Immobilization of free-ranging moose (*Alces alces*) with medetomidine-ketamine and remobilization with atipamezole

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Abstract: Seventeen free-ranging moose (*Alces alces*) (2 adult males, 13 adult females and 2 female calves) were immobilized with a combination of medetomidine hydochloride (MED) and ketamine hydrochloride (KET) in early autumn (August–September). Drugs were administrated with plastic projectile syringes fired from a dart gun, either from a car or by approaching the animals on foot. MED at 30 mg/adult and 15 mg/calf in combination with KET at 400 mg/adult and 200 mg/calf induced complete immobilization with sternal or lateral recumbency and loss of the corneal reflex in all individuals. The mean ± SD time from darting to when the animals were found was 18.3 ± 8.7 min for adults and the mean distance covered by these animals between darting and recumbency was 320 ± 200 m. No side effects of clinical significance were detected and registration of the rectal temperature (38.8 ± 0.5°C), heart rate (44 ± 7 beats/min), respiratory rate (31 ± 20 breaths/min) and relative arterial oxygen saturation (89 ± 3 %, n=8) during immobilization in adults showed that these physiological parameters were within the safe ranges established for moose. Blood samples from adults were analyzed for 17 haematological and 33 serum biochemical constituents and the results were compared to corresponding values found in moose immobilized with etorphine (ETO). Although the lower levels ($p<0.05$) found for haematocrit, red blood cells, haemoglobin and cortisol in the MED-KET group may indicate a difference in the stress response, the low muscle enzyme levels in both groups show that these immobilizing drugs and capture methods induce very little physical stress in moose. A hyperglycaemic response was found in MED-KET treated animals. Atipamezole hydrochloride (ATI) rapidly remobilized all animals and the time elapsing from ATI administration to standing was 3.9 ± 1.8 min after i.v./s.c. treatment (n=7) and 6.9 ± 3.4 min after i.m./s.c. injection (n=8). No side effects were detected after reversal. In conclusion, medetomidine-ketamine and atipamezole can be recommended for reversible immobilization of free-ranging moose in early autumn.

Key words: capture, drugs, haematology, serum biochemistry, Cervidae

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Introduction

Etorphine has been the drug of choice for immobilization of free-ranging moose (*Alces alces*), both in Scandinavia (Sandegren *et al.*, 1987) and in North America (Franzmann & Lance, 1988). Carfentanil, a more potent opioid than etorphine, has been used for moose capture in U.S.A. and Canada since 1984, mainly because a concentrated solution of etorphine was not commercially available (Franzmann & Lance, 1988). However, both agents are extremely toxic for humans (Haigh & Hudson, 1993) and there is a great need for a non-opioid alternative.

Free-ranging moose have been immobilized with xylazine (Doherty & Tweedie, 1989; Miller &

Litvaitis, 1992; Mikalsen & Arnemo, 1993) and xylazine-ketamine (Schwab *et al.*, 1984; Garner & Addison, 1994). However, these agents are less suitable for this purpose because of the large drug volumes needed and their variable effects.

In recent years, medetomidine, a more potent alpha$_2$-adrenoceptor agonist than xylazine, has been used in combination with ketamine for immobilization of various captive, non-domestic mammals (Jalanka, 1993). Atipamezole, a potent and selective alpha$_2$-adrenoceptor antagonist, is available for rapid and permanent reversal of the medetomidine-unduced effects (Jalanka, 1993). Jalanka & Roeken (1990) reported the use of medetomidine-ketamine in captive moose, but complete and reliable immobilization was not achieved with the doses tested. In other cervids like Svalbard reindeer (*Rangifer tarandus platyrhynchus*) and red deer (*Cervus elaphus*) medetomidine-ketamine was found to be effective for chemical capture of free-living individuals (Tyler *et al.*, 1990; Arnemo *et al.*, 1994).

