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Source: Journal of Zoo and Wildlife Medicine, 52(2) : 437-444

Published By: American Association of Zoo Veterinarians

URL: https://doi.org/10.1638/2020-0170

DOI: 10.1638/2020-0170 *Journal of Zoo and Wildlife Medicine* 52(2): 437–444, 2021

STANDING SEDATION WITH XYLAZINE AND REVERSAL WITH YOHIMBINE IN JUVENILE ASIAN ELEPHANTS (*ELEPHAS MAXIMUS*)

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Abstract: Evaluation and improvement of immobilization methods are important for wildlife welfare and biodiversity conservation. The sedative and physiological effects of xylazine (50–110 mg per elephant; 0.09–0.15 mg/kg IM) were evaluated in 15 juvenile Asian elephants (*Elephas maximus*) in Sri Lanka. The time from xylazine injection until first sign of sedation, handling, and reversal with yohimbine (0.009–0.03 mg/kg IV) were recorded. Behavioral signs, level of sedation (no effect, light, moderate, or deep) and response to handling were assessed. Rectal temperature, pulse, and respiratory rates were recorded and arterial blood samples were analyzed 30 and 45 min after xylazine injection. The first sign of sedation occurred within 5–18 min. Standing sedation was induced in all elephants, but the level of sedation varied differently over time for each elephant. Twelve elephants remained standing throughout the sedation period, while 3 elephants became laterally recumbent. Sedative effects included lowered head and trunk, droopy ears, snoring, and penis protrusion. Pulse rate, respiratory rate, and rectal temperature ranged between 30–45 beats/min, 4–12 breaths/min, and 35.6–37.2°C, respectively, at 30 min after xylazine injection, and there were no changes over time. Pulmonary function and acid–base balance were adequate (range partial pressures of arterial oxygen 73–123 mmHg and carbon dioxide 33–52 mmHg, arterial hemoglobin oxygen saturation 96–99%, pH 7.34–7.54, lactate 0.9–2.5 mmol/L). Yohimbine was administered 46–110 min after the injection of xylazine, and the first sign of recovery occurred within 1–4 min. Resedation after reversal with yohimbine was observed in two elephants. In conclusion, xylazine at the doses used induced light to deep sedation with stable physiology and most elephants remained standing.

INTRODUCTION

The Asian elephant (*Elephas maximus*) has been listed as endangered by the International Union for Conservation of Nature (IUCN) since 1986, and the population has declined dramatically over recent years. The decline has been attributed to fragmentation and loss of habitat, as well as poaching. Conflicts between humans and wild elephants are a result of forced interactions due to human exploitation of elephant habitat.[9] Sri Lanka has the highest density of Asian elephants in the world, with 10% of the global population,[9] in 3% of the global geographic range.[16] Therefore, Sri Lanka is an important country with regards to elephant conservation. Part of the conservation strategy to protect the elephants and reduce human–elephant conflicts include capture, translocation, and radio-collaring of elephants, which require immobilization. Health assessment, blood and tissue sampling, and medical care of elephants are other reasons for immobilization. At the Elephant Transit Home (ETH) in Sri Lanka, orphaned and injured wild juvenile elephants are rehabilitated and cared for until reintroduced to the wild at the age of 6 y. The elephants undergo health assessment during rehabilitation at ETH and are radio-collared upon release.

α_2-adrenoceptor agonists, such as xylazine and medetomidine, are commonly used for standing sedation in large domestic mammals[17,23] and wildlife species. Xylazine alone has been reported for standing sedation in captive and wild Asian elephants.[2,3,27,28,32] Medetomidine has been used alone as a sedative and analgesic for standing sedation for minor invasive procedures in Asian elephants.[24] Detomidine in combination with butorphanol has been reported for standing sedation of captive African (*Loxodonta africana*) and Asian elephants,[11,21] and for rhinoceros.[1,4] Azaperone alone has been used to induce standing sedation for intractable captive elephants undergoing routine procedures.[22,30] In contrast, when recumbency is required for safe handling of immobilized elephants, the potent opioid etorphine is the drug of choice, either alone or in

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combination with other drugs, such as acepromazine, azaperone, xylazine, or ketamine.[29]

