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Immobilization of Sika Deer with Medetomidine and Ketamine, and Antagonism by Atipamezole

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ABSTRACT: Forty wild sika deer (*Cervus nippon*) were immobilized with medetomidine and ketamine and reversed by atipamezole in summer and fall captures from September 1994 to October 1995. For large yearling and older deer, mean ± SD doses of 57.0 ± 15.6 μg/kg medetomidine and 1.64 ± 0.49 mg/kg (male) or 4.02 ± 1.16 mg/kg (female) of ketamine were administered by intramuscular injection. For calves and small yearlings, 69.3 ± 7.0 μg/kg medetomidine and 2.69 ± 0.44 mg/kg ketamine were administered. While immobilized, deer were easy to handle, and muscles were well relaxed. After intramuscular administration of atipamezole (about 5 times the dose of medetomidine), deer recovered rapidly and smoothly.

Key words: Atipamezole, chemical immobilization, *Cervus nippon*, ketamine, medetomidine, sika deer.

Medetomidine, a highly selective α-2 adrenoceptor agonist, either alone or in combination with ketamine has been used successfully to immobilize wild mammals including some deer species (Jalanka and Roeken, 1990; Tyler et al., 1990; Wolkers et al., 1994). A reported advantage of this chemical is the availability of the selective α-2 adrenoceptor antagonist, atipamezole. This may be especially advantageous when a large number of deer are captured and handled in a short period of time, such as when the drive trap, the corral trap, or the Alpine Capture System are used (Kaji et al., 1991; Oi and Suzuki, 1992; Uno et al., 1996). Without rapid reversal of immobilizing drugs, many animals must be attended simultaneously, increasing the burden on handlers.

When xylazine is used to immobilize deer, yohimbine or tolazoline are effective antagonists, (Jessup et al., 1983; Mech et al., 1985; Kreeger et al., 1986; DelGiudice et al., 1989), but rapid reversal requires intravenous injection, a skill not practical for every handler. In contrast, atipamezole is reportedly easy to handle and acts quickly even when injected intramuscularly. Moreover, the α-1/α-2 selectivity ratio of medetomidine is higher than that of xylazine (1,620 and 160, respectively), and the selectivity ratio of atipamezole is higher than that of yohimbine (8,526 and 40, respectively) (Virtanen, 1989; Jalanka and Roeken, 1990). In this study, we evaluated the response of wild sika deer to immobilization by medetomidine and ketamine and reversal by atipamezole.

In the summer and fall months between September 1994 and October 1995, we captured forty wild sika deer (*Cervus nippon*) inhabiting Nakanoshima Island on Lake Toya (Hokkaido, Japan; 42°36′N, 140°51′E). Deer were either free-range darted by a hand-made blowpipe (3 ml dart with 1.2 × 38.0 mm needle) or captured using the Alpine Capture System (Alpine deer group Ltd., New Zealand) and immobilized with medetomidine (Domitor, Orion Corp., Finland) and ketamine (Ketamine, Sankyo, Japan) to measure body size characteristics and to apply radiotelemetry collars. Initial drug dosages were based upon reported data from other species (Jalanka and Roeken, 1990; Tyler et al., 1990), with female deer generally receiving larger doses than males based upon a previous report (Bubenik, 1982) and our experience with xylazine/keta-

TABLE 1. Physical characteristics[a] of a free ranging sika deer captured and immobilized with medetomidine and ketamine at Nakanoshima Island on Lake Toya between September 1994 and October 1995.

