. The sole Andean cat receiving KM that needed a supplemental drug injection after 14 minutes had received an initial dosage of ketamine: 4.48 mg/kg, and medetomidine: 0.04 mg/kg (Table 1). In contrast, 3 of 6 Pampas cats given KM needed supplemental drug injections; the mean RedT was 18.7 ± 6.4 minutes with a mean initial drug dose of ketamine: 5.27 ± 1.21 mg/kg, and medetomidine: 0.05 ± 0.01 mg/kg. With KMM, a single Pampas cat required supplemental drug injection at 32 minutes; the initial drug dose it received was ketamine: 4.25 mg/kg, medetomidine: 0.03 mg/kg, and midazolam: 0.25 mg/kg (Table 1). The mean ImmT in the most used protocol (KM) were 50.8 ± 15.7 minutes for Andean cat and 45.7 ± 2.08 minutes for Pampas cat (Table 1).

Captures of both species occurred during the day (3 Andean cat and 3 Pampas cat captures) and night (3 Andean cat and 4 Pampas cat captures). One Andean cat was captured within 1 hour of sunrise and 1 Pampas cat was captured twice within 1 hour of sunset. All of the Andean cats ($n = 3$) and 66.7% of the Pampas cats ($n = 2$) captured during the day had hyperthermia (Table 2). Cats captured during crepuscular–nocturnal hours did not present signs of hyperthermia. No cases of hypothermia were recorded. The average initial body temperatures for Andean cats were 38.6 ± 0.6° C (101.6 ± 1.1° F) for night captures and 40.1 ± 2.5° C (104.1 ± 4.7° F) for day captures (Table 2). For Pampas cats, initial body temperatures averaged 38.2 ± 0.5° C (100.7 ± 1.3° F) for night captures and 39.2 ± 1.4° C (102.5 ± 2.5° F) for day captures (Table 2).

Initial heart rate after induction was greater in Andean cats (145.5 ± 15.4 bpm) compared with Pampas cats (111.3 ± 10.3 bpm) regardless of drug efficacy or protocol, with the exception of a single Pampas cat receiving KX (Table 2). Initial respiration rates were similar between species. Both species showed very similar oxygen saturation

Table 1. Description of each capture event of Andean (AC) and Pampas (PC) cats showing protocol used (KM: ketamine–medetomidine; KX: ketamine–xylazine; KMM: ketamine–medetomidine–midazolam), animal ID and body mass, drug doses based on real mass (KET: ketamine, MED: medetomidine, ATI: atipamezole, XYL: xylazine, MDZ: midazolam), immobilization period duration (IT: induction time, ImmT: immobilization time, RecT: recovery time, RedT: redosification time, in minutes).

			First dose (mg/kg)		Second dose (mg/kg)		Third dose (mg/kg)		Reversal dose (mg/kg)		Immobilization period (min)			
KM	**ID**	**Mass (kg)**	**KET**	**MED**	**KET**	**MED**	**KET**	**MED**	**ATI**	**Effective**	**IT**	**ImmT**	**RecT**	**RedT**
AC capture #[a]														
1^{N}	M2	5.8	4.14	0.03					0.17	Yes	8	45	105	
2^{N}	M2	5.6	5.89	0.07					0.35	Yes	5	42	116	
3^{N}	F1	4.7	6.52	0.05					0.21	Yes	7	69	73	
4^{C}	F3	4.6	5.43	0.05					0.27	Yes	22	30	123	
5^{D}	F1	4.6	8.51	0.04					0.21	Yes		70		
6^{D}	F2	4.6	7.61	0.05					0.32	Yes	5	49	47	
7^{D}	M1	5.8	4.48	0.04	4.48	0.02			0.32	No		61	150	14
Mean ± SD effective		5.10 ± 0.60	6.35 ± 1.56	0.05 ± 0.01							9.4 ± 7.2	50.8 ± 15.7	92.8 ± 31.9	
PC capture #[a]														
1^{D}	F2	3.6	6.85	0.08					0.41	Yes		48	149	
2^{D}	M2	3.4	7.35	0.06					0.44	Yes	7	45		
3^{C}	F3	3.0	12.07	0.09					0.33	Yes	4	44	132	
4^{N}	M1	4.5	4.0	0.04	1.1	0.01	2.2	0.02	0.33	No	5	75	60	14
5^{N}	M1	5.0	5.4	0.06	1.4	0.01	1.2	0.0	0.37	No		41	67	16
6^{D}	F1	3.5	6.43	0.07	2.8	0.0			0.42	No	5	48	140	26
Mean ± SD effective		3.83 ± 0.75	8.75 ± 2.88	0.07 ± 0.01							5.50 ± 2.12	45.7 ± 2.08	140.5 ± 12.0	
Mean ± SD ineffective			5.27 ± 1.21	0.05 ± 0.01	1.76 ± 0.90		1.70 ± 0.70	0.01 ± 0.014				54.66 ± 17.95	89.00 ± 44.30	18.7 ± 6.4