The aim of the present study was to evaluate medetomidine-ketamine and atipamezole for reversible immobilization of free-ranging moose in early autumn.

Material and methods

Data were collected in early autumn (August–September) 1992–1993. Seventeen free-ranging moose including 2 males and 13 females aged more than 24 months and 2 female calves (approximately 3 months old) were immobilized with a combination of medetomidine hydrochloride (MED) and ketamine hydrochloride (KET) as part of a study on moose ecology in Aust-Agder County, Norway.

Drugs were administered with plastic projectile syringes fired from a dart gun (DAN-INJECT®, J. Lund-Jørgensen, DK-7080 Børkop, Denmark), either from a car or by approaching the animals on foot. The doses for adults were 30 mg MED (Medetomidine hydrochloride 30 mg/ml, Orion Corporation Animal Health Division, FIN-20101 Turku, Finland) and 400 mg KET (Ketamine hydrochloride 200 mg/ml reconstituted from dry powder, Parke, Davis & Co. Ltd., Usk Road, Pontypool, Gwent, NP4 OYH, United Kingdom), and for calves 15 mg MED and 200 mg KET. To avoid disturbance during the induction phase, the standard procedure was to wait for 10 min after darting before tracking the animals with dogs (Norwegian elkhounds). The time from darting to when the animal was found («induction time») was recorded and the distance covered by the animal after darting (walking distance) was estimated. Immobilized animals were monitored (body posture and regularity and amplitude of respiration) to avoid clinical complications such as bloat and regurgitation and to detect signs of respiratory depression. The corneal reflex was used to assess the depth of anaesthesia in immobilized animals. The following physiological parameters were recorded 20–50 min after darting: rectal temperature (°C), heart rate (beats/min) and respiratiory rate (breaths/min). Relative oxygen saturation (%) was recorded in eight animals using pulse oximetry (NELLCOR® N-10, Nellcor Inc., Pleasanton, California 94588, USA) with the sensor applied to the tongue. Adult moose were tagged with a plastic eartag in both ears and fitted with radio collars (Televilt International AB, S-71700 Storå, Sweden). Calves received a plastic eartag and an eartag radiotransmitter (Televilt International AB).

Blood samples for haematology and serum biochemistry were drawn from the jugular vein of adult animals 20-50 min after darting, using 10 ml evacuated tubes and 0.9 x 40 mm needles (Venoject®, Terumo Europe NV, 3001 Leuven, Belgium). Serum was separated by centrifugation of the plain samples within 6 hours of collection. The serum and EDTA samples were stored in a refrigerator overnight and sent by post to the Central Laboratory for Clinical Chemistry, Norwegian College of Veterinary Medicine, PO Box 8146 Dep., 0033 Oslo, Norway, where they were analyzed for selceted parameters by standard procedures. For comparison, blood samples were collected from nine free-ranging moose (4 males and 1 female aged 12–16 months and 4 males aged more than 24 months) immobilized with etorphine in summer or early autumn (June–September) 1992–1994 in Nordland County, Norway (J. M. Arnemo, unpublished data). The animals were captured using the same equipment and methods as in the main part of this study.

Atipamezole hydrochloride (ATI) (Antisedan® 5 mg/ml, Orion Corportaion Animal Health Division) at five times the dose of MED (i.e. 150 mg ATI/adult and 75 mg ATI/calf) was administered to all animals for reversal of immobilization. The time from darting to injection of ATI (time to reversal) was recorded. The ATI dose was divided and given half i.v. and half s.c. in seven adults and one calf and half i.m. and half s.c. in eight adults and one calf. The times from ATI administration to

Table 1. Summary of drug doses, induction times, walking distances, physiological parameters, times to reversal and head-up and on-feet times in adult, free-ranging moose immobilized with medetomidine-ketamine and remobilized with atipamezole in early autumn (Augst-September) 1992–1993 in Aust-Agder County, Norway.