Evaluation and improvement of immobilization protocols are important both from an animal welfare perspective and for biodiversity conservation.[18] A central goal in research involving animals is to refine the methods used so the least harm possible is inflicted to each animal, in accordance with the 3Rs (refine, reduce, and replace).[18] Thus, knowledge about the physiological effects of immobilizing drugs and doses are necessary to reduce the risk of morbidity and mortality and to ensure safe immobilization. When handling of elephants at ETH requires immobilization, xylazine has routinely been used for standing sedation and yohimbine as a reversal drug for many years, as these drugs are readily available and affordable in Sri Lanka. Although xylazine is commonly used for sedation of Asian elephants in many countries, physiological or behavioral assessments have not been formally investigated. The aim of this study was to evaluate physiological and behavioral responses during standing sedation with xylazine and reversal with yohimbine in juvenile Asian elephants.

MATERIALS AND METHODS

Study area and animals

The study was conducted at the ETH, Udawalawe National Park, in Sri Lanka between 15 September and 01 October 2014. At that time, 45 juvenile elephants were undergoing rehabilitation at the ETH, of which 39 elephants (1 to 6 y old) were kept in a herd that was allowed to roam freely during the day along the outskirts of the Udawalawe National Park, accompanied by elephant handlers. Seven times a day the elephants were provided milk at the ETH. The study included 15 juvenile Asian elephants (8 females and 7 males) aged 2 to 6 y, with body weights between 400 and 1,000 kg. The elephants were sedated for health assessment, which included collection of biological samples (blood, trunk wash, swabs, feces) and body measurements. In addition, some of the elephants were radio-collared because they were going to be reintroduced to the wild. The elephants were used to the presence of the handlers, but sedation was necessary for the above procedures. The elephants were not fasted prior to sedation. Ambient temperature ranged from 29° to 37°C, and the barometric pressure ranged from 746 to 750 mmHg.

Drug doses and monitoring

The study animals were approached on foot in an open field in Udawalawe National Park, close to the ETH. Behavior immediately before and after hand-injection of xylazine was evaluated based on the following scoring: calm (standing or walking relaxed, unresponsive to surroundings); alert (aware and responsive to surroundings); or excited (playful or stressful behavior). Xylazine (Balanzine® 100 mg/ml, Health-Tech Pharmaceutical Co Ltd, Taipei, Taiwan) was administered in the gluteal muscle by hand-syringe with a 1.2 × 38-mm needle at a single dose ranging from 50 to 110 mg per elephant (0.09–0.15 mg/kg). The dose in mg administered to each elephant was determined based on body size estimation in the field and previous experiences at the ETH. The dose in mg/kg was calculated after the procedures based on actual body weight obtained at ETH. The time from xylazine injection to the first sign of drug effect, such as aberrant behavior or change in posture, was recorded, as well as the time until the elephant could be handled (hands-on) and monitoring was initiated. The level of sedation was evaluated based on the following scoring: 0, no effect; 1, light sedation (affected behavior and movement, slower reactions but mobile); 2, moderate sedation (depressed behavior, minor response to handling); and 3, deep sedation (unaware of their surroundings). The following body positions and behavioral signs were recorded: tail (normal or flaccid), ears (normal or droopy), head (normal or lowered), trunk (normal or lowered), snoring (absent or present), penis protrusion (absent or present), and shifting of weight-bearing of legs (absent or present).

The physiological variables that were recorded included respiratory rate (breaths/min) measured by feeling exhaled air at the tip of the trunk, pulse rate (beats/min) measured by palpation of an auricular artery, and rectal temperature (°C) measured by a handheld digital thermometer inserted approx. 10 cm into the rectum. The variables were monitored from hands-on and recorded at approx. 30 and 45 min after xylazine injection, if the level of sedation enabled handling of the elephant.

Arterial blood samples were collected from 12 elephants for analysis of pulmonary gas exchange and acid–base balance. A single sample was collected from 4 elephants, and two samples were collected from 8 elephants (Table 1). The samples were collected anaerobically from auricular arteries into preheparinized syringes approx. 30 and 45

Table 1. Physiological variables in juvenile Asian elephants sedated with xylazine (50–110 mg) injected IM by hand.

