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REVERSIBLE IMMOBILIZATION OF FREE-RANGING SNOW LEOPARDS (*PANTHERA UNCIA*) WITH A COMBINATION OF MEDETOMIDINE AND TILETAMINE-ZOLAZEPAM

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ABSTRACT: Conservation and research of the elusive snow leopard (*Panthera uncia*) have been hampered by inadequate knowledge about its basic life history. Global positioning system (GPS) collars can provide useful information, but there has been limited information available on safe capture methods, drug doses, and efficacy for effective immobilization of free-ranging snow leopards. We describe a drug protocol using a combination of medetomidine and tiletamine-zolazepam for the chemical immobilization of free-ranging snow leopards. We also describe physiologic responses to immobilization drugs, including rectal temperature, heart rate, respiratory rate, and relative hemoglobin oxygen saturation (SpO_2) recorded every 10 min. Our study was carried out in the Tost Mountains adjacent to the Great Gobi Desert, in southern Mongolia, between August 2008 and April 2012. Eighteen snow leopards were captured or recaptured with foot-snares on 42 occasions and anesthetized for marking with GPS collars. The snow leopards received on average (±SD) 0.020±0.04 mg/kg body mass medetomidine and 2.17±0.45 mg/kg tiletamine-zolazepam. The duration of ensuing anesthesia was 69±13 min, including an induction period of 10 (±4) min. Anesthesia was reversed with 4 mg (0.10±0.04 mg/kg) atipamezole administered intramuscularly. The mean value for SpO_2 for the 37 captures where we could record physiologic values was 91±4. The SpO_2 increased significantly during anesthesia (+0.06±0.02%/min), whereas rectal temperature (average 38.1±0.7 C/min, change −0.04±0.003 C/min), heart rate (average 97±9 beats/min, change −0.20±0.03 beats/min), and respiratory rate (average 26±6 breaths/min, change −0.11±0.03 breaths/min) decreased significantly. A dose of 80 mg tiletamine-zolazepam (2 mg/kg body weight) and 0.72 mg medetomidine (0.02 mg/kg body weight) safely immobilized all adult and subadult snow leopards (weight 25–45 kg) in our study. All measured physiologic values remained within clinically acceptable limits.

Key words: Anesthesia, capture, drug dose, Mongolia, physiology, vital rates.

INTRODUCTION

Ecologic research on elusive species that inhabit relatively inaccessible terrain and occur in low numbers often necessitates the animals being fitted with a tracking device, for example, global positioning system (GPS) collars. For large carnivores, this requires the animals to be chemically immobilized. From an ethical and animal welfare perspective, it is important that the immobilization process be safe and involve as little stress to the animal as possible (Powell and Proulx, 2003). Chemical immobilization must rely on a safe drug, or drug combination, and an appropriate dose, which not only anesthetize the animal, but also allow sufficient maintenance of physiologic processes such as respiration and heart rate (Fahlman et al., 2011).

The snow leopard (*Panthera uncia*) is an endangered and elusive species occurring in the mountains of Central Asia. Captive snow leopards have been successfully immobilized with tiletamine-zolazepam (TZ; Roth et al., 1994), medetomidine (MED)-ketamine (Jalanka, 1989a), and a

combination of xylazine and ketamine (Jalanka, 1989b). The three field studies that involved multiple immobilizations of wild snow leopards employed ketamine (Jackson, 1996), a combination of medetomidine and ketamine (Oli, 1997), and tiletamine-zolazepam (McCarthy et al., 2005). However, detailed reports on drug doses or physiologic responses of free-ranging snow leopards to chemical immobilization are not available.

Medetomidine is a widely used alpha$_2$-adrenoceptor agonist that produces sedation and analgesia. Adverse effects of medetomidine include bradycardia and bradypnea (Plumb, 2008). The drug effects can be reversed by atipamezole (Kreeger and Arnemo, 2012). Tiletamine-zolazepam, sold under the names Telazol, and Zoletil, is a two-component drug consisting of a dissociative anesthetic (tiletamine) and a benzodiazepine agonist (zolazepam) having minor tranquilizing properties (Plumb, 2008). Used alone, it causes profound analgesia, normal pharyngeal-laryngeal reflexes, and cataleptoid anesthesia. Adverse effects include marked salivation, which, in combination with retained laryngeal reflexes, can cause vomiting and retching (Plumb, 2008).