		n	Mean ± SD	Range
Medetomidine hydrochloride (mg/animal)		15	30	–
Ketamine hydrochloride (mg/animal)		15	400	–
Induction time[a] (min)		15	18.3 ± 8.7	1.3–35.0
Walking distance[b] (m)		15	320 ± 200	10–750
Rectal temperature (°C)		15	38.8 ± 0.5	38.2–39.8
Heart rate (beats/min)		15	44 ± 7	30–60
Respiratiory rate (breaths/min)		15	31 ± 20	10–68
Relative oxygen saturation (%)		8	89 ± 3	85–92
Atipamezole hydrochloride (mg/animal)		15	150	–
Time to reversal[c] (min)		15	49 ± 10	32–64
Head-up time[d] (min)	i.v./s.c.	7	1.9 ± 0.8*	1.3–3.3
	i.m./s.c.	8	4.1 ± 2.1	1.0–7.5
On-feet time[e] (min)	i.v./s.c.	7	3.9 ± 1.8	1.7–6.3
	i.m./s.c.	8	6.9 ± 3.4	1.5–10.5

[a] Time from darting to when the animal was found.
[b] Distance covered by the animal between darting and recumbency.
[c] Time from darting to administration of the antagonist.
[d,e] Times from administration of the antagonist to head-lifting and standing, respectively.
* Significant difference ($p<0.0.5$) between routes of administration.

when the animal lifted its head (head-up time) and to when it was standing (on-feet time) were recorded.

The ambient temperature during the trials ranged from 12 to 20°C. The animals were periodically tracked by radiotelemetry for up to two years after treatment.

Statistical calculations were performed with NCSS® (Number Cruncher Statistical System, Kaysville, Utah 84037, USA). The two-sample *t*-test was used to compare the head-up and on-feet times after i.v./s.c. and i.m./s.c. administration of ATI, respectively, and to compare haematological and serum biochemical values from moose treated with medetomidine-ketamine and etorphine, respectively. Logarithmic transformation was used for parameters that were not normally distributed (white blood cell and neutrophil counts, aspartate aminotransferase and creatinine). P-values <0.05 were considered to be significant.

Results

Data on drug doses, induction times, physiological paramteres, times to reversal and head-up and on-feet times for adult animals are summarized in Table 1. Medetomidine-ketamine induced complete immobilization with loss of the corneal reflex in both adults and calves. Due to the tracking procedure, the actual induction times are not known for all animals. However, three animals were observed going down, one adult female after 1.33 min and two calves close to their immobilized dams after 4.0 and 5.0 min, respectively. Most animals were found in sternal recumbency, they offered no resistance to handling and could easily be turned over to their sides. Examination of the calves revealed rectal temperatures of 39.9 and 40.0°C, heart rates of 58 and 68 beats/min and respiratory rates of 28 and 32 breaths/min.

Clinical complications were not detected during immobilization. However, one adult female developed periodic apnoea 40 min after darting and was immediately given ATI i.v./s.c. without further evaluation of the severity of respiratory depression. This individual had twin calves and was in poor body condition.

Haematological and serum biochemical values are summarized in Tables 2 and 3, respectively.

Immobilization was rapidly reversed by administration of ATI (Table 1). Head-up and on-feet

Table 2. Haematological values in chemically immobilized free-ranging moose (*Alces alces*): a comparison between medetomidine-ketamine and etorphine. Data are given as mean ± SD.

