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Field Anesthesia of the Maned Wolf (*Chrysocyon brachyurus*) in Bolivia

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ABSTRACT: Fifteen maned wolves (*Chrysocyon brachyurus*) were anesthetized a total of 43 times as part of a long-term ecology and health study in a remote region of northeastern Bolivia. We administered tiletamine-zolazepam (TZ) to wolves in box traps or free-ranging, from blinds or on foot, at a mean dosage of 4.6 mg/kg intramuscularly. Detailed anesthetic information was recorded in 24 of these events in 11 wolves (six males, five females), and wolves were monitored closely post procedure with very high frequency or global positioning system telemetry collars. Anesthetic induction was smooth and rapid in all cases, with a mean 6.4 min from injection to recumbency. Vital parameters were stable during the majority of procedures. As expected with this drug combination, recovery was long (mean time to standing 163 min [range: 80–235 min]) but smooth, and animals were monitored in most cases in box traps until stable for release. One case of apnea and prolonged recovery is reported. In two cases, wolves recovered normally but were found to move minimally in the 2.5–4 d postprocedure before resuming normal movements. Overall, TZ provided safe, stable immobilization of free-ranging maned wolves in remote and extreme field conditions, although postanesthesia monitoring via telemetry is recommended.

Key words: Chrysocyon brachyurus, field anesthesia, immobilization, maned wolf, tiletamine-zolazepam.

The maned wolf (*Chrysocyon brachyurus*) is the largest South American canid and considered near threatened by the *International Union for Conservation of Nature (IUCN) Red List* (Paula and DeMatteo 2016). An ecological and health study of this canid has been pursued in Parque Nacional Noël Kempff Mercado in northeastern Bolivia since 1999 (Emmons 2012). While the remoteness of this park has been a major factor in the continued protection of the maned wolves and other species within its borders, field conditions are difficult, with few roads, all in poor condition. Additionally, at times of the year the study site is only accessible on horseback or with canoes due to seasonal flooding. In this study, a small number of animals were followed intensively over the past 15 yr with radiotelemetry collars and serial health data. Other studies of maned wolf populations with better accessibility, where the animals reside closer to and among human habitations, can provide some comparative data (Furtado et al. 2006). However, through this long-term monitoring of individuals and pairs, novel information has been amassed on breeding, territories, vocalizations, movements, and climatic effects such as fires on the wolves and ecosystem (Emmons 2012). We report the detailed results of 24 anesthesia events in 11 of the 15 animals studied to date, especially in regard to safety, practicality, and recovery in a remote environment.

Free-ranging maned wolves were anesthetized from 1999–2014. Animals were anesthetized with tiletamine and zolazepam (TZ; Telazol®, Zoetis Inc., Kalamazoo, Michigan, USA; reconstituted with 5 mL of sterile water to yield a 100 mg/mL solution of 50 mg/mL of each drug) after being trapped in large wood or metal guillotine traps baited with chickens, dried meat, or canned sardines (Emmons 2012). Traps were set each afternoon and checked each morning. Drugs were administered via a 3-mL plastic dart and a 30×1.5 mm nonbarbed needle (Telinject USA, Inc., Agua

Dulce, California, USA) by using a standard 11-mm×1-m blowpipe with attached foot pump (Telinject Vario 1V, Telinject USA, Inc.) or, in a few cases, using a pole syringe and an 18-ga, 38-mm needle at a distance of <1 m. Some animals were darted from blinds at night or on foot after being tracked via a very high frequency (VHF) collar on horseback with the same plastic darts and a dart rifle (Dan-Inject JM Standard, DanInject, Børkop, Denmark).

Vital measurements (heart rate via auscultation or pulse oximetry, respiratory rate via visual observation, body temperature via digital thermometer) were recorded every 5–10 min during anesthetic events, and all time points were used to calculate the mean values. Pulse oximetry was used in the majority of procedures when available (Nellcor™ OxMax *N*-65, Medtronic, Minneapolis, Minnesota, USA) to record heart rate and oxygen saturation. The time from dart placement until the first signs of anesthetic effects (first effect), the time from dart placement until the animal assumed sternal or lateral recumbency (time to recumbency), and the time from dart placement until the animal could be approached and safely manipulated (time to working anesthesia) were recorded. Recovery was closely monitored in the trap for most procedures that occurred during daylight. Time from the end of anesthesia until the head was up, until the animal stood for the first time, and until release from the trap (which occurred when the animal appeared to ambulate in a controlled and coordinated manner) were recorded. The procedure length was defined as the time from dart placement until the end of the manipulations and beginning of recovery. Most animals had radio collars with VHF or GPS capabilities of various types placed at the time of anesthesia over the course of the study. Each animal was weighed and measurements were taken, age estimated based on dental wear, and biologic sampling and physical examination were performed, as previously described (Deem et al. 2012). Animals were monitored starting 1–2 d postanesthesia via VHF or GPS to assess movement.