Furthermore, a combination of MED and TZ has reportedly been used for safe, efficient, and reversible immobilization of many wildlife species, including free-ranging brown bears (*Ursus arctos*; Fahlman et al., 2011), lions (*Panthera leo*; Jacquier et al., 2006), California sea lions (*Zalophus californianus*; Haulena and Gulland, 2001), captive polar bears (*Ursus maritimus*; Caulkett et al., 1999), and free-ranging black bears (*Ursus americanus*; Caulkett and Cattet, 1997). We report the first successful use of a MED and TZ combination for wild snow leopards. Our objectives were to evaluate the physiologic response of wild snow leopards to immobilization, and to describe a drug combination and dose that can safely and effectively immobilize average-sized subadult and adult snow leopards.

MATERIALS AND METHODS

Study area, capture, and immobilization

In 2008, we started a long-term ecologic study of snow leopards in Mongolia. A key component of the study was to capture and fit snow leopards with GPS collars (for a detailed description of the study, see McCarthy et al., 2010). The study area was located in the Tost Mountains, in the South Gobi province of Mongolia. Our primary base camp was located at 43°11′N, 100°36′E. Annual precipitation in this region is <130 mm/yr, temperatures range from −35 C to 38 C, and there are strong winds all year, especially in winter and spring. Elevation ranges between 1,900 and 2,550 m.

Our data come from snow leopard captures conducted August 2008 to April 2012. Snow leopards were caught in modified Aldrich-style foot-snares (Poelker and Hartwell, 1973; Novak, 1980) placed in steep-walled, narrow canyons. The snare design follows Frank et al. (2003), with the exception that the snares were anchored with a four-way cross stake ground anchor, consisting of four 60-cm metal stakes,17 mm in diameter, with a nut welded to one end. The stakes were hammered in at about 45° angle from the ground and perpendicular to one another. This prevented the captured animal from escaping with the snare cable attached to its leg. A spring was also attached between the anchor and the snare to cushion the impact in case the animal struggled. Each snare was equipped with a trap-site VHF transmitter (TBT-500, Telonics Inc., Mesa, Arizona, USA) emitting a continuous signal at a unique frequency. A change in signal pulse rate indicated the trap had been sprung. We checked the trap transmitter signals every 3 hr from early evening to late morning from a mountain peak using a handheld receiver (Communications Specialists R-1000, Communications Specialists, Orange, California, USA) and antenna (Y-4FL, Followit, Lindesberg, Sweden). Starting in autumn 2010, we used an automatic trap surveillance system that constantly monitored the traps. The system scans the trap transmitters and sounds an alarm within a maximum of 8 min after a snare has been sprung (Johansson et al., 2011). This greatly reduced our response time, allowing us to be at the capture site in an average of 40 min, and a maximum of 70 min after a cat had been snared.

Trapped snow leopards were chemically immobilized with a combination of TZ (Telazol, 286 mg tiletamine+286 mg zolazepam, Fort Dodge Laboratories, Inc., Fort Dodge,

Iowa, USA) and MED (Domitor vet 1 mg/mL, Orion Pharma Animal Health, Espoo, Finland). The drugs were mixed to a concentration of 50 mg zolazepam, 50 mg of tiletamine, and 0.9 mg of medetomidine/mL by adding 5 mL of Domitor to one vial of Telazol (the drug combination henceforth referred to as MTZ). Drugs were administered by 1.5-mL dart syringes with a 1.5×30-mm collared needle (Daninject, Borkøp, Denmark) fired from a CO_2-powered rifle (Daninject J.M. Special) fitted with a red dot sight (Aimpoint Comp, Aimpoint, Malmö, Sweden) and a powerful light (NexTorch T6A, NexTorch, Guangdong, China).

One person approached the captured snow leopard and darted it from a distance of 7–15 m, and the capture site was vacated immediately to avoid stressing the animal. After 6–7 min, the animal was approached to ensure that it was not lying in a position that could obstruct its airways. If unsuccessful anesthesia was confirmed (animal movements observed), the animal was left for another 5 min. If still unanesthetized for any reason (e.g., unsuccessful drug delivery/induction, or dart placement), another full dose was administered, approximately 13–15 min after the first dart.

Handling and monitoring

The anesthetized animal was placed in lateral recumbency on an insulated blanket (Fjellduken, Jerven AS, Odda, Norway). If body temperature fell below 36.5 C, the blanket was folded over the animal, and rubber hot-water bottles were placed in the groin and axillaries. Eye gel (Viscotears, CIBA Vision AG, Hetlingen, Switzerland) was applied to the cornea, and the animal was blindfolded to protect its eyes from dust and light. In cases where the capture site was deemed unsafe for cat recovery (steep slopes in more than one direction close to the snare), the anesthetized animal was moved to a predetermined handling and awakening site.

