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CASE REPORT

Wildlife

Utilisation of dexmedetomidine, ketamine and midazolam for immobilisation and health assessment of captive white-bellied spider monkeys *(Ateles belzebuth)* in the Amazon rainforest of Iquitos, Peru

Edmundo Parada[1] | **Heather Schwartz**[2] | **Aaron Yiu Lam**[1] | **Oliver Baca-Montero**[3] | **Liesel Laubscher**[4]

[1]Rainforest Awareness Rescue and Education Center–RAREC, Loreto, Iquitos, Peru

[2]Nashville Zoo at Grassmere, Nashville, Tennessee, USA

[3]Facultad de Medicina Veterinaria y Zootecnia, Universidad Nacional Autónoma de México, Ciudad de Mexico, Mexico

[4]Wildlife Pharmaceuticals, White River, Mpumalanga, South Africa

Correspondence
Edmundo Parada, Rainforest Awareness Rescue and Education Center–RAREC, Loreto, Iquitos, Peru.
Email: edmundoparadalopez@gmail.com

Abstract

This study presents data collected from 41 captive white-bellied spider monkey *(Ateles belzebuth)* immobilisations conducted between 2022 and 2024. The anaesthetic protocol employed consisted of dexmedetomidine (0.04 mg/kg), ketamine (5 mg/kg) and midazolam (0.25 mg/kg), with supplementary intramuscular doses dexmedetomidine (0.02 mg/kg) and ketamine (2.5 mg/kg) administered as needed. The protocol demonstrated fast and efficient induction times, with no reported complications, indicating its safety and efficacy. During immobilisation, all animals were placed in dorsal recumbency, with monitored physiological parameters including heart rate, respiratory rate, temperature, SpO_2 and capillary refill rate. Additionally, blood samples were collected for haematology and biochemistry analysis. The dose of atipamezole administered was 10 times that of dexmedetomidine. Data on time to recumbency, duration of immobilisation, recovery times and post-antagonist drug administration recovery were recorded. Moreover, details regarding the type of restraint and pre-anaesthetic activity level were included in the analysis.

KEYWORDS

anaesthesia, dexmedetomidine, haematology, ketamine, midazolam, spider monkey

BACKGROUND

The white-bellied spider monkey (*Ateles belzebuth*) is a New World Primate (NWP) distributed across Colombia, Venezuela, Peru, Ecuador and Brazil. Seventy percent of their diet comprises of over 120 plant species and their fruits, which they consume whole, playing a critical role in seed dispersal.[1] Currently, this species is classified as endangered due to poaching, habitat loss and the pet trade, necessitating human intervention for their protection and conservation.[2]

Health assessments are crucial for the well-being of captive primates. However, challenges exist in obtaining accurate biochemical and haematological values for various NWP species. While such data are available for other NWPs like the black-handed spider monkeys (*Ateles geoffroyi*) and black howler monkeys (*Alouatta pigra*),[3,4] there is a notable absence of blood parameter data for the white-bellied spider monkeys.

As one of the largest NWPs, white-bellied spider monkeys pose potential risks to handlers as well as risks associated with anaesthesia and immobilisation, which have not been fully described.[5] This underscores the necessity of developing safe and effective sedation methods, especially as the decline in their population increases the need for captivity interventions.

Few protocols have been investigated and fully described for the immobilisation of NWPs. Tiletamine-zolazepam has been used with varying degrees of sedation and anaesthesia in black spider monkeys (*Ateles paniscus chamek*).[6] Similarly, the combination of midazolam and butorphanol, with either ketamine or dexmedetomidine, has proven effective in sedating the howler monkeys (*Alouatta guariba clamitans*).[7] Furthermore, studies have provided reliable insights into successful use of ketamine and medetomidine protocols for immobilising captive chimpanzees.[8]

Given the lack of information on protocols for quick-acting and prolonged sedation in white-bellied spider monkeys, it is crucial to investigate and report on these protocols to provide valuable information for veterinary practitioners. The combination of ketamine with $\alpha 2$ agonists or benzodiazepines, which has been widely used in other species,[5] could offer a safe anaesthetic solution for both the monkeys and their handlers.

The aim of this study was to report on the anaesthetic efficacy and side effects of a dexmedetomidine, ketamine and midazolam protocol for immobilising white-bellied spider

monkeys. Additionally, it seeks to establish haematology and biochemistry values for this species, obtained during routine health assessments at the Rainforest Awareness Rescue and Education Center (RAREC).