	Males	Females	Fawns	Total
Body weight (kg)	62.9 ± 13.1[b] (19)	54.2 ± 14.7[c] (16)	23.5 ± 5.7 (5)	54.5 ± 18.0 (40)
Induction dose				
Medetomidine (μg/kg)	50.5 ± 13.1[b,d] (19)	60.8 ± 17.1 (16)	69.3 ± 7.0 (5)	57.0 ± 15.6 (40)
Ketamine (mg/kg)	1.64 ± 0.49[b,d] (19)	4.02 ± 1.16[c] (16)	2.69 ± 0.44 (5)	2.72 ± 1.38 (40)
Induction time (min)	14.6 ± 7.8[b,d] (17)	9.9 ± 9.2 (16)	5.2 ± 3.3 (5)	11.4 ± 8.6 (38)
Rectal temp (C)	39.6 ± 1.4 (10)	40.2 ± 2.1 (3)	40.3 (1)	39.8 ± 1.4 (14)
Respiratory rate (breaths/min)	38.0 ± 15.7 (10)	53.0 ± 16.0 (4)	20 (1)	40.8 ± 17.1 (15)
Heart rate (beats/min)	59.7 ± 10.4 (9)	52.0 ± 5.7 (2)	64 (1)	58.8 ± 9.7 (12)
Dose of atipamezole (μg/kg)	252.3 ± 65.7[b,d] (19)	307.1 ± 85.8 (16)	346.5 ± 35.1 (5)	286.0 ± 78.4 (40)
Recovery time (min)	4.1 ± 1.3[d] (18)	2.7 ± 1.5 (15)	3.0 ± 1.4 (5)	3.4 ± 1.6 (38)
Total dose of ketamine (mg/kg)	1.67 ± 0.48[b,d] (19)	4.02 ± 1.16[c] (16)	2.69 ± 0.44 (5)	2.73 ± 1.39 (40)
Handling time (min)	38.1 ± 16.3[d] (17)	58.4 ± 23.4 (16)	45.2 ± 10.4 (5)	47.6 ± 21.0 (38)

[a] Expressed as $\bar{x} \pm$ SD (n).
[b] Significant ($P < 0.05$) difference between males and fawns.
[c] Significant ($P < 0.05$) difference between females and fawns.
[d] Significant ($P < 0.05$) difference between males and females.

mine. Upon reflection, these higher initial doses may not have been appropriate as a first test of medetomidine/ketamine on sika deer. For adult and large yearling deer (five of nine yearlings), a solution of 3 mg of medetomidine per 100mg (male) or 200mg (female) of ketamine was prepared, and delivered with 0.5 mg of atropin sulfate (Atropin sulfate, Tanabe, Japan) by a Telinject 2V rifle (5 ml dart with 1.5 × 30.0 mm needle), or a hand-made blowpipe. For calves and small yearling deer, a mixture of 1.5 mg of medetomidine and 60 mg of ketamine was used. This was delivered with 0.25 mg of atropine sulfate by a hand made blowpipe.

For all immobilized deer, scale weights and body measurements were recorded, blood and feces samples were taken, and ear tags were attached. Radio collars were also affixed to thirteen deer. Times from first injection to induction (defined as when a deer became sternally recumbent and laid down its head), and from injection of atipamezole (Antisedan, Orion Corp., Finland) to recovery (defined as when a deer stands and walks easily) were recorded. Although attempts were made to measure respiratory rates, heart rates and rectal temperatures of immobilized deer, the limited number of handlers precluded measurement of all animals. These rates were recorded for some deer at approximately 28 (mean ± SD = 28.2 ± 12.0), 31 (31.1 ± 11.5) and 20 (20.1 ± 9.0) min, respectively. A deer showing signs of recovery during handling was given a second injection of ketamine equal to approximately 2/5 of the initial dose. All reported statistics are based on the Mann-Whitney *U*-test using StatView computer software (StatView, SAS Institute, Corey North Carolina, USA).

Several minutes after the administration of medetomidine/ketamine, deer became sternally recumbent before laying down their heads. As shown in Table 1, mean (±SD) induction times were significantly longer in males (14.6 ± 7.8 min) than in females (9.9 ± 9.2) ($P < 0.05$) or fawns (5.2 ± 3.3) ($P < 0.05$). These results may be more reflective of dosage differences than any sex based difference in sensitivity to the drug combination.

The range of effective induction doses for medetomidine (35.7–98.4 μg/kg) was within that reported for artiodactyls (Jalanka and Roeken, 1990; Tyler et al., 1990). Although the deer used in our study were from an isolated population and therefore might respond differently to immobilizing drugs than deer from the original stock (Fletcher, 1974), a population bottleneck about 100 yr ago on Hokkaido may limit the divergence of the Nakanoshima population (Kaji, 1995; Nagata et al., 1995). More studies will be needed to clarify this relationship.

