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Low dose ketamine-xylazine protocol for immobilization of problematic wild rhesus macaques (*Macaca mulatta*)

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Rhesus macaques, known for their adaptability and proximity to human settlements, often pose challenges when their behaviour becomes problematic or pose a threat to both the environment and human population. Chemical immobilization of problematic rhesus macaques has emerged as an approach to mitigate these challenges. This study investigated the use of ketamine (a dissociative anaesthetic) 5 mg/kg body wt combined with xylazine (α_2-adrenoreceptor agonist) 2 mg/kg body wt in achieving temporary immobilization for the capture of problematic rhesus macaques and then transport them to a safe and natural habitat. The anaesthetic combination was delivered intramuscularly through a dart with the mean induction time of 3.56±0.15 min. Different physiological variables were recorded at different time intervals once the animals were safe to handle. It was found that this combination provided 86.21±1.63 (mean±SE) min window of anaesthesia and analgesia with a mean recovery period of 30.19±1.67 min that provided sufficient time to translocate problematic rhesus macaque.

Keywords: *Anaesthesia, Chemical immobilization, Darting, Ketamine-Xylazine, Rhesus macaque*

Extensive urbanization and use of forest lands as crop field has resulted in increased incidences of human-rhesus macaque conflict.

The Territorial Forest Division, Jabalpur regularly encounters the problems arising due to rhesus macaques. The School of Wildlife Forensic and Health, NDVSU, Jabalpur received many requests from forest department for chemical capture of these monkeys, where physical capture was not feasible. Wildlife capture requires use of anaesthetic drugs in higher doses (Glander *et al*., 1991) for short period induction of anaesthesia aiming to mere capture of the problematic animals or animals in distress, unlike anaesthesia during surgical procedures. There is lack of systematic studies and the standard operating procedures for safe dosing of immobilizing drugs and chemical capture of problematic rhesus macaques. Keeping this in view, the present study was planned to evaluate the doses of ketamine-xyalzine combination for smooth capture of problematic rhesus macaques.

The animals used in this study were six adult problematic rhesus macaques having history of human-rhesus macaque conflict in different areas of the Territorial Forest Division, Jabalpur (MP), India.

The problematic wild rhesus macaques were first located in the conflicting site and visually assessed for potential immobilization. Such animals were then either followed or provisioned food bait in a little quantity to attract them, until a good opportunity arose to safely dart the animals by using DAN inject gun. This required waiting until the animals were paused for some moment and presented the bulk of muscle mass of either hind limb as a target site for darting. Assuming the animal's body weight between 8 kg and 12 kg, the combination of xylazine (2 mg/kg body wt) and ketamine hydrochloride (5 mg/kg body wt) was injected. The animals were darted with CO_2 powered variable pressure DAN-Inject riffle (Model No. 9361 MOD JM) using 3 mL light weight plastic darts and 1.5 X 30 mm needles with side port.

When the macaques gained lateral or sternal recumbency and did not show any positive response to touch, they were placed on sterile cotton cloths. The hairs of one of the hind limbs were clipped and prepared for the blood collection from femoral vein. The anaesthetized animals were kept in a cage after recording various parameters and observed for recovery from anaesthesia in the cage itself. They were fed and watered at about 3 hr after complete recovery from anaesthesia and later released in safe and natural habitat.

The onset of anesthesia (min) was recorded as the time period between administration of the immobilizing drug through the dart to the onset of ataxia. The duration of anaesthesia was recorded as the time (min) period between the loss of pedal reflex and the return of ocular reflex. The complete recovery from anaesthesia (min) was recorded as the time period from return of ocular reflex to the time of standing and coming back to normal gait. It included reversal of tongue reflex, head raise, unassisted standing and coming back to normal gait.

Different physiological parameters like rectal temperature (°F), respiratory rate (breaths/min), heart rate (beats/min), oxygen saturation (SpO_2%) and blood pressure (mmHg) were recorded at various time intervals using a multi-parameter Vet patient monitor (New Gen Medical Systems, New Delhi).

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The data were analysed using paired 't' test and one way Analysis of Variance.

In the present study, all the cases encountered were of male rhesus macaques. The estimated weights ranged from 8 kg to 11 kg (mean 9.17±0.48 kg). After immobilization, the actual weights of the macaques were taken, which ranged from 8.8 kg to 10.8 kg (mean 9.60±0.27 kg). As per Prater (2005), the weight of male rhesus macaques range from 7 kg to 10 kg, whereas females are smaller and lighter weighing 5-6 kg.

The doses of ketamine and xylazine used for immobilization were 5 mg/kg and 2 mg/kg body weight, respectively, considering the animals' weight between 8 kg and 12 kg. The combination of the two drugs was found to be safe and effective for smooth immobilization of macaques.

The weights of the macaques were taken post-immobilization and the effective doses of the immobilizing drugs were calculated on actual weight basis. The mean effective dose for ketamine was 4.76±0.14 mg/kg body wt and xylazine 1.90±0.06 mg/kg body wt. It was evident from the findings that the ketamine and xylazine combination was effective even in lower doses for smooth immobilization of problematic rhesus macaques.