CASE PRESENTATION

This research was conducted at RAREC, located in the Amazon jungle approximately 47 km from Coronel FAP Francisco Secada Vignetta International Airport in Iquitos, Peru. Established in 2011, RAREC rescues and rehabilitates endangered Amazonian wildlife, provides community education, and advances scientific knowledge for Amazon Rainforest preservation. RAREC operates as a licensed rescue centre and a registered non-profit institution.

Immobilisation records of white-bellied spider monkeys from 2022 to 2024 were analysed. The monkeys were housed in two enclosures. The main enclosure (20 × 20 × 15 m) housed 11 individuals and included four additional management cages of varying sizes: one measuring 3 × 3 × 2.5 m, one measuring 5 × 5 × 4 m, and two measuring 10 × 3 × 4 m. The second enclosure housed four individuals with a main area of 15 × 15 × 15 m and a management cage measuring 5 × 3 × 2.5 m.

All enclosures were equipped with ample platform areas in the aerial space to ensure the comfort of the individuals. Shelters provided protection from the elements, and hiding spaces offered privacy.

A handmade aluminium blowgun was used to immobilise the animals. Darts (3 mL) from Teledart with a 1.5 mm plain needle were used to administer the immobilising medicines, which consisted of dexmedetomidine (0.04 mg/kg; Dexmedesed 0.5 mg/mL, Dechra Veterinary Products), ketamine (5 mg/kg; Quetamin 100 mg/mL, Laboratorios Biomontu) and midazolam (0.25 mg/kg; Midanex 5 mg/mL, Laboratorios AC Farma). The weight of the animal used for dose calculation during the first immobilisation was estimated based on the visual appearance of the monkeys and the experience of the veterinarian in charge. For subsequent anaesthetic procedures, the actual bodyweight that had previously been recorded was used.

In cases where the initial injection failed due to inaccurate targeting or dart malfunction, a backup dart with the same immobilising mixture was employed. If the initial dart partially sedated the monkey, a follow-up dart with half the dose was administered. All procedures were performed during routine check-ups, and most subjects were healthy. Only six individuals required a supplementary anaesthetic dose after darting.

The animals were fasted from food and water 12 hours before procedure, and following immobilisation, they were placed on a concrete table under a blanket, positioned in dorsal recumbency with their eyes covered, and vital signs (SpO_2, temperature, respiration rate and heart rate) were monitored. Ideally, the animals were placed on an intravenous line for the administration of emergency medications. This was never required.

After completing the procedures, all animals received 0.25–0.40 mg/kg atipamezole hydrochloride (Antisedan 5 mg/mL, Zoetis) intramuscularly in the triceps brachii muscle region.

LEARNING POINTS/TAKE-HOME MESSAGES

- The dexmedetomidine, ketamine and midazolam protocol provides fast induction (2–7 minutes) and adequate recovery times (31–74 minutes) for white-bellied spider monkeys, ensuring safety and efficacy.
- The protocol maintains stable heart rate, respiration and oxygen saturation during anaesthesia.
- Haematology and biochemistry profiles align with those of other New World Primates, offering valuable baseline data.
- The protocol is effective for routine health assessments and escape recovery, showcasing protocol versatility.
- Ongoing studies are essential to refine anaesthesia protocols and improve captive spider monkey welfare.

The atipamezole was calculated as 10 times the dexmedetomidine dose that the animal received. They were then placed in a carrier until fully awake, and subsequently reintegrated into the troop after being offered their afternoon diets in a management cage.

The spider monkeys, known for their intelligence, exhibited recall of previous darting experiences, leading to avoidance behaviours during subsequent attempts. Employing swift and effective immobilisation techniques was crucial to minimise the stress of the animals. The design of the enclosures allowed staff to move the monkeys into smaller management cages, facilitating safer and easier darting. To further reduce stress, staff maintained a composed demeanour and employed occasional distraction techniques when necessary.