			First dose (mg/kg)				Immobilization period (min)			
KX	**ID**	**Mass (kg)**	**KET**	**XYL**	**Effective**	**IT**	**ImmT**	**RecT**	**RedT**	
PC capture #[a]										
1^{N}	F3	3.4	7.65	0.74	Yes	5	31	110		

			First dose (mg/kg)			Second dose (mg/kg)				Reversal dose (mg/kg)		Immobilization period (min)			
KMM	**ID**	**Mass (kg)**	**KET**	**MED**	**MDZ**	**KET**	**MED**	**KET**	**MED**	**ATI**	**Effective**	**IT**	**ImmT**	**RecT**	**RedT**
AC capture #[a]															
1^{N}	F3	4.6	4.78	0.03	0.24					0.16	Yes	10	54	95	
PC capture #[a]															
1^{C}	F3	3.3	4.55	0.03	0.23					0.15	Yes	13	38	97	
2^{N}	M3	4.0	4.25	0.03	0.25	0.25	2.5	0.0	0.0	0.12	No	10	52	80	32

[a] ^{D} Indicates animals captured during the day, ^{N} indicates animals captured during the night, and ^{C} indicates animals captured during crepuscular hours.

Table 2. Description of each capture event of Andean (AC) and Pampas (PC) cats showing protocol used (KM: ketamine–medetomidine; KX: ketamine–xylazine; KMM: ketamine–medetomidine–midazolam), animal ID, initial physiological parameters and range (HR: heart rate (beats/min), RR: respiratory rate (respirations/min), Temp: rectal temperature in ° C and ° F, O_2 sat: % oxygen saturation).