Soon after darting, the macaques became restless with frightened looks. Thereafter, they gradually became calm and exhibited different signs including ataxia, drooping of eyelids, drooping of head, folded hands, sitting on haunches, swaying gently back and forth followed by adoption of lateral or sternal recumbency. The onset time of anaesthesia was recorded at this point. The mean induction time for onset of anaesthesia was 3.56±0.15 min (Table 1). The induction was smooth, excitement free and satisfactory. No apnoea was observed during the course of anaesthesia. There was no salivation, urination or defecation observed. No episodes of vomition or regurgitation were observed in the anaesthetized animals.

The findings of the present study are in accordance with Kumar and Kumar (2015), who have anaesthetized rhesus macaques by intramuscular injection of ketamine (10 mg/kg body wt) and xylazine (2 mg/kg body wt) and recorded mean induction time of 4.06±0.22 min. The ketamine doses used in this study were lower and found to be effective.

The average duration of anaesthesia in the present study was 86.21±1.63 min (Table 2). This finding is similar to the finding of Kumar and Raj (2012), who observed the mean duration of anaesthesia as 82.27±4.96 min by intramuscular administration of ketamine (8 mg/kg body wt) and xylazine (2 mg/kg body wt) for vasectomy in rhesus macaques by electrocauterization.

The mean recovery time in this study was 30.19±1.67 min (Table 1). Kumar *et al.* (2011) observed the mean recovery time of 48±0.18 min in rhesus monkeys given intramuscular injection of ketamine (10 mg/kg body wt) and xylazine (2 mg/kg body wt). Thus, the mean recovery time in this study was lower, which could be due to the low doses of anaesthetic combination used. High doses of anaesthesia are required for surgical interventions in animals, however, lower doses are advised for mere capture or biological sampling in rhesus macaques.

Table 1: Post-immobilization anaesthesia parameters in rhesus macaques.

Case	Anaesthesia parameters (in min)		
No.	Onset	Duration	Recovery
RM01	3.39	83.19	31.23
RM02	4.01	86.11	24.46
RM03	3.36	89.23	27.12
RM04	3.41	80.31	33.47
RM05	3.14	91.24	29.28
RM06	4.03	87.19	35.56
Mean±SE (n=6)	3.56±0.15	86.21±1.63	30.19±1.67

The drug regime used in the present study caused a decrease in the rectal temperature at 15, 30, 45 and 60 min post-immobilization as compared to 5 min recording (Table 2). A slight increase in rectal temperature was observed in one macaque, which might be due to the high ambient temperature. However, it was managed efficiently by fogging of water with sprayer. The decrease in body temperature is a typical finding related with general anaesthesia and has been documented in several studies following the use of α_2-agonists in non-human primates (Lee *et al.*, 2003; Selmi *et al.*, 2004). Ketamine can increase the body temperature due to increased muscle tone (Sun *et al.*, 2003), but in combination with α_2-adrenoreceptor agonist usually it causes a reduction in body temperature by blocking the hypothalamic thermoregulatory centre and decreasing muscular activity (Sinclair, 2003).

The respiratory rate decreased initially up to 30 min and then showed gradual increase towards normal range (Table 2). The respiratory depression can be attributed to CNS depression produced by α_2-adrenoreceptor stimulation; however, the degree of depression with α_2-agonist alone is less than that with other sedatives, even at sub-lethal doses (Tewari, 2012).

The heart rate progressively decreased over a period of 60 min post-immobilization in the present study. The reason behind the depression of heart rate was the administration of xylazine attributing to combined action of baro-receptor reflex and vasoconstriction mediated by α_2-receptors (Settle *et al.*, 2010). However, ketamine has a tendency to stimulate the cardiovascular system by presenting sympathomimetic properties that increases heart rate and thus cardiac output. Although, these changes fall

Table 2: Physiological variables at various time intervals post-immobilization.

Time after drug administration (min)	T5	T15	T30	T45	T60
Rectal temperature (°F)	100.58±0.25	100.43±0.26	100.25±0.32	100.10±0.38	99.93±0.52
Respiration rate (breaths/min)	29.50±1.66	27.50±1.38	24.83±1.30	26.33±0.71	27.67±1.26
Heart rate (beats/min)	92.33±3.88	88.50±3.65	84.17±3.66	81.83±3.80	81.17±3.57
Oxygen saturation (%)	86.83±1.76	87.83±1.62	89.33±1.38	91.33±1.12	93.17±0.70
Systolic arterial pressure (mmHg)	122.83±2.54	127.67±2.17	131.50±2.05	126.83±1.82	122.33±1.31
Diastolic arterial pressure (mmHg)	81.00±1.26	83.67±1.12	85.33±0.88	80.83±1.01	77.33±0.92

within the normal physiological parameters of this non-human primate species (Unwin, 2005).

The mean peripheral oxygen saturation (SpO_2%) and mean systolic and diastolic arterial pressure recorded are presented in table 2. The initial increment in the systolic blood pressure was observed that could be attributed to action of α_2-agonists on the peripheral α_2-adrenoreceptors causing a dramatic increase in systemic vascular resistance, which resulted in an increase in the arterial pressure. With due course of time, the peripheral effects of α_2-agonist subside and hence the arterial pressure decrease towards normal values. The same phenomenon explains the trends that are observed in diastolic pressure also (Sinclair, 2003).

In conclusion, the drug combination of ketamine (5 mg/kg body wt) and xylazine (2 mg/kg body wt) used in the present study was found suitable for field immobilization of problematic rhesus macaques.

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