Standard body measurements were taken, and blood, hair, and ear swabs were collected for serologic, genetic, and parasitologic analyses. Age was estimated based on body weight, size, and tooth wear (Stander, 1997). Smaller wounds (either capture related or from precapture events) were cleaned with 2% iodine solution, and, if deemed appropriate, a 500-mg dose of amoxicillin (Betamox, 100 mg/mL, Norbrook Laboratories Ltd., Carlisle, UK) was administered intramuscularly. Female snow leopards were visually inspected for signs of current or previous lactation. The animals were equipped with GPS collars (North Star, King George, Virginia, USA or GPSPlus, Vectronic, Berlin, Germany) programmed to record the animal's location every 5 hr and uplink the data via Globalstar satellites. Data from the GPS collars were monitored to ensure postcapture recovery.

Accurate drug induction times were not recorded because we waited out of sight to minimize disturbing the darted snow leopards. Instead, we recorded the time from dart impact to when we approached the snare and were able to handle the snow leopard. Once fully sedated, vital rates were measured and recorded approximately every 10 min throughout the anesthesia. Rectal temperature was monitored with a digital thermometer. Respiratory rate was measured by counting the number of chest movements for 30 sec. Heart rate and relative hemoglobin oxygen saturation (SpO_2) were measured throughout the anesthesia with a pulse oximeter (Nellcor N65 Oximax handheld pulse oximeter, Nellcor Inc., Boulder, Colorado, USA) by attaching the sensor (Vetsat, Nellcor Inc.) to the ear. Capillary refill times were estimated but not recorded, as an extra parameter of blood circulation. To reverse the effect of MED, atipamezole hydrochloride (Antisedan vet 5 mg/mL, Orion Pharma Animal Health) was administered intramuscularly in the quadriceps or triceps at a dose five times higher than the medetomidine dose. Duration of anesthesia was defined as the time from when the last dart was fired to the time when the snow leopard first raised its head after collaring (head-up time). Time to recovery and time to walking were defined as the time from injection of the reversal drug to the head-up time and the time from injection of the reversal drug to the animal walking steadily. In case of a spontaneous recovery toward the end of the anesthesia, a full dose of antidote was nevertheless administered before releasing the animal.

Statistical analysis

The data were analyzed using mixed linear models in the statistical software R 2.12.1 (R-Development Core Team, 2010) with package lme4. We included snow leopard individuals and capture events as random factors, as some individuals were captured more than once and some measurements were taken several times during a capture event. Reported mean values of drug dose and physiologic parameters are for each capture. The effect of time on the variables was tested with a *t*-test ($df=16$, number of individuals: 2), testing whether the slope was significantly different from 0. Alpha was set to 0.05.

TABLE 1. Description of individual snow leopards (*Panthera uncia*) captured and immobilized in Tost Mountains of South Gobi Province, Mongolia, August 2008–April 2012. Snow leopards were weighed using a digital scale with an accuracy of 0.1 kg; hobbles were placed around the front and hind legs, and two researchers lifted the animal. Weight is given as a range when the same individual was caught more than once. Age estimates are based on tooth wear and body size.

ID	Sex	First capture	No. immobilizations	Weight (kg)	Estimated age first capture (yr)
M1	M	August 2008	8	37–45	4–6
M2	M	September 2008	2	44	5–7
M3	M	February 2009	5	42–45	4–6
M4	M	April 2009	5	33–39	2–3
M5	M	April 2009	1	33	2–3
F1	F	May 2009	1	30	2–3
M6[a]	M	July 2009	1	30	3–5
M7	M	February 2010	1	39	3–4
M8	M	April 2010	3	33–40	2–3
F2[b]	F	May 2010	1	25	2
F3	F	August 2010	2	37–42	5–7
F4	F	October 2010	1	36	4–6
F5	F	April 2011	2	30	2–3
F6	F	April 2011	3	37	4–6
M9[c]	M	October 2011	1	31	1.5
M10	M	April 2012	2	43–44	3–4
F7	F	April 2012	2	36	7–9
F8	F	April 2012	1	34	2–3

[a] Caught in wolf trap.

[b] Offspring of F4.

[c] Offspring of F3, still travelling with his mother at time of capture.