		Initial parameters				Throughout immobilization (range)			
KM	**ID**	**HR**	**RR**	**Temp (° C/° F)**	**O_2 sat %**	**HR**	**RR**	**Temp (° C/° F)**	**O_2 sat %**
AC capture #[a]									
1^N	M2	152	28	39.1/102.3	78	100–152	24–32	36/96.8–39.1/102.38	78–85
2^N	M2	132	30	38.7/101.6	72	96–132	20–30	37.7/99.8–38.8/101.8	71–82
3^N	F1	140	28	37.8/100	89	106–140	20–32	36.1/96.9–37.8/100	89–93
4^C	F3	120	50	36.7/98	70	110–120	40–50	36.7/98.1–37.6/99.6	70–80
5^D	F1	168	48	42.5/108.5	91	91–168	24–48	36/96.8–42.5/108.5	91–99
6^D	F2	160	25	41.9/107.4	76	120–14	20–25	39.3/102.7–41.9/107.4	76–91
7^D	M1	142	44	39.6/103.2	74	140–142	32–42	39.6/103.2–40.28/104.5	74–75
Mean ± SD effective		145.3 ± 18	34.8 ± 11.1	39.4/102.9 ± 2.3/36.1	79.3 ± 8.8				
PC capture #[a]									
1^D	F2	104	40	38.4/101.1	……	48–104	24–68	38.05/100.5–39.27/102.7	
2^D	M2	120	64	40.8/105.4	…..	80–120	24–44	37.2/98.9–40.8/105.4	
3^C	F3	96	60	38.4/101.1	….	96–128	40–60	37.3/99.1–38.4/101.1	
4^N	M1	112	20	37.1/98.8	….	108–112	20–28	36.3/97.3–37.1/98.8	
5^N	M1	120	34	38.6/101.5	…..	108–120	34–36	37.9/100.2–38.6/101.5	
6^D	F1	120	60	38.4/101.1	83	108–140	40–60	35.7/96.3–38.4/101.1	83–84
Mean ± SD effective		106.66 ± 12.22	56.66 ± 12.85	39.2/102.5 ± 1.38/34.4					
Mean ± SD ineffective		117.33 ± 4.61	38.00 ± 20.29	38.03/100.4 ± 0.81/33.4					
KX	**ID**	**HR**	**RR**	**Temp (° C/° F)**	**O_2 sat %**	**HR**	**RR**	**Temp (° C/° F)**	**O_2 sat %**
PC capture #[a]									
1^N	F3	156	40	38.7/101.6	85	120–156	40–52	37.1/98.8–38.7/101.6	85–88
KMM	**ID**	**HR**	**RR**	**Temp (° C/° F)**	**O_2 sat %**	**HR**	**RR**	**Temp (° C/° F)**	**O_2 sat%**
AC capture #[a]									
1^N	F3	150	36	39/102.2	80	90–150	36–40	36.5/97.7–39/102.2	80
PC capture #[a]									
1^C	F3	99	64	38.1/100.5	70	80–100	16	36.7/98.1–38.1/100.5	70
2^N	M3	120	36	38.1/100.5	100	90–120	36–40	36/96.8–38.1/100.5	98–100

[a] ^{D} Indicates animals captured during the day, ^{N} indicate animals captured during the night, and ^{C} indicates animals captured during crepuscular hours.

for all immobilization protocols; Andean cats had a mean of 78.7 ± 7.6% (range = 70–99%, $n = 8$), and Pampas cats a mean of 84.5 ± 12.3% (range = 70–100%, $n = 4$; Table 2).

DISCUSSION

Based on our findings, Andean and Pampas cats can be safely and effectively anesthetized with a combination of ketamine–medetomidine. Even though all captures were safe, the combination of ketamine–xylazine and ketamine–medetomidine–midazolam cannot be recommended as a suitable protocol without more study. Notably, our mean effective ketamine–medetomidine doses for Pampas cats were higher than those reported by Beltrán et al. (2009) in a similar environment (high-altitude Andes in Bolivia; 5.0 mg/kg of ketamine and 0.05 mg/kg of medetomidine), and those reported for 2 similar-sized felids, ocelot (*Leopardus pardalis;* ketamine: 5.8 ± 2 mg/kg, medetomidine: 0.06 ± 0.017 mg/kg) and Geoffroy's cat (*L. geoffroyi;* ketamine: 5.3 ± 1.1 mg/kg, medetomidine: 0.076 ± 0.014 mg/kg; Fiorello et al. 2006). This difference may in part be due to overestimation of body mass for some cats (resulting in higher doses), random individual variation in drug response for some individuals and the effect that can have on data with smaller sample sizes. Our overestimations of body mass were most likely due to the thick fur of these cats; therefore, we recommend that future researchers consider this potential source of bias when immobilizing carnivores in extreme environments at high altitude. Administration of KM to additional Pampas cats is needed to refine dosages.

