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IMMOBILIZATION OF FREE-RANGING HOFFMANN'S TWO-TOED AND BROWN-THROATED THREE-TOED SLOTHS USING KETAMINE AND MEDETOMIDINE: A COMPARASION OF PHYSIOLOGIC PARAMETERS

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ABSTRACT: Free-ranging Hoffmann's two-toed sloths (*Choloepus hoffmanni*; $n=26$) and brown-throated three-toed sloths (*Bradypus variegatus*; $n=15$) were manually captured and immobilized with 2.5 mg/kg ketamine + 0.02 mg/kg medetomidine administered intramuscularly. Physical examinations were conducted on each sloth 10 min after initial injection, and blood, fecal, and ectoparasite samples were collected. Heart rate, respiratory rate, body temperature, indirect systolic blood pressure, and indirect peripheral oxygen saturation were monitored every 5 min for the duration of anesthesia. After 45 min, atipamazole (0.1 mg/kg) was administered intramuscularly, as an antagonist to medetomidine, in order to facilitate recovery. All recoveries were smooth, rapid, and uneventful. Physiologic parameters were compared across time, gender, and species. All sloths, regardless of species and gender, demonstrated a time-dependent decrease in heart rate and blood pressure, and an increase in respiratory rate, during the course of anesthesia. Peripheral oxygen saturation was similar for all sloths over time. There were significant species differences for heart rate (*Choloepus* > *Bradypus*), respiratory rate (*Choloepus* > *Bradypus*), and systolic blood pressure (*Bradypus* > *Choloepus*), while there were significant gender differences for body temperature (males > females) and blood pressure (males > females). Results of this study suggest that the ketamine–medetomidine mixture, as described above, is a safe and effective anesthetic combination in free-ranging two- and three-toed sloths, although peripheral blood pressure should be monitored during anesthesia.

Key words: Atipamazole, *Bradypus variegatus*, *Choloepus hoffmanni*, immobilization, ketamine, medetomidine, physiology, three-toed sloth, two-toed sloth.

INTRODUCTION

Sloths comprise the largest mammalian biomass in neotropical rainforests (Eisenberg and Thorington, 1973), yet information is limited regarding anesthesia and physiologic monitoring in these animals. One previously published study of injectable anesthetics in free-ranging two-toed sloths (*Choloepus didactylus*) recommended the use of ketamine in combination with an alpha$_2$-agonist for both handling and basic clinical procedures (Vogel et al., 1998). Less is known about anesthesia and its physiologic effects in three-toed sloths (*Bradypus* spp.).

As an alpha$_2$-agonist, medetomidine is more potent and receptor-specific than xylazine (Vainio et al, 1989). It has been used to anesthetize a wide range of nondomestic species, especially in combination with dissociative anesthetics (Jalanka and Röken, 1990; Vogel et al., 1998; Sladky et al., 2000; Larsen et al., 2002; Heard et al., 2006). Adverse effects associated with medetomidine include bradycardia, hypertension, respiratory depression, and hypothermia (Jalanka and Röken, 1990; Kreeger et al., 1996; Vogel et al., 1998; Sladky et al., 2000; Larsen et al., 2002). Medetomidine is rapidly and completely antagonized by administration of atipamazole, a specific alpha$_2$-antagonist (Jalanka and Röken, 1990; Kreeger et al., 1996).

The objective of this study was to compare the physical and physiologic effects of ketamine–medetomidine (KM) anesthesia over time, and between species and genders of two- and three-toed sloths, under field conditions in Costa Rica.

MATERIALS AND METHODS

All data collection occurred at Finmac Cacao Plantation in northeast Costa Rica (La Rita District, Limon Province; 10°19′01.88″N, 83°35′34.03″W).

The mean ambient temperature during the collection period was 28.69±2.57 C. Fifty-four free-ranging two-toed and three-toed sloths were captured using teams of observers and by locating individual sloths using transmissions from previously placed radio collars. Sloths were manually captured and immediately placed into burlap sacks, followed by transport to a central-processing location where the sloth-containing sacks were hung from hooks on a wall.