The purpose of immobilising these spider monkeys was to conduct routine check-ups, including pre-anaesthetic activity evaluation, transport to the clinic, full physical exams, blood sample collection for haematology and biochemistry profiles and images of each individual's face and limbs were taken to update their medical records. Physiological parameters during the anaesthetic protocol were recorded using a domestic animal monitor (CONTEC08A-VET, Contec Medical Systems) for non-invasive blood pressure and SpO_2 measurement, stethoscopes (Littmann Classic III), thermometers and ultrasonography (Butterfly IQ2, Butterfly Network).

INVESTIGATIONS

Analysis was done retrospectively on the dataset collected from 2021 to 2024.

DIFFERENTIAL DIAGNOSIS

Not applicable.

TREATMENT

The anaesthetic protocol employed consisted of dexmedetomidine (0.04 mg/kg), ketamine (5 mg/kg) and midazolam (0.25 mg/kg), with supplementary intramuscular doses of dexmedetomidine (0.02 mg/kg) and ketamine (2.5 mg/kg) administered as needed.

OUTCOME AND FOLLOW-UP

The following immobilisation times were measured:

1. Time to recumbency (time from darting to final recumbency);
2. Time from darting to reversal (time from darting to when reversals were administered);
3. Time to sitting (time from injection of reversals to when the animal is sitting);
4. Time to full recovery (time from injection of reversals to when the animal is walking and climbing).

The health assessment bloodwork included:
Blood biochemistry:

1. Urea (mg/dL)
2. Creatine (mg/dL)
3. Total proteins (g/dL)
4. Albumin (g/dL)
5. Total globulins (g/dL)
6. Glutamic oxaloacetic transaminase (U/L)
7. Glutamate-pyruvate transaminase (U/L)
8. Total bilirubin (mg/dL)
9. Direct bilirubin (mg/dL)
10. Indirect bilirubin (mg/dL)
11. Alkaline phosphatase (U/L)
12. Gamma-glutamyltransferase (U/L)

Blood count:

1. Red blood cells ($10^3/mm^3$)
2. Haemoglobin (g/dL)
3. Average corpuscular volume (fL)
4. Mean corpuscular haemoglobin (pg)
5. Mean corpuscular haemoglobin concentration (%)
6. Leukocytes (/µL)
7. Banded neutrophils (%)
8. Neutrophils (%)
9. Monocytes (%)
10. Lymphocytes (%)
11. Eosinophils (%)
12. Basophils (%)
13. Platelets (/µL)
14. Mean platelet volume (fL)

Parameters monitored during immobilisation:

1. Heart rate (beats per minute)
2. Respiration rate (breaths per minute)
3. Peripheral oxygen saturation (% SpO_2)
4. Rectal temperature (°C)

To evaluate the pre-anaesthetic activity level of the animals, we used the following criteria:

- None: Animals were not moving at all inside the enclosure.
- Low: Animals showed slow movement, moving very little. Most of these individuals were not aware of the darting procedures.
- Moderate: Animals moved around, trying to avoid being close to the person darting but not exhibiting fear.
- High: Animals were aware of the darting process and were afraid of it. Usually, these animals moved around rapidly, trying to escape from the management cages.

To evaluate the pre-anaesthetic demeanour of the animals, we used the following criteria:

- Depressed: Animals that were not aware of their surroundings, likely due to an underlying health condition.
- Alert: Animals that were clearly aware of the situation and attentive throughout the procedure.
- Apprehensive: Animals that were visibly hesitant or unsure of the situation.
- Aggressive: Animals that were actively trying to attack or defend themselves, mostly under escape protocols.

RESULTS

Data were collected from a total of 41 spider monkey immobilisations. All immobilising agents were administered into the semitendinosus or semimembranosus region of the hindlimbs or the biceps/triceps regions of the forelimbs. The results of the retrospective analysis of these data are presented in Table 1, with no reported complications. Ambient temperatures during the immobilisation procedures ranged from 28°C to 32°C. The ages of the animals ranged from 12 months to 12 years, with a total of 25 female and 16 male immobilisation events. Physiological monitoring and data collection occurred at various times after darting; therefore, only means and standard deviations are reported for heart rate, respiration rate, SpO_2 and rectal temperature.

Blood samples were collected from 15 individuals, but only 12 blood samples were included for haematology and biochemistry testing as presented in Tables 2 and 3; all of these were considered healthy individuals by physical examination according to the database. These samples were consistently obtained from the femoral, jugular or coccygeal veins. Due to the absence of veterinary laboratories in Iquitos, the samples were sent to a human laboratory. All samples were refrigerated and transported for up to 1.5 hours until reaching the laboratory.