Fifteen maned wolves were anesthetized a total of 43 times. Seven males and eight female individuals were assessed, with 19 procedures performed on males and 24 on females. The mean body mass of adult wolves (≥2 yr) at the time of each procedure was 26.9 kg (range 23–29 kg) for adult males and 25.5 kg (range 21–29 kg) for adult females.

Of the 43 total procedures, 24 procedures (six males, five females) had detailed information regarding anesthesia and movement data postanesthesia; these procedures were used for further analysis. Four of these animals were anesthetized once, two were anesthetized twice, one was anesthetized three times, two were anesthetized four times, and one wolf was anesthetized five times. The mean dose of TZ used was 116±21 mg (range 90–170 mg) at a mean dosage of 4.6±1.03 mg/kg (range 3.4–7.7 mg/kg). Tiletamine-zolazepam mean dosage used for the immobilization of wolves via pole syringe or plastic dart in box traps (n=20; mean 4.4±0.7 mg/kg, range 90–140 mg) was lower than that used when darting free-ranging animals (n=4; mean 5.2±2.2 mg/kg, range 100–170 mg). Supplemental doses of ketamine (25–100 mg intramuscularly or intravenously; Ketaset®, Fort Dodge Laboratories, Fort Dodge, Iowa, USA) were used for four TZ procedures (three induced in box traps and one darted free-ranging) in order to deepen the anesthetic plane to allow for collection of samples. The mean values for induction and recovery time points are presented in Table 1, and the vital parameters are presented in Table 2.

No immobilization-related mortalities occurred in the 24 detailed anesthetic procedures with TZ or in any of the total 43 anesthetic events in this population. Postanesthesia monitoring via VHF or GPS collar points revealed normal movement in the majority of the 24 detailed anesthetic procedures on days 2–3 after the procedure. Nonanesthetized collared maned wolves throughout our study moved an average distance of 11.1 km/d throughout the year (range of monthly averages: 7.3–14.05 km/d) (Emmons et al. 2012). Typically, the day after an anesthetic procedure, if fixes were made,

TABLE 1. Induction, procedure, and recovery times for 24 immobilizations of 11 (six male, five female) free-ranging maned wolves (*Chrysocyon brachyurus*) anesthetized with tiletamine-zolazepam in remote field conditions in northeastern Bolivia.

Parameter (min)	Mean	SD	Range
Procedure length[a]	61.7	10.4	38–78
Initial effect	5.7	3.5	1–12
Time to recumbency	6.4	3.0	3–12
Time to working anesthesia	20.3	35.1	7–142
Time until head up	97.8	34.5	60–189
Time until standing	162.9	59.7	80–235
Time until release[b]	321.3	100.8	139–500

[a] From time of injection to end of manipulations.

[b] In cases when animal was placed in trap postanesthesia and monitored until coordinated.

TABLE 2. Physiologic parameters for 24 immobilizations of 11 (six male, five female) free-ranging maned wolves (*Chrysocyon brachyurus*) anesthetized with tiletamine-zolazepam in remote field conditions in northeastern Bolivia.

Parameter	Mean	SD	Range
Body weight (kg)	25.9	2.6	21–29
Heart rate (beats/min)	129.4	25.1	60–192
Respiratory rate (breaths/min)	32.1	9.4	16–50
Rectal temperature (C)	38.1	0.8	36.2–40.1
Oxygen saturation (%)	94.7	3.2	90–100

the animals moved less (4–10 km) than this average. By days 2–3, the animals moved distances in this expected range. In three instances, however, a longer time of limited to no movement was noted after the procedure. In the first case, the male was at least 10 yr old and had been anesthetized uneventfully 1 yr prior. The wolf became apneic under anesthesia, was successfully provided emergency care, recovered very slowly, and was released from the trap 7 h after the end of the procedure. The animal moved little for several days after release but did recover and was trapped 2 yr later and appeared healthy, but was not anesthetized again. In the second case, a 4 yr male was darted from a blind and was observed visually to recover as expected immediately after the procedure and demonstrated little movement for the following 4 d, but subsequently resumed normal movements. This was the first anesthetic event, and the same protocol was used six more times over the next 4 yr with normal recoveries. The third case was a 5 yr male that was antigen-positive for *Dirofilaria immitis*, with a heart murmur noted at the time of the procedure (Deem et al. 2012). This wolf experienced the second-longest recovery time until head up (120 min) and was noted to be ataxic the day following anesthesia and demonstrated little movement for 2.5 d postprocedure (moved less than 15 km total in the 4 d postprocedure and less than 2 km on day 1 postprocedure). The male was anesthetized with the same protocol 1 yr prior without issue and twice subsequently, once with TZ and once with ketamine and xylazine, and experienced unremarkable anesthesia and recovery (with day 2 movements of 10–16 km per day), but still had a noticeable heart murmur on all later examinations.