A total of 41 sloths (*Bradypus variegates*, n=15 and *Choloepus hoffmanni*, n=26) were captured and anesthetized. Body weights were determined using a hanging scale, and appropriate drug dosages were calculated. In order to calculate drug dosages for females-with-young, weights were estimated; actual weights were determined once females were anesthetized. *Bradypus variegatus* masses ranged from 1.2–5.0 kg and *C. hoffmanni* ranged from 2.0–7.0 kg. Pre-anesthetic heart and respiratory rates were collected using a stethoscope and direct observation of respirations. Animals were injected directly through natural holes in the burlap sacks, which had been suspended off the ground. The first two *C. hoffmanni* received an intramuscular (IM) dose of ketamine hydrochloride (100 mg/ml; Ketavet®, Revetmex, Colonia Prado Churubsco, Deleg. Coyoacan, Mexico) at 2.5 mg/kg in combination with medetomidine (1 mg/ml; Domitor®, Pfizer Animal Health, Exton, Pennsylvania, USA) at 0.025 mg/kg, but a marked hypertension and bradycardia prompted a decrease in the medetomidine dosage. The protocol was modified for the remaining sloths, with the dosage of ketamine remaining at 2.5 mg/kg and the medetomidine dosage decreased to 0.02 mg/kg. Ten minutes after initial drug administration, the restraint sacks were opened and the level of anesthesia was assessed. An appropriate anesthetic plane was determined by complete muscle relaxation, loss of palpebral reflex, loss of jaw tone, lack of spontaneous movement, and lack of response to handling and removal from the sack. Animals partially sedated (n=4) were given supplementary drugs based on subjective assessment of their level of anesthesia. All of these animals displayed spontaneous movements and mild-to-moderate muscle tone. Nine sloths displayed no sedative effect from the initial injection. The complete lack of anesthetic effect in these animals was attributed to unsuccessful drug administration rather than to a failure of the KM; animals were injected through holes in a burlap sack and a few injections were administered by less-experienced personnel. Therefore, the lack of any anesthetic effects at 10 min was recorded as a failure of injection, and a full, second dose of KM was administered.

Once fully anesthetized, sloths were removed from their restraint sacks and physical examinations were completed. Blood samples were collected for assessment of standard physiologic parameters, and morphometric measurements and fecal, hair, and ectoparasite samples were obtained. A passive integrated transponder tag (ID 100US, Trovan Ltd., Santa Barbara, California, USA) was placed subcutaneously between the shoulder blades for future identification, and lactated Ringer's solution was administered subcutaneously (100 ml/animal).

During each anesthetic event, the following physiologic parameters were monitored at 5 min intervals: heart rate, respiratory rate, body temperature, indirect systolic blood pressure (BP), and indirect peripheral oxygen saturation (SpO$_2$). Heart rate was measured using cardiac auscultation and rate of respiration by direct observation. Body temperature and SpO$_2$ were measured using a combination pulse oximeter and a separate rectal thermometer (V3395, SurgiVet Inc., Waukesha, Wisconsin, USA) with the pulse oximeter probe placed on the tongue, on the prepuce, or within the rectum. Blood pressure was measured by first placing a Doppler flow probe (Model 811-B, Parks Medical Electronics, Aloha, Oregon, USA) on the radial artery. A pediatric pressure cuff (Pedisphyg™ 5 cm cuff; CAS Medical Systems, Branford, Connecticut, USA) was then placed on the forelimb and attached to a sphygmomanometer (Welch Allyn Medical Products, Skaneateles Falls, New York, USA).

Following a minimum of 45 min after initial injection, 0.1 mg/kg atipamazole (5 mg/ml; Antisedan®, Pfizer Animal Health) was administered IM to antagonize the medetomidine. At the first signs of spontaneous movement, sloths were returned to their restraint sacks and observed for at least 1 hr before release back to their original capture site. All sloths recovered from the anesthetic events uneventfully.

Data from six *C. hoffmanni* were excluded from statistical analysis; two received higher dosages of medetomidine and four required supplemental doses of anesthetics. Additionally, gender of four *B. variegatus* and one *C. hoffmanni* were not determined due to young age or incomplete data, and these animals were also excluded from analyses.

Data were analyzed using PROC MIXED of the SAS® Software (SAS® Institute, Cary, North Carolina, USA). Separate, repeated-measures analysis of variance (ANOVA) models, with first-order autoregressive correlation structures, were fit to each physiologic parameter. Each model contained factors for species, gender, time (min post-administration of anesthetic, from 0–45 min, in 5 min intervals), and all associated interactions. Post-ANOVA pair-wise comparisons of least-squares means were corrected for multiple comparisons using the Tukey-Kramer method. For all parameters except for respiratory rate, plots of the residuals from the models indicated that the assumptions of normality and constant variance across groups were met. One extreme outlier, 140 respirations per minute (RPM), was excluded on the basis of a recording error. Square-root transformation was used on the remaining respiratory rate data to meet the assumptions for testing purposes; however, means reported are in the original scale. The ANOVA models were used solely for comparison purposes; all values reported (mean±standard deviation [SD] or lowest mean±SD–highest mean±SD) were computed from the raw data. This was done so that, for a single observation, standard deviations represented the average deviation from the mean rather than from the mean of the entire cohort. Calculated P values <0.05 were considered statistically significant.