	30 ± 5 min		45 ± 5 min		
Variable[a]	Mean ± SD	Median (range)	Mean ± SD	Median (range)	*n*
Pulse rate (beats/min)[b]	36 ± 5	34 (30–45)	35 ± 7	32 (28–48)	10
Respiratory rate (breaths/min)[c]	7 ± 2	8 (4–12)	8 ± 3	8 (5–14)	12
Temperature (°C)[d]	36.7 ± 0.5	36.8 (35.6–37.2)	36.7 ± 0.6	36.8 (35.8–37.4)	8
PaO_2 (mmHg)[e]	106 ± 11	106 (89–123)	92 ± 14	93 (73–109)	8
$PaCO_2$ (mmHg)[e]	40 ± 6	40 (33–52)	47 ± 3[A]	46 (42–51)	8
SaO_2 (%)[e]	98 ± 1	99 (96–99)	97 ± 2	97 (94–98)	8
pH	7.43 ± 0.07	7.43 (7.35–7.54)	7.39 ± 0.02	7.39 (7.34–7.43)	8
Lactate (mmol/L)	1.8 ± 0.5	1.8 (0.9–2.5)	1.9 ± 0.5[A]	2.0 (1.1–2.5)	8

[a] The study included 15 elephants, but physiological variables could not be measured at the intended time in all individuals, due to circumstances such as too light sedation level.
[b] Recorded by palpation of an auricular artery.
[c] Measured by feeling exhaled air at the tip of the trunk.
[d] Measured by a handheld digital thermometer inserted approx. 10 cm into the rectum.
[e] PaO_2 and $PaCO_2$ = partial pressures of arterial oxygen and carbon dioxide; SaO_2 = arterial hemoglobin oxygen saturation. Blood gas values and pH are presented at standard temperature (37°C).
[A] Significant difference over time ($P < 0.05$).

min after initial drug injection. Firm pressure was applied at the sample site for 2 min post sampling to avoid development of a hematoma. The samples were processed immediately by using a portable analyzer and cartridges (i-STAT®1 Portable Clinical Analyzer and i-STAT cartridges CG4+, Abbott Laboratories, Abbott Park, IL 60064, USA). The portable analyzer has been validated for selected blood chemistry values in Asian elephants.[33] The analyses in the present study included measured values for partial pressures of arterial oxygen (PaO_2), carbon dioxide ($PaCO_2$), and pH, and calculated values for arterial hemoglobin oxygen saturation (SaO_2). Blood gas values and pH at standard temperature (37°C) are presented because temperature measurement was not possible during all sample times, and measured body temperatures ranged from 36.5 to 37.4°C. To ensure optimal temperature for the portable analyzer, it was stored in a cooler bag with ice packs inside a Styrofoam box with additional ice packs to enable infield analysis in the hot environment. Intravenous fluids (1–2 L isotonic sodium hydrochloride) were administered in an auricular vein throughout handling. Hypoxemia was defined as mild (PaO_2 60–80 mmHg) or marked (<60 mmHg), and hypercapnia as mild at $PaCO_2$ 45–60 mmHg.

For reversal of the effects of xylazine, yohimbine hydrochloride (Reverzine® 10 mg/ml Bomac Pty Limited, Hornsby, New South Wales 2077, Australia) was administered by rapid injection in an auricular vein at approx. 1 mg per 10 mg xylazine (0.009–0.03 mg/kg), which equaled a total dose of 5–20 mg. The time from xylazine injection to administration of yohimbine was recorded. The time for reversal was decided during each immobilization, depending on sampling procedures and field circumstances. The times from yohimbine injection until first sign of recovery and, when possible, to full recovery (normal mentation and ambulation; no visible signs of sedation) were recorded.

Ethical considerations

The elephant work was conducted under approval by the Department of Wildlife Conservation in Sri Lanka and in accordance with international ethical guidelines. The elephants included in the study were sedated for ongoing management purposes, and sampling was performed by experienced veterinarians with minimal discomfort for the animals because the samples were collected when the elephants were sedated. Physiological data and blood sample analysis were part of the monitoring conducted during sedation. This contributes to the principle of the 3Rs through reduction—because no animals were sedated solely for research purposes, and refinement—because identification of physiological alterations during sedation is the basis to enable establishment of methods for improvement.