RESULTS

Trapping

We trapped snow leopards in 10 areas between August 2008 and April 2012. We captured 17 snow leopards, nine males and eight females, on 41 occasions. In addition, one male (M6) was anesthetized and released from a steel-jaw wolf trap set by local herders. Immobilization data from this anesthesia were also included in the analysis. Physiologic data were collected for 37 captures. On five occasions, ambient temperature was between −18 to −23 C (without considering wind chill), which precluded recording of physiologic data for safety reasons. On those occasions, we only fitted the collars. Forty captures occurred at night or early morning, and one capture occurred during daytime. Eight snow leopards were caught once, the other nine were captured between two and eight times each. A livestock herder killed M2 3 mo after he was collared. The other three adult males caught early in the study (M1, M3, and M4) had the highest capture frequency (eight, five, and five times, respectively; Table 1).

Drug doses

The first two snow leopards (M1, M2) were anesthetized with 60 mg of TZ (1.69 mg/kg and 1.36 mg/kg, respectively) and 0.54 mg of MED (0.015 mg/kg and 0.012 mg/kg, respectively). M2 was not adequately anesthetized to be handled on the first attempt, so the dose was increased to 70 mg TZ (1.67 mg/kg) and 0.63 mg MED (0.015 mg/kg) in the following three captures (all of male M3), resulting in anesthesia durations of 53, 36, and 85 min, respectively. Thereafter, the dose was further increased to 80 mg TZ (mean 2.25±0.44 mg/kg) and 0.72 mg MED (mean 0.020±0.004 mg/kg) for the next 37 captures.

TABLE 2. Drug doses and physiologic response of anesthetized snow leopards (*Panthera uncia*) captured and immobilized in Tost Mountains of South Gobi Province, Mongolia, August 2008–April 2012. Values for *t* and *P* are from *t*-tests.

Parameter[a]	Mean±SD	Range	Slope[b] ±SE	*n*	*t*	*P*
MED (mg/kg)	0.020±0.004	0.015–0.032		36	–	–
TZ (mg/kg)	2.17±0.45	1.67–3.53		36	–	–
Induction time (min)	10±4	5–19	NS	30	0.47	>0.4
Duration anesthesia (min)	69±13	35–94	NS	31	0.66	>0.25
Rectal temperature (C)	38.1±0.7	34.9–40.5	–0.04±0.003 C/min	130	14.6	<0.0001
Heart rate (beats/min)	97±9	51–124	–0.20±0.034	126	5.82	<0.001
Respiration (breaths/min)	26±6	16–42	–0.11±0.032	84	3.85	<0.01
SpO_2 (%)	91±4	71–99	0.06 (±0.022) %/min	115	2.71	<0.05

[a] MED = medetomidine; TZ = tiletamine-zolazepam (doses are mg/kg body weight); SpO_2 = relative oxygen saturation in hemoglobin measured with a pulse oximeter.

[b] Change in physiologic parameter per minute, derived using mixed linear models; NS = not statistically significant.

Induction, duration of anesthesia, and recovery

When approached, the captured snow leopards lay flat on the ground. If the darter came closer than 8 m, they lunged in an attempt to escape. Once darted, and upon the retreat of the darter, the animals generally remained silent, indicating that they remained still during induction. Mean estimated induction time for all drug doses used was 10 min. The induction time was not significantly related to drug dose (Table 2). Average duration of anesthesia was 69 min, and mean (±SD) time to recovery from administration of antidote to the snow leopard raising its head was 5±11 min (range 5–53 min). In 20 of the 42 anesthetic procedures, the snow leopards awoke spontaneously before the antidote was administered. In 18 such cases, the recovery was slow, with 3–6 min of eye blinking and slow head movements, providing ample time to administer the antidote. One young female (F5) stood up within 1 min after the first signs of spontaneous recovery and had to be physically restrained to receive the antidote both times she was captured. It took, on average, 4±7 min (range 2–19 min) from the time the antidote was given until the snow leopard raised its head and another 6±7 min (range 1–31 min) until it was walking steadily (Table 2).