RESULTS

Based upon physical examinations and body condition, all sloths were considered healthy. Anesthetic depth was sufficient for all procedures, with good muscle relaxation achieved in 37 of 41 sloths. Four sloths had fair-to-poor muscle relaxation, but responded to supplemental anesthetic drugs, suggesting partial failure of initial injection. Subsequent tracking of the radio-collared sloths has shown no adverse effects or abnormal behavior associated with the anesthetic or diagnostic procedures.

For all sloths, mean respiratory rate was significantly higher pre-anesthesia (35.7±19.0 RPM) then at all time points during the anesthetic procedures (7.7±4.1–9.3±4.6 RPM), although respiratory rates did increase over time (7.7±4.1 at 10 min versus 9.3±4.6 RPM at 45 min). Once anesthetized, *C. hoffmanni* had significantly higher mean respiratory rates than *B. variegatus* (8.7±4.3–10.5±5.2 versus 5.6±2.4–8.0±3.3 RPM, respectively) (Table 1). There were no significant gender differences, gender-by-species, gender-by-time, species-by-time, or gender-by-species-by-time interactions.

Mean heart rate was significantly higher pre-anesthesia for all sloths (87.5±17.7 beats per minute [BPM]) compared to all time points during the anesthetic procedures (62.1±10.2–68.7±9.7 BPM). During the anesthetic procedure, mean heart rates decreased over time for all sloths (68.7±9.7 BPM at 10 min versus 62.1±10.2 BPM at 45 min). In addition, *C. hoffmanni* had significantly higher mean conscious heart rates than *B. variegatus* (94.9±17.5 versus 76.0±11.0 BPM) but once anesthetized, both species had similar mean heart rates (60.2±8.2–69.2±9.5 and 64.8±12.4–68.0±10.4 BPM, respectively) (Table 2). There were no significant species or gender differences, gender-by-time, or gender-by-species-by-time interactions.

Mean systolic BP was significantly higher in *B. variegatus* than in *C. hoffmanni* (124.2±34.2 mm Hg versus 104.6±19.7 mm Hg); higher in males than females (123.6±31.3 mm Hg versus 108.9±18.4 mm Hg); and, for all sloths, significantly higher in the first 25 min of the anesthetic episode compared to the final 20 min (115.7±27.7–130.1±29.0 mm Hg versus 103.2±28.8–111.5±26.0 mm Hg, respectively) (Table 3). When evaluating the

TABLE 1. Respiratory rate measured as respirations per minute (mean±SD), for male and female two- and three-toed sloths, induced with intramuscular ketamine (2.5 mg/kg) and medetomidine (0.02 mg/kg). The number in parentheses = n for that time point.

Time	*Bradypus variegatus*		*Choloepus hoffmanni*	
(min)	Male	Female	Male	Female
0[a]	36.7±21.8 (6)	27.0±10.5 (4)	27.0±8.7 (6)	39.2±20.1 (5)
10[b]	5.2±2.2 (6)	6.0±2.8 (2)	8.0±0.0 (7)	8.0±2.3 (7)
15[b]	5.3±2.1 (6)	8.0±5.7 (2)	8.5±1.4 (8)	8.6±5.1 (9)
20[b]	8.0±0.0 (6)	5.3±2.3 (3)	9.5±3.0 (8)	9.6±7.1 (10)
25[b]	6.3±2.1 (7)	4.3±3.5 (3)	11.0±3.5 (8)	9.2±5.7 (11)
30[b]	6.9±2.0 (7)	7.0±2.0 (4)	9.7±3.9 (7)	9.5±5.7 (11)
35[b]	5.6±2.3 (7)	7.0±2.0 (4)	9.0±4.1 (8)	9.4±4.9 (11)
40[b]	6.9±3.0 (7)	7.0±2.0 (4)	7.5±3.3 (8)	9.5±4.8 (11)
45[b]	8.6±3.6 (7)	9.3±2.3 (3)	11.0±5.7 (8)	9.7±5.2 (10)

[a] Represents significant difference between this time point and every other time point.