Table 2. Handling and response times (min) in juvenile Asian elephants after hand-injection with xylazine (50–110 mg IM) for standing sedation and yohimbine (5–20 mg IV) for reversal.

Time from xylazine until	Median	Range	Mean ± SD	*n*
Initial effect (first sign of sedation)	10	5–18	11 ± 4	15
Hands on	28	10–50	29 ± 11	15
Light sedation[a]	15	10–20	14 ± 4	14
Moderate sedation[a]	45	15–90	38 ± 20	13
Deep sedation[a]	57	30–70	54 ± 17	4
Reversal with yohimbine[b]	79	46–110	77 ± 17	14
Time from reversal to first sign of recovery	2	1–4	2 ± 1	11

[a] Light sedation = affected behavior and movement, slower reactions but mobile; moderate sedation = depressed behavior, immobile but still some response to handling; deep sedation = immobile and no responses to handling. Level of sedation was recorded in 14 of 15 elephants because grading was not included in the protocol for the first study animal. Sedation levels varied differently over time for each elephant. In some elephants, the level of sedation changed several times during the procedure and did not follow a continuum from light to moderate to deep.

[b] Four animals received a second dose of yohimbine. The table shows time to first reversal.

Statistical analysis

Data were assessed for normality visually through the Quantile–Quantile plot in GraphPad Prism 2020 (GraphPad Software, Inc, La Jolla, CA 92037, USA). A paired *t*-test was done in Excel® 2013 to compare physiological values at 30 and 45 min after xylazine injection. A P-value < 0.05 was considered statistically significant. Descriptive statistics for physiological variables, handling, and response times are presented as mean ± standard deviation, and median (range, i.e. min–max).

RESULTS

Before foot approach for hand-injection of xylazine, 14 elephants were calm, and one was alert. Following injection, 9 elephants remained calm, 6 became alert; none were excited. The most common initial signs of drug effect were slower movements, lowered trunk, and that the elephant stayed despite the herd moving away. Xylazine at the doses used induced standing sedation at varying levels in all 15 elephants (Table 2). Twelve elephants remained standing throughout the sedation period, while 3 elephants became laterally recumbent after 31, 50, and 85 min, respectively, at a moderate to deep sedation level. To prevent one ataxic elephant from going into recumbency at an unsuitable location, it was given a low dose of yohimbine (4 mg) after 23 min sedation.

Level of sedation was recorded in 14 of 15 elephants, whereas evaluation of depth was not included in the protocol for the first study animal. All elephants reached at least light sedation (Table 2). Thirteen of 14 elephants deepened from light to moderate sedation, and 4 of these reached deep sedation. Sedation levels varied differently over time for each elephant. In some elephants, the level of sedation changed several times during the procedure and did not follow a continuum from light to moderate to deep. Light sedation lasted for periods of 5–45 min, moderate sedation for periods of 10–40 min, and deep sedation for periods of 10–30 min. During light sedation, the elephants resisted tail lifting for measurement of rectal temperature, and they could sway their ears and move their trunk. When moderately sedated, the elephants responded only slightly to handling, but showed resistance when rectal temperature was measured. During deep sedation, the elephants were indifferent to the surroundings and all procedures could be performed without resistance. Three of the four elephants that reached deep sedation remained standing, and one became laterally recumbent. Disturbances around the study animal, such as if the elephant herd moved away, delayed the onset of any visible effects of xylazine, lightened the depth of sedation, or both. No elephants were given additional doses of xylazine during the procedures.

Protrusion of the penis was documented during standing sedation within 5–30 min after xylazine injection in 5 of 7 male elephants. Snoring was documented intermittently in 14 of 15 elephants at various time periods and at different levels of sedation. All elephants showed signs of muscle relaxation as indicated by lowered and flaccid trunk, lowered head, and droopy ears. Shifting of weight-bearing of legs was observed more frequently during light than moderate sedation and did not occur during deep sedation. Tail flaccidity

was difficult to evaluate and was therefore removed from the protocol.