The dose range of ketamine needed for effective immobilization of males was also within ranges reported in the literature, but females in our study required higher doses than that previously reported for artiodactyls (Jalanka and Roeken, 1990; Tyler et al., 1990). Given the relatively longer induction time for male deer in our study, higher dosage rates may be needed for optimal immobilization. Although the necessary ketamine doses were almost one-half of those needed for xylazine mixtures (Suzuki, 1994), comparison is difficult because of differences in capture method and subsequent differences in excitability and drug receptivity of captured animals.

In immobilized deer, ear touch response was minimal, and muscles were well relaxed. Handling times varied from 21 to 97 min and the additional hand injection of ketamine was necessary in only one case. Because data for normal heart and respiratory rates in sika deer are not available, we relied on indices of body weight and size, and data from other deer species. The respiratory rates observed during our study (40.8 ± 17.1 bpm) were intermediate to those reported for captive fallow deer immobilized with xylazine/ketamine (8 to 16 bpm; Stewart and English, 1990), and free ranging desert mule deer immobilized with xylazine/ketamine (54 bpm, mean value; DelGuidice et al., 1989). No animal displayed signs of bloating or respiratory depression, but the elevated respiration rates may reflect preinduction excitement. Heart rates were stable and slow for all sex and age categories compared with data from other deer species (Stewart and English, 1990; DelGuidice et al., 1989), perhaps related to bradycardia caused by medetomidine (Jalanka and Roeken, 1990).

The rectal temperatures of female deer were slightly higher than those of males or fawns. Rectal temperatures ranged from 38.2 to 42.6 C and exceeded 40 C in four of 14 deer. Although Seal et al. (1978) warned that immobilized deer with rectal temperatures of 40.0 C or higher were in danger, others have reported that rapid reversal of immobilization in overheated deer can decrease that danger (Mech et al., 1985). In this study as well, the four individuals with apparent hyperthermia recovered easily without notable problems. This demonstrates one advantage that the use of atipamezole allows.

Before complete recovery, a 30 kg yearling female suddenly died. An errant dart intended for an adult female (average weight 54.2 kg) penetrated the yearling's chest. Despite the high dosage, there was no apparent trouble while the animal was immobilized, and after administration of atipamezole, she showed signs of a normal recovery. Jalanka (1989) reported several examples in which no adverse effects were apparent in animals that received high doses of medetomidine. Field necropsy showed damage to the lung had occurred. With this finding and the fact that the deer showed normal signs of recovery after injection of atipamezole, it appears the mortality was more a result of the dart penetrating her chest than the high drug dosage.

After handling procedures were completed, atipamezole was administered in doses about five times that of the original medetomidine dose (Jalanka and Roeken, 1990). Female deer recovered more quickly than males, despite receiving higher doses of medetomidine. This may be a direct result of the higher dose of atipamezole administrated to females. In addition,

handling time for females was significantly longer and may have contributed to more rapid recovery. Despite being administered intramuscularly, atipamezole reversed the effects of medetomidine/ketamine more rapidly than tolazoline was reported to reverse xylazine/ketamine (Suzuki, 1994). In our experience, when tolazoline is administered to animals immobilized with xylazine/ketamine, their recovery is not immediately complete, with some animals having difficulty walking for an extended period. In the current study, deer given atipamezole recovered fully and were able to run immediately.

The stages of recovery after administration of atipamezole were predictable, smooth, and rapid. A recovering deer first moved its ears, lifted its head, sat up in a sternal position and eventually stood up and walked or ran away from the handling area. In almost all cases, this sequence was completed in a few minutes.

Medetomidine combined with ketamine was effective in immobilizing sika deer, and antipamezole proved to be a quick and smooth antagonist. Our results confirm earlier reports of its effectiveness and safety (Jalanka and Roeken, 1990). More controlled studies are needed to identify optimal dosage rates and potential sex-based differences.

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