[b] Represents significant difference between species, but not gender at this time point.

species-by-time interaction, *B. variegatus* had higher BP than in *C. hoffmanni*, at every time point during anesthesia, except at the initial and final time points (15 and 45 min). When analyzing the species-by-gender-by-time interactions, male *B. variegatus* had higher BP than female *B. variegatus* at 15 min, higher than male *C. hoffmanni* at 15, 20, 30, and 40 min, and higher than female *C. hoffmanni* at all time points. There were no significant gender-by-species interactions.

There were no significant differences in mean peripheral oxygen saturation across all variables and interactions (93.1±5.0%). Male sloths had significantly higher mean rectal temperatures than females (34.72±1.43 C versus 33.80±0.98 C), but there were no other significant differences regarding body temperature.

After a minimum of 45 min anesthesia, sloths were administered intramuscular atipamazole to facilitate recovery. While time-to-recovery was not recorded, all sloths were placed back in their sacks generally within 5–10 min of atipamazole injection. Recovery was smooth and was indicated by initial limb movements, followed by head movements and a rapid return to full faculties. A number of sloths

TABLE 2. Heart rate measured as beats per minute (mean±SD), for male and female two- and three-toed sloths, induced with intramuscular ketamine (2.5 mg/kg) and medetomidine (0.02 mg/kg). The number in parentheses = n for that time point.

Time	*Bradypus variegatus*		*Choloepus hoffmanni*	
(min)	Male	Female	Male	Female
0[a]	78.0±9.4 (7)	72.0±8.0 (4)	90.5±16.6 (8)	95.3±16.7 (11)
10	64.0±5.7 (6)	61.3±6.1 (3)	67.5±11.8 (8)	68.9±5.6 (9)
15	64.5±6.4 (6)	53.7±16.6 (3)	63.9±8.5 (8)	70.0±6.3 (10)
20	66.0±6.0 (6)	52.7±18.1 (3)	62.8±8.3 (8)	63.7±7.3 (11)
25	66.1±10.0 (7)	50.3±10.0 (3)	62.6±8.1 (8)	62.9±8.3 (11)
30	63.3±3.7 (7)	54.5±11.5 (4)	62.3±8.6 (7)	62.8±7.9 (11)
35	66.6±8.3 (7)	53.3±11.5 (4)	61.1±8.0 (8)	62.6±7.8 (11)
40	66.7±10.5 (7)	50.8±8.1 (4)	61.9±7.0 (7)	60.5±8.0 (11)
45	64.1±9.7 (7)	50.5±2.1 (2)	60.8±7.4 (8)	59.8±9.3 (9)

[a] Represents significant difference between species, but not gender, at this time point.

TABLE 3. Systolic blood pressure measured in mm Hg (mean±SD), for male and female two- and three-toed sloths, induced with intramuscular ketamine (2.5 mg/kg) and medetomidine (0.02 mg/kg). The number in parentheses = n for that time point.

Time	*Bradypus variegatus*		*Choloepus hoffmanni*	
(min)	Male	Female	Male	Female
15[a]	167.6±20.9 (5)	91.0 (1)	121.4±22.2 (7)	129.7±13.0 (6)
20[b]	153.2±25.5 (6)	141.0±24.0 (2)	114.9±23.7 (7)	116.8±12.6 (6)
25[b]	146.3±28.6 (7)	138.7±15.0 (3)	108.6±16.9 (8)	108.8±14.4 (11)
30[b]	142.0±27.8 (7)	123.0±15.7 (4)	96.5±19.4 (8)	103.5±15.0 (11)
35[b]	142.0±28.5 (7)	115.0±11.6 (4)	99.7±15.9 (6)	97.9±15.7 (11)
40[b]	136.4±28.5 (7)	111.8±12.7 (4)	96.3±22.1 (8)	97.1±15.6 (11)
45	133.1±26.8 (7)	101.7±7.2 (3)	96.4±21.0 (8)	96.6±15.6 (9)

[a] Represents significant difference between gender, but not species, at this time point.

[b] Represents significant differences between species, but not gender, at this time point.

(approximately 15%) began to show spontaneous movements, prior to atipamazole administration, beginning approximately 40 min after initial KM injection. These sloths were given a full dose of atipamazole and their recoveries were also rapid and smooth.