There was no significant change in pulse rate ($t_9 = 0.58$, $P = 0.58$), respiratory rate ($t_{11} = 1.39$, $P = 0.19$), or rectal temperature ($t_7 = 0.18$, $P = 0.86$) over time between 30 and 45 min after xylazine injection (Table 1). The pulmonary gas exchange and acid–base balance were adequate in all 12 sampled elephants at their respective sample times (range PaO_2 73–123 mmHg, $PaCO_2$ 33–52 mmHg, SaO_2 94–99%, pH 7.34–7.54, lactate 0.9–2.5 mmol/L). In the eight elephants with serial samples, there was no change over time in PaO_2, SaO_2, or pH, while the $PaCO_2$ ($P = 0.047$) and lactate ($P = 0.03$) increased (Table 1). Mild hypoxemia was recorded during standing sedation in one elephant (PaO_2 73 mmHg) and during sedation in lateral recumbency in another elephant (PaO_2 76 mmHg). Mild hypercapnia was recorded in five elephants ($PaCO_2$ 47–52 mmHg, all standing).

All elephants were given yohimbine at the end of the procedure. Four elephants showed signs of recovery before yohimbine was administered. Time from administration of yohimbine for reversal until first sign of recovery was recorded in the remaining 11 elephants (Table 2) that did not rouse prior to yohimbine. After reversal, detailed recovery data were collected for various time lengths in the elephants, depending on field circumstances. Time until full recovery was documented in 6 of 15 elephants and occurred between 7 and 70 minutes of reversal with yohimbine. Elephants not fully recovered were left lightly sedated in the herd supervised by the elephant handlers, who had contact with the responsible veterinarian.

Resedation after reversal with yohimbine was observed in two elephants. They had been sedated for 46 and 65 min, respectively, when the first injection of yohimbine was administered, and the animals were pushed back to the ETH because of nightfall. Due to deep resedation and lateral recumbency, a second dose of yohimbine was administered 116 and 49 min, respectively, after the first yohimbine dose.

Side effects due to sedation included green discharge from the mouth (approx. 300–400 ml) in one standing elephant that was moderately sedated. In another elephant, a variation in the heart rhythm was audible on auscultation, but no further diagnosis was made because electrocardiography was not performed. All animals were judged healthy based on physical examination.

DISCUSSION

This is the first study in Asian elephants that reports in-depth physiological and behavioral effects during sedation with xylazine, a commonly used sedative for standing sedation in this species. The xylazine doses used in the present study reliably and smoothly induced sedation at varying levels with stable physiology and no major complications. Similar xylazine doses have been reported in juvenile and adult Asian elephants.[14,27,29] Hand-injection of xylazine was possible to conduct calmly without inducing excitement to the elephants at the ETH because the animals were accustomed to human presence.

Onset of sedation (mean 10 min) with the doses used in these juveniles (50–110 mg) was similar or faster than reported in adult Asian elephants (10–20 min) sedated with 100–300 mg xylazine,[2] and similar to what has been reported for adults sedated with detomidine and butorphanol (mean 10 min).[4] On the other hand, faster onset to sedation has been reported with medetomidine (approx. 6 min) in adult Asian elephants.[24] Fast and smooth onset of sedation is desired, especially under field circumstances where a rough or slow induction may increase the risk of the animal getting injured or disappearing out of sight.

Notable signs of sedation with xylazine included e.g. lowered head and trunk, droopy ears, penis protrusion, and snoring, which also have been described in Asian elephants during standing sedation with other α_2-adrenoceptor agonists, such as medetomidine, and detomidine in combination with butorphanol.[4,24] In elephants sedated with medetomidine, the tail was flaccid and there was no resistance during manual lifting of the tail.[24] In the present study, flaccidity of the tail was difficult to assess accurately by observation only, whereas touching and lifting the tail often disturbed the elephant, and was thus not a good method for assessment of muscle tone. Sensitivity to touch has been described in horses sedated with α_2-adrenoceptor agonists.[8]