For the Andean cat, none of the protocols we used had been previously tested. For the sole Andean cat previously immobilized, Delgado et al. (2004) used only ketamine at a dose of 10 mg/kg. We strongly recommend combining ketamine with either an alpha 2 agonist or benzodiazepine sedative, which allows reduction of the amount of ketamine by nearly half, thus helping to moderate ketamine-related adverse effects (e.g., rough induction and recoveries, poor muscle relaxation, convulsions; West et al. 2014).

Accordingly, and given that it has been tested on the most animals to date, we recommend the combination of ketamine–medetomidine at a dosage range of ketamine: 6–9 mg/kg, and medetomidine: 0.05–0.08 mg/kg, with utilization of Atipamezole (5 mg/mL) as reversal drug for field immobilization of Andean cat and Pampas cat. Although the addition of midazolam to the ketamine–medetomidine combination increases muscle relaxation, provides antiseizure protection, and may allow for further reduction in ketamine dosage, we did not find a distinct advantage to this protocol in the 3 animals we tested, and, in fact, found slightly longer induction times, potentially due to an excessive reduction in ketamine, or simply to individual variation related to small sample size. Additional immobilizations would be needed to determine if adding midazolam to the currently recommended ketamine–medetomidine protocol improves immobilization quality (West et al. 2014). For animals that required supplemental drug doses, the RedT for cats given KM tended to be shorter than for the cats given KMM, perhaps because the addition of midazolam produced a slightly greater sedative effect at a lower ketamine dose. We needed about 30–70 minutes to safely process an animal and collect all needed data. Normally with a team of 4 people, 45 minutes was enough time; however, when personnel were limited (3 people) or in a case where a collar failed during fitting and we needed to replace it, we needed more time.

We had no serious anesthetic complications or mortalities during the capture and immobilization process. Respiration and heart rates remained consistent with normal values reported for other Neotropical felid species (Varela 2009). The higher heart rate we observed for the Andean cat could be an adaptation to the low oxygen concentration at high altitudes, a sign of increased stress during capture, or a combination of both (Varela 2009).

Low oxygen saturation levels (70–85%) observed in some individuals was most likely due to alpha-2 agonist-induced vasoconstriction or poor pulse oximeter connectivity. Even though oxygen saturation above 90% is desirable, anesthetized animals often have oxygen saturation of 70–90% (i.e., similar to those we recorded) with no apparent harm (Kreeger et al. 2002). Despite less than ideal oxygen saturation levels, none of the radiocollared cats died within 2 weeks post-immobilization, and recaptured animals were in good condition and had generally maintained body mass between captures. To optimize oxygen saturation, we recommend oxygen supplementation during anesthesia whenever possible.

Initial body temperature was greatly influenced by the time of capture, with consistently higher postinduction temperatures observed for cats captured during the day and lower temperatures for cats captured during the night. Although the ambient temperatures in the study area were frequently very low at night (min.: −20° C/−4° F), we recorded no cases of hypothermia during night captures. This could be due to the preemptive measures we implemented to prevent hypothermia, the fact that both species have a thick layer of fur adapted to withstand cold conditions, or a combination of both factors. Typically, because of the difficult terrain, it took approximately 30–40 minutes for team members to hike to a trap after the alarm was activated. Animals trapped during the day may have been trying to break free from the trap in substantially warmer conditions and with some sun exposure. In these cases, interventions to cool the animal brought the temperature back into normal range within an average of 25 minutes.

Based on our experience and the results reported here, we recommend the following precautionary actions in conditions like those found in the high-altitude Andes (lack of oxygen and great daily thermal amplitude): 1) use an effective alarm system to constantly monitor the traps and minimize time between capture and immobilization; 2) place traps in locations that remain in the shade most of the time; 3) use a drug combination that has a reversible component (antagonist); 4) be ready to address thermoregulatory issues, most specifically hyperthermia; 5) provide supplemental oxygen to minimize hypoxemia; and 6) release pressure of the drug containers while gaining altitude, to avoid rupture of containers due to pressure changes.

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