Capillary refill rate was consistently less than 2 seconds for all animals.

The pre-anaesthetic activity level and demeanour of the animals are presented in Table 4.

DISCUSSION

Successful immobilisation of white-bellied spider monkeys is vital for health assessments, particularly in captivity where

TABLE 1 Data collected during immobilisation of 41 white-bellied spider monkeys.

Parameter	Mean ± SD	Range	Median (interquartile range)
Estimated bodyweight (kg)	8.41 ± 1.89	3.50–13.00	8.00 (7.76–10)
Actual bodyweight (kg)	8.07 ± 1.51	3.80–10.00	8.05 (7.70–9.20)
Actual ketamine dose (mg/kg)	5.07 ± 0.51	4.00–7.00	0 (5–5)
Actual dexmedetomidine dose (mg/kg)	0.04 ± 0.02	0.02–0.15	5.00 (0.04–0.45)
Actual midazolam dose (mg/kg)	0.2 ± 0.08	0.10–0.30	0.25 (0.1–0.25)
Time from darting to recumbency (minutes)	3.98 ± 1.44	2.00–7.00	4.00 (3–5)
Actual atipamezole dose (mg/kg)	0.36 ± 0.09	0.15–0.40	0.40 (0.4–0.4)
Time from darting to reversal (minutes)	41.00 ± 7.78	25.00–58.00	40.00 (36–45)
Time to first sign of recovery (minutes)	7.46 ± 4.09	1.00–21.00	6.00 (5–10)
Time to full recovery (minutes)	48.66 ± 8.37	31.00–74.00	47.00 (44–55)
Heart rate (beats per minute)	107.22 ± 12.38	80.00–140.00	1.00 (1–2)
Respiration rate (breaths per minute)	34.60 ± 8.21	18.00–56.00	108.00 (102.20–112.16)
SpO_2 (%)	97.36 ± 2.26	90.00–100.00	34.66 (30.60–40)
Rectal temperature (°C)	37.92 ± 0.88	36.10–40.72	98.00 (96.50–99)

TABLE 2 Biochemistry of blood collected from 12 white-bellied spider monkeys.

Parameter	Mean ± SD	Range	Median (interquartile range)
Urea (mg/dL)	30.50 ± 9.77	20.00–53.00	27.00 (25.25–34.25)
Creatine (mg/dL)	1.63 ± 0.33	1.20–2.10	1.55 (1.38–1.85)
Total proteins (g/dL)	7.17 ± 0.78	5.70–8.20	7.30 (6.60–7.73)
Albumin (g/dL)	4.03 ± 0.35	3.30–4.50	4.05 (3.80–4.33)
Total globulins (g/dL)	3.18 ± 0.83	1.80–4.40	3.35 (2.65–3.73)
Glutamic oxaloacetic transaminase (U/L)	98.17 ± 68.40	29.00–282.00	88.00 (58.75–106.00)
Glutamate-pyruvate transaminase (U/L)	45.75 ± 025.45	29.00–122.00	40.00 (30.75–48.00)
Total bilirubin (mg/dL)	1.73 ± 1.44	0.50–5.80	1.40 (0.95–1.60)
Direct bilirubin (mg/dL)	0.78 ± 0.75	0.10–2.80	0.55 (0.48–0.83)
Indirect bilirubin (mg/dL)	0.94 ± 0.72	0.30–3.00	0.75 (0.58–0.93)
Alkaline phosphatase (U/L)	162.83 ± 78.45	31.00–285.00	164.50 (102.50–208.50)
Gamma-glutamyltransferase (U/L)	14.73 ± 9.41	1.60–30.00	15.50 (8.38–19.25)

routine check-ups are essential. Few species-specific anaesthetic protocols have been described for *Ateles* species. Karesh et al. (1998) reported that tiletamine–zolazepam at doses of 11–19 mg/kg produces fast anaesthetic induction (1–4 minutes), but with long recovery times (up to 147 minutes) using flumazenil, emphasising the need for better protocols. Fagundes et al. (2020) analysed the use of ketamine–butorphanol–midazolam and dexmedetomidine–butorphanol–midazolam combinations for short immobilisation of howler monkeys, achieving good sedation for up to 30 minutes, with recovery times of 16–70 minutes.