Tiletamine-zolazepam has been used for many years for the immobilization of both captive and free-ranging carnivores (Furtado et al. 2006; Larsen and Kreeger 2014). This drug combination typically provides a smooth and fast induction, safe and stable anesthesia, and often a longer recovery compared to other drug regimens (Larsen and Kreeger 2014). Further advantages of TZ include the lyophilized formulation, which allows both storage under extreme field conditions for extended periods as well as the ability to concentrate the powder to the desired concentration for darting. Dosing is also straightforward and easy to calculate in the field. As in many wildlife studies, the weight of the animals that we darted was unknown, and when darting from blinds at night, it was not possible to know which animal would be encountered before choosing a dose and loading the dart. The margin of safety of TZ is presumed sufficient so that a standard drug amount (100–120 mg) was placed into the darts ahead of time for animals that were 17–28 kg. As expected, recoveries in our study were relatively long, and excessively long in two animals, but the recovery stage was smooth

in all animals with full recovery in all wolves. Postprocedure monitoring revealed resumption of typical movement by the time animals were located 1–3 d postanesthesia, but in three cases movement was noticeably decreased for 2.5–4 d. A cause for this was not discernable, but due to the temporal proximity to the procedure, we suspect this was drug- and procedure-related. All three animals fared well; they were followed for 1–3 yr and appeared to have recovered uneventfully. In this remote ecosystem, this long recovery phase did not pose a problem to this apex predator, but in other situations this could have been detrimental to individual animals.

Mean TZ drug dosages in this study (4.6 mg/kg) were higher than those in a study of maned wolves in Brazil (2.77 mg/kg; Furtado et al. 2006) and, although induction times were similar, heart and respiratory rates were lower and in a more expected range in our study and recovery time was longer. These findings are likely dose-related, but the drug doses in this study were well within the recommended dosages for this species and other free-ranging canids (Larsen and Kreeger 2014). Multiple side effects were observed by Furtado et al. (2006), most notably compulsive licking, hypersalivation, muscle tremors, and twitching. We did not see these effects in our study, which is likely due to the slightly higher dosages we used resulting in a deeper plane of anesthesia. We saw apnea in the one aged male described above, which was likely related to underlying health issues. Overall, both studies had acceptable results for the safe immobilization of free-ranging maned wolves when careful monitoring was applied.

Other drug combinations and protocols have been successfully used in this species, such as ketamine and alpha agonists (Larsen and Kreeger 2014). Two wolves in our study were anesthetized with ketamine and xylazine and reversed with yohimbine, which provided a good induction and stable anesthesia. In one case, a 3-yr-old female moved minimally for 6 d postanesthesia following this protocol; however, normal movements were noted thereafter until the animal's death 10 mo later. Ketamine-xylazine is considered a generally safe protocol, but the alpha agonist effects of xylazine and other drugs in this class cause varying degrees of cardiac and respiratory depression (Larsen and Kreeger 2014; Chinnadurai et al. 2016), so this combination typically should be dosed more carefully than TZ and is not necessarily superior in difficult field conditions.

It should be noted that the results of this study are from a small number of animals, some of which were repeatedly immobilized (but typically at least a year apart). Therefore, statistically meaningful comparisons were not possible, and immobilizations, not individual animals, were used as a basis for the analyses in which male and female data were pooled.

In remote and extreme field conditions, all drugs and drug combinations will have certain positive as well as unwanted effects. Despite the assumed safety and logistical advantages of TZ for field anesthesia of carnivores, and the overall successful immobilization of maned wolves with TZ in our study, we report three cases of nonfatal postanesthetic complications due to prolonged recovery. There are numerous reports in the literature of anesthesia of free-ranging carnivores, but few report movements in the postanesthetic period, which is a vital and understudied component to consider when choosing an anesthetic protocol. Field veterinarians and biologists should be aware of postanesthetic complications and, when possible, monitor animals postprocedure to further evaluate the feasibility and safety of this combination in field conditions.

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