Physiologic response

Trends in physiologic responses of anesthetized snow leopards are summarized in Table 2 and Figure 1. Rectal temperature, heart rate, and respiratory rate decreased significantly during anesthesia, whereas relative hemoglobin oxygen saturation (SpO_2) increased. Mean values were first calculated for each capture and averaged. The mean rectal temperature was 38.1 C for the entire immobilization period. One snow leopard (F5) exhibited moderate hyperthermia (body temperature >40 C). This occurred during the only daytime capture in our study. The lowest body temperatures (34.9, 35.5, and 35.8 C) were recorded on three relatively warm nights, but with strong winds, approximately −5 C ambient temperature and an estimated wind speed of 60–80 km/hr. Mean heart rate for all snow leopards was 96 beats per minute (bpm). One recording showed a heart rate of 51 bpm, and all other recordings exceeded 70 bpm. The mean respiratory rate (breaths per minute) was 26 for the entire immobilization period, and the respiratory rate decreased throughout the anesthesia. No shallow breathing was observed during anesthesia. SpO_2 had a mean value of 91 for the entire immobilization period. The values ranged between 71 and 84 during the first two

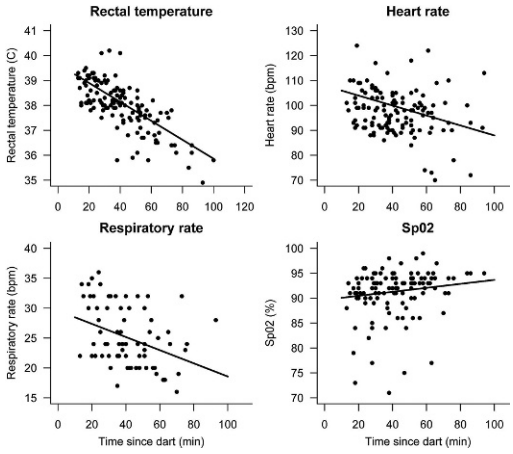

FIGURE 1. Temporal trends in physiologic parameters of anesthetized free-ranging snow leopards (*Panthera uncia*). Rectal temperature, heart rate, respiratory rate, and SpO_2 (relative oxygen saturation in hemoglobin) were measured during 37 captures in Tost Mountains, South Gobi, Mongolia. Data were analyzed using mixed linear models where capture event and individual were treated as random factors.

captures; thereafter, no value below 84 was recorded. Capillary refill time never exceeded 2 sec, and in most cases was around 1 sec. Muscle relaxation was within normal range, and no excessive salivation, retching, or vomiting was observed.

Capture-associated lesions and mortalities

In eight captures, the snow leopards experienced mild superficial skin abrasions, small cuts, or between two and four fissured claws (mild onychoschisis). In one adult female (F4, accompanied by her collared daughter), seven claws were fissured, and lesions were deemed moderate to severe. No mortality occurred within 3 mo after any anesthesia event.

DISCUSSION

The drug combination and dose we employed generated safe and efficient anesthesia in wild snow leopards with clinically acceptable physiologic responses. Observed side effects included mild hypoxemia (SpO_2 readings <90%; Kreeger and Arnemo, 2012). Specifically, a standard dose of 80 mg TZ and 0.72 mg MED provided safe immobilization for average-size (weight 25–45 kg) adult and subadult snow leopards. A standard dose that works on most individuals without having to estimate their weight is useful, as body weight estimation prior to darting can be subjective and made more difficult by the animal's behavior or capture circumstances (e.g., in the case of snow leopards lying flat when approached or body partially hidden behind a rock or other obstruction). The dose used in this study may need to be adjusted for animals outside the weight range of the snow leopards that we captured.

We believe that the key to avoiding injuries and mortalities when capturing animals with foot-snares is to minimize the time the animal spends in the snare. Before employing the automatic trap surveillance system, we observed some mild injuries. However, after we began to use the system, and the response times lowered to about 40 min, we observed no injuries in 15 subsequent captures.

Induction

Induction time was defined as the interval between darting and recumbency with lack of responsiveness to tactile stimuli. Because we did not monitor the snow leopards continuously after darting, but let several minutes pass between the observations, the presented induction times are overestimates, and the true induction times could be 3–4 min shorter. Despite this overestimation, induction times were short and similar to other free-ranging felids immobilized with the same drug combination. Two previous studies report the mean induction time for free-ranging African lions to be 14 min ($n=6$) and 5.9 min ($n=17$) when immobilized with medetomidine and tiletamine-zolazepam (Fahlman et al., 2005; Jacquier et al., 2006). Captive snow leopards immobilized with medetomidine and ketamine had similar induction times as the wild snow leopards in our study (Jalanka, 1989a).