The combination of dexmedetomidine, ketamine and midazolam appears to work synergistically for spider monkey immobilisation likely due to their complementary physiological effects. Dexmedetomidine, an α_2-adrenergic agonist, induces sedation and analgesia by acting on presynaptic α_2 receptors in the central nervous system, reducing norepinephrine release and inhibiting sympathetic activity.[9] Ketamine, an NMDA receptor antagonist, produces dissociative anaesthesia by blocking excitatory neurotransmission, resulting in sedation, analgesia and hypertonia.[10] Midazolam, a benzodiazepine, enhances the sedative effects of dexmedetomidine and ketamine by potentiating GABAergic neurotransmission, leading to anxiolysis and anterograde amnesia.[11] Together, these drugs create a balanced anaesthesia protocol that ensures rapid induction, stable sedation and minimal side effects during primate immobilisation procedures.

Our protocol, combining dexmedetomidine, ketamine and midazolam, resulted in fast induction times (2–7 minutes) with adequate recovery times (31–74 minutes) and no reported complications. This protocol shows improvements compared to the times reported by Karesh et al. (1998) and similar times to those reported by Fagundes et al. (2020), indicating its safety and efficacy. Heart rate, respiration rate and oxygen saturation remained within the acceptable reference values reported for primates,[12] which are desirable during anaesthesia. However, temperature varied widely between individuals, with some exhibiting mild hypothermia

TABLE 3 Blood counts of blood collected from 12 white-bellied spider monkeys.

Parameter	Mean ± SD	Range	Median (interquartile range)
Red blood cells (10^3/mm^3)	6390.83 ± 1459.39	5140.00–9980.00	5945.00 (5585.00–6362.50)
Haemoglobin (g/dL)	14.23 ± 2.02	11.30–17.60	14.25 (12.45–15.13)
Haematocrit (%)	42.90 ± 6.02	34.00–52.80	42.75 (37.63–45.75)
Average corpuscular volume (fL)	81.28 ± 3.74	76.40–87.90	81.05 (77.85–84.08)
Mean corpuscular haemoglobin (pg)	25.08 ± 3.75	17.50–30.00	25.65 (24.70–27.40)
Mean corpuscular haemoglobin concentration (%)	30.78 ± 4.13	22.90–36.60	31.60 (30.18–32.55)
Leukocytes (/μL)	10,408.33 ± 3479.98	5320.00–17,940.00	9405.00 (8115.00–13,195.00)
Banded neutrophils (%)	0.83 ± 1.03	0.00–3.00	0.50 (0.00–1.25)
Neutrophils (%)	73.08 ± 3.32	68.00–78.00	74.00 (70.00–76.00)
Monocytes (%)	1.75 ± 1.06	1.00–4.00	1.00 (1.00–2.25)
Lymphocytes (%)	22.75 ± 4.05	17.00–28.00	23.00 (19.00–26.25)
Eosinophils (%)	1.58 ± 1.00	0.00–3.00	1.00 (1.00–2.25)
Basophils (%)	-	-	-
Platelets (/μL)	437,083.33 ± 157,100.12	187,000.00–774,000.00	406,500.00 (344,250.00–529,750.00)
Mean platelet volume (fL)	10.90 ± 2.86	9.10–19.60	10.25 (9.33–10.90)

TABLE 4 Pre-anaesthetic activity and demeanour data of 41 immobilised white-bellied spider monkeys.

Pre-anaesthetic activity level (*n*)			
None	**Low**	**Moderate**	**High**
0	9	14	18
Pre-anaesthetic demeanour (*n*)			
Depressed	**Alert**	**Apprehensive**	**Aggressive**
1	36	0	4

or hyperthermia.[13] This variability may be associated with α_2 agonist-induced impairment of thermoregulation, but other factors such as high ambient temperature, increased muscular activity during pursuit or muscle relaxation can also influence it.[14] Additionally, the animal exhibited varying levels of pre-anaesthetic activity and demeanour, which may be indicative of varying levels of stress experienced—this pre-anaesthetic stress could have further exacerbated the variability observed in temperature as stress is known to affect temperature.[15]

Ketamine, in combination with α_2 agonists or benzodiazepines, has been widely used for safe immobilisation in wide variety of species, highlighting its potential suitability for primates.[8] Our combination had not been previously reported in spider monkeys, and some opioids like butorphanol are not accessible in certain countries, making this protocol a viable alternative for safe chemical restraint in this species.