Disturbances during the induction period delayed the onset of sedation, as reported previously,[2,6] and disturbances during standing sedation lightened the level of sedation. These effects can be explained by the increased levels of catecholamines during states of excitement in which they compete with xylazine for the binding sites on the adrenoceptors. Therefore, the sedative effects get less pronounced in an excited animal compared with those in a calmer, less anxious animal.[31] Thus, it is important to ensure calm surroundings before and during sedation, which can be difficult

during field procedures. However, the use of a blindfold is simple and recommended. The conducted procedures were judged as minorly invasive and nonpainful, and could be performed during standing sedation with xylazine, although the level of sedation could vary over time between light, moderate, and deep. Because the depth of sedation was lightened by lifting the tail, inserting a rectal thermometer, or collection of feces from the rectum, such procedures appeared to present a greater disturbance than injections or blood withdrawal. For safety of personnel, it is imperative that the animal remains in a stable and predictable level of sedation so the planned procedures can be performed.

Standing sedation was the desirable position after xylazine administration to the juvenile elephants. However, the risk of recumbency should be considered because three elephants became laterally recumbent, and another elephant developed ataxia and was given a low dose of yohimbine to prevent it from lying down. Lying down may have been a response to the muscle weakness induced by xylazine, but recumbency was not associated with the deepest level of sedation. Juvenile elephants voluntarily spend considerable time lying down, similarly to foals. Xylazine causes profound sedation and marked ataxia with frequent recumbency in foals, whereas adult horses rarely become recumbent even when very ataxic,[5] similarly to adult elephants.

The juveniles in the present study had similar respiratory rates during xylazine sedation as compared with those reported in unsedated adult Asian elephants in standing position (range 4–12 breaths/min),[12,29] or in lateral recumbency (mean ± SE; 6 ± 1 breaths/min),[13] and in adult Asian elephant bulls during standing sedation with xylazine (mean ± SE; 9 ± 0.5 breaths/min).[27] In contrast, in newborn unsedated Asian elephant calves, respiratory rates up to 140 breaths/min have been recorded.[35] However, the depth of respiration is seldom reported, but will influence the efficacy of breathing. In the present study, the respiratory rate, pulse rate, and rectal temperature remained stable between recordings, standardized at approx. 30 and 45 min after xylazine injection. In comparison, during the first 30 min of sedation with medetomidine in laterally recumbent adult Asian elephants, the respiratory rate and pulse rate decreased, whereas there was no change in body temperature.[24] Heart rates in unsedated adult Asian elephants have been reported to range within 29–55 beats/min while standing,[12] and 33–57 beats/min during lateral recumbency,[12,26] whereas higher heart rates have been reported in newborn elephant calves (70-140 bpm).[35] The pulse rates recorded for the juvenile elephants in the present study were similar to the heart rates recorded in adult Asian elephants sedated with xylazine (0.1 mg/kg),[26] whereas sedation with xylazine in combination with ketamine during lateral recumbency resulted in a higher heart rate.[26] The mean heart rate decreased from approx. 51 beats/min before sedation to 36 beats/min after 30–50 min sedation with xylazine alone and to 45 beats/min with xylazine–ketamine.[26] α_2-adrenoceptor agonists commonly induce decreases in heart rate and respiratory rate in many species, mainly as a result of their sympatholytic effect.[15] The bradycardic effect may be counteracted if combining α_2-adrenoceptor agonists with ketamine.

The normal body temperature in elephants is 36–37°C, though the temperature can vary throughout the day and night due to ambient temperature.[34] Rectal temperatures measured in the xylazine-sedated juveniles were similar to temperatures reported in newborn elephant calves,[35] and in unsedated adult Asian elephants.[13]