Duration and recovery

The duration of anesthesia was adequate for equipping snow leopards with collars, recording biologic data, and sampling blood and hair. Longer duration has been reported in free-ranging lions (Jacquier et al., 2006; Fahlman et al., 2005) and cheetahs (*Acinonyx jubatus*; Deem et al., 1998) immobilized with the same drug combination, although those investigators used higher MED and lower TZ doses than we did. The higher dose of MED most likely explains the longer duration. Also, when ambient temperature was favorable and the capture site was considered to be safe, we minimized the duration by providing the antidote as soon as possible, thus reducing the anesthetized state. In situations where ambient temperature and wind speed could have cooled down the snow leopard rapidly while recovering, or where the surrounding terrain of the capture site was steep, we chose to keep the animal anesthetized until it showed signs of recovery (eye blinking or head movements). This led to the relatively high number of spontaneous recoveries we observed. It is noteworthy that none of the snow leopards exhibited any aggressive behavior towards the capture team.

As the snow leopards recovered, they invariably walked toward steep slopes. In rugged terrain or in areas with open water, an animal that is still under influence of drugs is at risk of injury or mortality. Therefore, it is desirable to ensure that sedated animals recover in relatively safe terrain, away from cliffs or water sources, although completely avoiding steep terrain is not possible with snow leopards, because that is their prime habitat.

Physiologic response

An initial elevation in body temperature is to be expected due to stress when free-ranging animals are captured. The gradual decrease in body temperature, as was observed in this study, is also to be expected and reflects the bradycardia and bradypnea caused by the drugs (Plumb, 2008), and it was further increased by low ambient temperatures and wind. We did not measure wind speed, but we believe it had a much higher influence on the body temperature than just ambient temperature. In approximately half of the captures, we warmed the animals with blankets, hot water bottles, or body heat once body temperature went below approximately 36.5 C. Similar effects of ambient temperature and drugs have been reported in captured and immobilized free-ranging wolverines (*Gulo gulo*; Fahlman et al., 2008) and gray wolves (*Canis lupus*; Ballard et al., 1991).

The steady declines in heart and respiratory rates we observed were expected, and they can be attributed to diminishing effect of the drugs (Plumb, 2008). There is, to our knowledge, no previous information on respiratory rates of free-ranging snow leopards. We recorded a respiratory rate of 13–16 breaths per minute in two sleeping, captive snow leopards in a zoo (Johansson, unpubl. data). In our study, the anesthetized snow leopards had a substantially higher respiratory rate, interpreted as a physiologic response to the elevation in body temperature (Fahlman et al., 2011).

Baseline data for heart rates in wild snow leopards are lacking. The effect of stress and the tiletamine presumably caused an initial mild to moderate tachycardia, which was possibly exacerbated by MED, as has been reported in lions (Fahlman et al., 2005). Hence, we believe that the heart rates during anesthesia were within clinically acceptable ranges. All oxygen saturation (SpO_2) values were above 84%, except for recordings made during the first two anesthetic events (which were of lower dosages than other captures). We believe this was the result of incorrect probe attachment to the animal's ear in the first two events, due to the initial inexperience of the field personnel in handling the device.

Fahlman et al. (2010) showed that hypoxemia can occur despite good SpO_2 values and recommended monitoring of arterial blood gases and providing a constant supply of oxygen. The reliability of pulse oximetry has been discussed in humans as well as animals, and differences between actual arterial values and externally monitored pulse oximetry values have been reported (Yelderman and New, 1983; Hendricks and King, 1993). However, it is prudent to monitor the trend of recorded values of SpO_2 in order to detect when supplemental oxygen, or other actions, is needed.

Management implications

The drug dose of approximately 2 mg/kg tiletamine-zolazepam and 0.02 mg/kg medetomidine used in this study provided safe anesthesia of wild snow leopards in adverse climatic conditions for approximately 45–60 min. The mean induction time of 9.8 min was safe for the animals in this study, though their ability to move during induction was restricted by the snare. In situations where snow leopards can move freely after being darted, a more rapid induction may be required. Snow leopards subjected to higher doses may need to be kept in a cage or otherwise constrained until fully recovered from the drugs because recovery may be prolonged, and the cats may be subject to greater risk of injuries in the mountainous terrain. When preparing to capture snow leopards, it is important to focus on safety measures and to keep the animal warm to avoid hypothermia. Notably, in our only daytime capture, the animal expressed mild hyperthermia. Therefore, on warmer days, it is equally important to carry equipment to lower the animals' body temperature if needed.

Values for physiologic variables for all parameters were within clinically acceptable limits and in our opinion not harmful to the animals. However, in order to treat any sign of hypoxemia, the use of supplemental oxygen is recommended. In this study, logistic constraints such as extreme remoteness, limited staff number, and small capacity to store and analyze samples prevented us from exploring supplemental oxygen and arterial blood gas sampling and analysis.

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