This protocol adheres to established practices for restraint and physiological support in primate immobilisation, enhancing its reliability and safety.[16] Notably, we observed induction times as short as 1 minute, demonstrating the protocol's efficiency.

Blood parameters are vital indicators of health, essential for assessing the physiological status of the animals and diagnosing potential health issues.[17] The blood parameters found in the white-bellied spider monkeys were similar to those reported for other NWPs like black spider monkeys (*A. paniscus chamek*).[6] Our results for red blood cell count, haemoglobin and haematocrit align closely with values reported by Pérez-Brígido et al. (2021), indicating consistency in these haematological parameters. However, our recorded values for neutrophils, creatinine and total protein were notably higher than those reported by Pérez-Brígido et al. (2021), likely due to differences in the health status of the animals included in the Pérez-Brígido et al. (2021)—haematology in the current study was only performed on healthy animals.[3] This discrepancy underscores the importance of considering the health status of animal subjects when interpreting biochemical and haematological data. Seasonal, age or sex variability, as well as small sample sizes, must also be considered when comparing individuals.[18]

The successful immobilisation procedure was facilitated by careful monitoring of physiological parameters, including heart rate, respiratory rate, temperature, SpO_2 and capillary refill rate. Bloodwork comprising haematological and biochemistry profiles provided valuable insights into the health status of the spider monkeys, filling a crucial knowledge gap regarding this species. The obtained reference values for various blood parameters will serve as a diagnostic tool for future health assessments and facilitate the detection of any deviations from normal values.

In conclusion, the dexmedetomidine, ketamine and midazolam protocol demonstrated efficacy and safety in immobilising white-bellied spider monkeys for routine health assessments. Notably, eight of the immobilisation procedures were escape protocols for recovering animals that had escaped from enclosures, indicating the protocol's suitability for such purposes. The protocol allowed for fast induction (2–7 minutes), maintenance (25–58 minutes) and full recovery after atipamezole administration (31–74 minutes). The haematology and biochemistry data obtained provide valuable baseline information for future health monitoring efforts. Further research into anaesthesia protocols and health assessment methods

is essential to ensure the welfare of captive spider monkey populations.

AUTHOR CONTRIBUTIONS

Edmundo Parada contributed to data collection; interpretation and manuscript writing. **Heather Schwartz**; **Oliver Baca** and **Aaron Lam** contributed to data interpretation and manuscript writing. **Liesel Laubscher** participated in data analysis; interpretation and manuscript writing.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

FUNDING INFORMATION

Data used for this retrospective study was collected from routine health examinations on white-bellied spider monkeys. These examinations were funded by the RAREC and the Nashville Zoo.

ETHICS STATEMENT

This study was done retrospectively on data collected during routine health examinations, so no ethical approval was obtained.