As an example of the relative safety of KM, a free-ranging juvenile *B. variegatus* orphan, with severe facial trauma, was administered KM (2.86 mg/kg and 0.014 mg/kg) in order to debride and treat wounds. Despite being severely debilitated, the sloth was anesthetized and recovered uneventfully (C. Hanley, unpubl. obs.).

DISCUSSION

Ketamine–medetomidine inductions were characterized as smooth and rapid, with good muscle relaxation, in both two- and three-toed sloths. Physiologic parameters were consistent with initial hypertension, mild hypoxemia, and bradycardia. After a minimum anesthetic duration of 45 min, recoveries were unremarkable and rapid, generally within 10 min of administration of atipamazole. All sloths recovered completely and were subsequently released to the site at which they were initially captured, validating the safety and efficacy of KM in both two- and three-toed sloths under field conditions. In an ongoing study of sloth ecology, in which the same sloth population has been longitudinally monitored, there have been no reports of untoward effects in any of the sloths used in our study.

Respiratory depression was observed in all sloths after administration of KM, although respiratory rate increased with anesthetic duration, possibly as a function of ketamine and medetomidine metabolism. No sloths developed apnea, which has been previously described in two-toed sloths using KM (Vogel et al., 1998). Respiratory rate in conscious sloths doubled with feeding (Pedrosa et al., 2002) and varied with environmental temperature, agitation, alertness, and activity (Gilmore et al., 2000). Previous studies reported resting respiratory rates of 8 to 11 RPM in both free-ranging and captive two-toed sloths (Meritt, 1985) and 8.6±5.3 RPM in unrestrained three-toed sloths (Santos et al., 1998). Manual restraint, transportation, and initial manipulation in our sloths may have accounted for the higher pre-anesthetic respiratory rates of 32.5±15.5 and 38.7±21.9 RPM in *C. hoffmanni* and *B. variegatus*, respectively.

Bradycardia was observed in all sloths after KM administration. Pre-anesthetic heart rates were higher for *C. hoffmanni* than for *B. variegatus*, likely due to the higher level of observed agitation in the former. These results are consistent with previously published data (Britton, 1941). The mean conscious heart rate of *B. variegatus* in our study (76.0±11 BPM) was similar to that previously reported; 79.8±22.3 and 84±15 BPM (Duarte et al., 1982, 2004). In another study, wild *C. didactylus* anesthetized with KM had an initial mean heart rate of 61±15 BPM with a moderate decrease to 46±13 BPM (Vogel et al., 1998). In our current study, *C. hoffmanni* had higher mean heart rates while anesthetized (69.2±9.5 BPM at 10 min to 60.2±8.2 BPM at 45 min) compared to mean heart rates reported previously (61±17 BPM at 5 min to 47±10 BPM at 45 min; Vogel et al., 1998). This discrepancy may be explained by the different medetomidine dosages used in the two studies, 0.04 mg/kg compared to 0.02 mg/kg used in our study; or to species differences between *C. didactylus* and *C. hoffmanni*.

Based on the normotensive blood pressures recorded in previous studies (Duarte et al., 2003; Johansen et al., 1966), hypertension was observed initially in many sloths after KM administration, especially in *B. variegates*. Overall, in our study, systolic blood pressure varied significantly between species, gender, and time. The highest mean systolic pressures in all groups were recorded at 15 min post-KM administration. *Choloepus hoffmanni*, as well as female sloths of both species, were normotensive throughout the procedure, while *B. variegatus* and males in both species were hypertensive for the first 20 min. The phenomenon of initial hypertension after KM administration has been observed in other species as well (Vaino et al., 1989; Jalanka and Roken, 1990; Sladky et al., 2000; Larsen et al., 2002). In red wolves, for example, delaying the administration of ketamine after initial medetomidine administration reduces the early hypertensive effects, suggesting that there is a synergistic effect of the 2-drug combination that contributes to hypertension for the first 15–30 minutes after drug administration (Larsen et al., 2002). The low dosage of medetomidine used in our study may have limited the hypertensive side effects observed in other species (Sladky et al., 2000). Furthermore, the decrease in systolic blood pressures over time was potentially due to metabolism of the ketamine or the medetomidine. In a previous study, systolic blood pressure in unanesthetized three-toed sloths ranged from 147–230 mm Hg (Johansen et al, 1966). However, a later study reported that mean systolic/diastolic arterial blood pressure in conscious, relaxed three-toed sloths was 129/86 mm Hg (Duarte et al., 1982). The causes of result differences between these two studies are not clear, but may have been due to monitoring equipment used, or to adaptation of the subjects to captivity and testing. Alternatively, posture and its effect on heart rate and blood pressure have been previously studied in *B. variegatus*. Three-toed sloths (*Bradypus tridactylus*), tilted either from erect-to-supine or supine-to-erect body position, showed a significant increase in blood pressure and heart rate, which returned to baseline values within 4 min (Duarte et al., 1982). In our study, sloths were maintained in ventral or dorsal recumbency during the entire procedure; therefore, no postural changes occurred that could have affected blood pressure. Additionally, circadian rhythms may also affect physiologic parameters such as blood pressure. In one study of *B. variegatus*, higher blood pressures (systolic, diastolic, and mean) were recorded during the light period and were associated with feeding and movement (Duarte et al., 2003). In a different study of *B. variegatus*, heart rate was slower during the light period and was directly associated with a decrease in motor activity (Silva, 1996). Since neither study measured both heart rate and blood pressure, direct comparisons to our study are not possible. However, an increase in blood pressure would cause a reflexive drop in heart rate and vice-versa, such that each study compliments the other. In our study, circadian rhythms should not have been a confounding factor, as sloths were processed during the light period.