This is the first study presenting arterial blood gases during standing sedation in Asian elephants. The pulmonary gas exchange and acid–base balance were adequate with the xylazine doses used; no marked hypoxemia, hypercapnia, or acidemia were recorded in the arterial blood samples, which were collected at approx. 30 and 45 min after xylazine injection. The PaO_2 was above 80 mmHg in 10 of the 12 elephants that arterial samples were collected from. The lowest PaO_2 during standing sedation was 73 mmHg and during lateral recumbency was 76 mmHg, and the highest $PaCO_2$ was 52 mmHg, which are only mild changes in gas exchange. The p50 (pressure of O_2 when 50% of the hemoglobin is saturated) in Asian elephants is approx. 25 mmHg at 37°C.[7] The low p50 in elephants results in an underestimation of SaO_2 by blood gas analysis with the portable analyzer because it calculates saturation from measured PaO_2 on the basis of standard oxygen dissociation curves in humans. Thus, the hemoglobin may have been fully saturated also at the lowest PaO_2 level (PaO_2 73 mmHg) documented in this study. In nonsedated, adult female Asian elephants, the PaO_2 (mean ± SE) was 103 ± 2 mmHg when standing, and it decreased to 77 ± 4 mmHg after 15 min in lateral recumbency.[13] Similar values of PaO_2 (mean ± SEM) were reported in nonsedated Asian and African elephants while standing (96 ± 2 mmHg) and after 15

min of lateral recumbency (84 ± 3 mmHg).[12] Even though awake adult elephants in lateral recumbency and the sedated juveniles in the present study did not develop a marked hypoxemia, longer periods of recumbency during immobilization may increase the risk of hypoxemia, especially in adult elephants.

Regurgitation can be a risk during chemical immobilization when the swallowing reflex may be weak or absent, in conjunction with relaxation of the gastroesophageal sphincter. To avoid aspiration of ingesta, positioning of the recumbent elephant is crucial.[10] Discharge of gastric contents from the mouth was seen in one elephant in the present study but because it occurred while standing the risk of aspiration was small. Increased salivation was not observed in this study, but has been described during standing sedation of an Asian elephant bull using xylazine and ketamine,[20] and in African elephant bulls during standing sedation with medetomidine and butorphanol.[19] Adverse gastrointestinal side effects (such as bloat or mild colic) have been described during standing sedation of African elephants with detomidine and butorphanol,[21] but it was not observed during xylazine sedation of the elephants in the present study. Deviant behavior during xylazine immobilization, such as violent excitation, has been reported previously in an adult Asian elephant,[25] but was not observed in the juveniles in this study.

The occurrence of resedation after reversal in two elephants may have been due to xylazine not being completely antagonized by yohimbine. A variability across species in yohimbine's effectiveness as an α_2-adrenoceptor antagonist has been described.[15] Prolonged drowsiness following xylazine sedation and yohimbine reversal in captive Asian elephants has previously been reported.[30] If no reversal drug is administered, recovery after xylazine sedation may take up to 10 h in Asian elephants.[2] When immobilizing wild animals in the field, it is important to have a quick and complete recovery, for example, to prevent separation from the herd or to decrease the risk of injury by other species. Recently, xylazine sedation in elephants at ETH has been reversed with atipamezole, which previously was not available in Sri Lanka. Recovery times are faster with atipamezole compared with yohimbine in juvenile Asian elephants (Perera, pers. comm.). Yohimbine has less specific α_2–α_1 selectivity than atipamezole, which is the current most selective α_2-adrenoceptor antagonist. In captive Sumatran elephants, intravenous administration of detomidine and butorphanol provided standing sedation adequate for minor clinical procedures, and reversal with atipamezole and naltrexone resulted in rapid and complete recovery within 2–15 min.[11] Further studies are needed to evaluate effective doses and physiological effects of various drug combinations for standing sedation with quick induction and recovery in Asian elephants.

CONCLUSIONS

The xylazine doses used in juvenile Asian elephants produced light to deep sedation with stable physiology and no severe adverse effects. Xylazine is useful for standing sedation for minorly invasive and nonpainful procedures. Resedation may occur after using yohimbine as a reversal.

Acknowledgments: The authors thank the elephant handlers at the Elephant Transit Home in Sri Lanka. Earandika Karunarathna, Salinda Buddika, Dr. Michelle Oakley, and Shantha Waidyarathna provided infield support. Funding for physiological evaluation of xylazine sedation was provided by the Swedish Research Council (2017–05479)–Swedish Research Links program (2013–6722) with Professor N.P. Sunil-Chandra as a main collaborator. Material support was provided by Scandivet and Boule Medical AB.

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Accepted for publication 1 January 2021