ORCID

Oliver Baca-Montero https://orcid.org/0009-0006-0798-3048

Liesel Laubscher https://orcid.org/0000-0002-5982-2653

REFERENCES

1. Pozo WE. Agrupación y dieta de Ateles belzebuth belzebuth en el Parque Nacional Yasuní, Ecuador. Anu Investig Cientifica. 2004;2(1):77–102.
2. Link A, Palacios E, Stevenson PR, Boubli JP, Mittermeier RA, Shanee S, et al. The IUCN Red List of Threatened Species 2021. IUCN; 2021. https://doi.org/10.2305/IUCN.UK.2021-1.RLTS.T2276A191684587.en
3. Pérez Brígido CD, Romero Salas D, Cruz Romero A, Serna Lagunes R, Bravo Ramos JL, Sánchez Montes S, et al. Hematological and biochemical profile of spider monkey (*Ateles geoffroyi*) in captivity. Agro Productividad. 2021;14(6). https://doi.org/10.32854/agrop.v14i6.1974
4. Rovirosa-Hernández MJ, García-Orduña F, Caba M, Canales-Espinosa D, Hermida-Lagunes J, Torres-Pelayo VR. Blood parameters are little affected by time of sampling after the application of ketamine in black howler monkeys (*Alouatta pigra*). J Med Primatol. 2011;40(5):294–299.
5. Ølberg RA, Sinclair M. Monkeys and gibbons. In: West G, Heard D, Caulkett N, editors. Zoo animal and wildlife immobilization and anesthesia. 2nd ed. Iowa, USA: Blackwell Publishing; 2014. p. 375–86.
6. Karesh WB, Wallace RB, Lilian R, Painter E, Rumiz D, Braselton WE, et al. Immobilization and health assessment of free-ranging black spider monkeys (*Ateles paniscus chamek*). Am J Primatol. 1998;44:107–23.
7. Fagundes N, Castro ML, Silva RA, De Lima MPA, Braga CS, Dos Santos EAR, et al. Comparison of midazolam and butorphanol combined with ketamine or dexmedetomidine for chemical restraint in howler monkeys (*Alouatta guariba clamitans*) for vasectomy. J Med Primatol. 2020;49(4):179–87.
8. Watuwa J, Mbabazi R, Sente C, Musinguzi J, Laubscher L. A retrospective study on the immobilisation of captive chimpanzees (*Pan troglodytes*) at UWEC, Uganda. Vet Rec Case Rep. 2023;11(2):e602–7.
9. Gertler R, Brown HC, Mitchell DH, Silvius EN. Dexmedetomidine: a novel sedative-analgesic agent. Proc (Bayl Univ Med Cent). 2001;14(1):13–21.
10. Mion G, Villevieille T. Ketamine pharmacology: an update (pharmacodynamics and molecular aspects, recent findings). CNS Neurosci Ther. 2013;19:370–80.
11. Caramalac SM, de Souza AF, Caramalac SM, de Albuquerque VB, da s azuaga LB, de o Frazílio F. Comparative study between ketamine-S-dexmedetomidine and ketamine-S-midazolam-methadone in the anesthesia of capuchin monkeys (*Sapajus apella*). Ciênc Rural. 2022;52(4). https://doi.org/10.1590/0103-8478cr20200823
12. Merck & Co. MSD veterinary manual. Rahway, NJ, USA: Merck & Co.; 2024.
13. Von Huben SN, Lay CC, Crean RD, Davis SA, Katner SN, Taffe MA. Impact of ambient temperature on hyperthermia induced by (±)3,4-methylenedioxymethamphetamine in rhesus macaques. Neuropsychopharmacology. 2007;32(3):673–81.
14. Caulkett NA, Arnemo JM. Chemical immobilization of free-ranging terrestrial mammals. In: Tranquilli WJ, Thurmon JC, Grimm KA, editors. Lumb & Jones' veterinary anesthesia and analgesia. Iowa, USA: Blackwell Publishers; 2007. p. 807–32.
15. Vinkers CH, Penning R, Hellhammer J, Verster JC, Klaessens JHGM, Olivier B, et al. The effect of stress on core and peripheral body temperature in humans. Stress. 2013;16(5):520–30.
16. Reinhardt V, Liss C, Stevens C. Restraint methods of laboratory nonhuman primates: a critical review. Anim Welfare. 1995;4(3):221–38.
17. Pierre PJ, Sequeira MK, Corcoran CA, Blevins MW, Gee M, Laudenslager ML, et al. Hematological and serum biochemical indices in healthy bonnet macaques (*Macaca radiata*). J Med Primatol. 2011;40(5):287–93.
18. Ihrig M, Tassinary LG, Bernacky B, Keeling ME. Hematologic and serum biochemical reference intervals for the chimpanzee (*Pan troglodytes*) categorized by age and sex. Comp Med. 2001;51(1):30–37.

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MULTIPLE-CHOICE QUESTION

Which combination of drugs was found to be effective for the fast induction and short recovery times in the immobilisation of white-bellied spider monkeys (*Ateles belzebuth*)?

POSSIBLE ANSWERS TO MULTIPLE-CHOICE QUESTION

Tiletamine–zolazepam
Ketamine–butorphanol–midazolam
Dexmedetomidine–ketamine–midazolam
Flumazenil–dexmedetomidine–butorphanol

CORRECT ANSWER

C) Dexmedetomidine–ketamine–midazolam.

This combination of drugs was found to be effective for the fast induction and short recovery times in the immobilisation of white-bellied spider monkeys. Dexmedetomidine provides sedation, ketamine induces anaesthesia and midazolam enhances sedation and reduces anxiety. Together, they create a balanced and efficient anaesthesia protocol for the immobilisation procedure.