Indirect peripheral oxygen saturation, measured using a pulse oximeter, was relatively constant in both species—and across genders—during KM anesthesia and remained within a clinically safe range in all animals. These consistent results were unexpected under field conditions and confirm the relative safety of this anesthetic combination for both sloth species. In a previous study, SpO_2 was only 87% at the beginning of anesthesia and increased over time to 96% in *C. didactylus*; anesthesia was induced using KM at 3.0 mg/kg and 0.04 mg/kg, respectively (Vogel et al., 1998). In that study, three animals were potentially hypoxemic (SpO_2 <80%), although the authors reported no associated adverse clinical signs (e.g., tachycardia or cyanosis). Additionally, the authors reported significant difficulty in acquiring consistent and reliable pulse oximeter readings. In our study, we found that re-adjustment of the pulse oximeter probe resolved the problem in cases of apparent hypoxia, with subsequent readings of ≥90%. In three-toed sloths, a rectal reflectance probe was the most reliable method for obtaining consistent results, while both the rectal and tongue probes worked well in two-toed sloths. In male *C. hoffmanni*, placement of the finger probe on the prepuce was highly reliable. The difference between the data from our study and those of the previous study may be due to the difference in medetomidine dosages, lower peripheral blood pressures, sensitivity of the pulse oximeters (e.g., different models were used in each study), or to species-specific variation.

Although medetomidine may cause hypothermia in many mammal species (Jalanka and Röken, 1990; Vogel et al., 1998; Sladky et al., 2000; Larsen et al., 2002), the sloths in our study maintained constant body temperatures throughout the anesthetic procedure. In comparison, rectal temperatures in free-ranging *C. didactylus* decreased with increasing anesthetic duration (Vogel et al., 1998). The differences between the studies may be a function of KM dosage or of the fact that sloths are incomplete homeotherms; that is, their body temperature correlates closely with environmental temperature (Silva et al., 1996). Therefore, location of the study site, or time of the day or year, may contribute to body-temperature fluctuation in sloth species.

KM provided approximately 45 min of anesthesia, but some animals began to rouse spontaneously after 40 min. This was consistent with previous data describing the effects of KM anesthesia on two-toed sloths, during which KM provided an average of 42±9 min of anesthetic duration, with some spontaneous recovery described (Vogel et al., 1998).

Intramuscular ketamine (2.5 mg/kg), combined with medetomidine (0.02 mg/kg), provided safe and effective anesthesia in both two- and three-toed sloths, regardless of gender or age. This combination provided approximately 45 minutes of anesthetic duration, and the medetomidine was effectively antagonized with atipamazole (0.1 mg/kg). Changes in heart rate, respiratory rate, and indirect systolic blood pressure were consistent with the physiologic effects of this anesthetic combination observed in other species (Jalanka and Röken, 1990; Vogel et al., 1998; Sladky et al., 2000; Larsen et al., 2002). However, the physiologic changes observed in our study were mild and did not cause anesthetic complications, nor did they require intervention. Therefore, KM should be considered a safe anesthetic combination for use in two- and three-toed sloths undergoing handling or clinical and minor surgical procedures.

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