Parameter (unit)	Medetomidine-ketamine (n = 15)		Etorphine (n = 9)
Haematocrit (*L/L*)	0.37 ± 0.02	*	0.47 ± 0.04
Red blood cells ($x10^{12}$/L)	5.62 ± 0.46	*	7.09 ± 0.46
Haemoglobin (g/L)	129 ± 7	*	166 ± 18
Mean corpuscular volume (fL)	65.3 ± 3.8		66.5 ± 4.0
Mean cell haemoglobin (pg)	23.1 ± 1.6		23.2 ± 1.6
Mean corpuscular haemoglobin concentration (g/L)	353 ± 10		350 ± 17
Red cell distribution width (%)	16.3 ± 0.7		15.9 ± 0.7
Haemoglobin distribution width (g/L)	19.7 ± 2.0		19.7 ± 2.2
Platelets ($x10^9$/L)	202 ± 85		234 ± 77
Mean platelet volume (fL)	5.5 ± 1.0		5.3 ± 0.6
White blood cells ($x10^9$/L)	4.28 ± 1.21		4.33 ± 1.88
Neutrophils ($x10^9$/L)	1.96 ± 0.87		2.48 ± 1.60 (n = 8)
Lymphocytes ($x10^9$/L)	1.30 ± 0.43		1.32 ± 0.31 (n = 8)
Monocytes ($x10^9$/L)	0.12 ± 0.06		0.16 ± 0.07 (n = 8)
Eosinophils ($x10^9$/L)	0.80 ± 0.37	*	0.23 ± 0.18 (n = 8)
Basophils ($x10^9$/L)	0.38 ± 0.29 (n = 13)		0.25 ± 0.13 (n = 8)
Large unstained cells ($x10^9$/L)	0.10 ± 0.04		0.13 ± 0.06 (n = 8)

* Significant difference ($p<0.05$) between groups.

times for the calves were 0.83 and 1.33 min, respectively, after i.m./s.c. injection, and 5.0 and 8.0 min, respectively, after i.m./s.c. administration. Reversals were calm and without side effects. All animals got up at the first attempt and were able to walk or run in a coordinated manner, although a slight stiffness of gait was seen in a few individuals. All animals urinated shortly after they were on-feet.

All treated animals recovered completely and no drug-related complications or behavioural changes were detected during the follow-up radiotracking study. In spring 1993, all females (n=4) with intact transmitters produced single calves. In spring 1994, only two out of seven females produced calves. Three females died from natural causes: one cow probably had dystocia and was found dead 9 months after tagging; one cow fell into a ditch 10 months after tagging and, although rescued, died within 24 hours; one cow drowned in a lake 17 months after tagging. One of the males lost the transmitter one month after tagging and was shot during the regular hunt shortly afterwards. Both calves lost their transmitters during their first winter. One female was short during the regular hunt two months after tagging, while three females lost their transmitters 9, 10 and 15 months after tagging, respectively.

Discussion

The medetomidine-ketamine combination was very efficient for the capture of free-ranging moose. All animals became completely immobilized after one injection and no side effects of clinical significance were detected. Absence of the corneal reflex in immobilized animals indicates that the depth of anaesthesia may be suitable for surgical intervention (Booth, 1988).

Rapid induction is essential in the chemical capture of wildlife so that the animals can be found, handled and monitored within a short time after drug administration. Due to the tracking procedu-

Table 3. Serum biochemical values in chemically immobilized free-ranging moose (*Alces alces*): a comparison between medetomidine-ketamine and etorphine. Data are given as mean ± SD.

Parameter (unit)	Medetomidine-ketamine (n = 15)		Etorphine (n = 9)
Protein, total (g/L)	67.4 ± 3.1		69.9 ± 3.2
Albumin (g/L)	37.1 ± 3.7	*	43.6 ± 5.1
Globulin, total (g/L)	30.3 ± 5.3		26.4 ± 3.8
∝-globulin (g/L)	10.7 ± 1.4	*	8.7 ± 1.8
ß-globulin (g/L)	7.0 ± 1.2		6.8 ± 0.8
ɣ-globulin (g/L)	12.6 ± 3.5		10.8 ± 2.6
Albumin:globulin ratio	1.28 ± 0.34	*	1.69 ± 0.38
Urea (mmol/L)	5.5 ± 2.4		5.4 ± 1.7
Creatinine (µmol/L)	147 ± 29		155 ± 56
Uric acid (µmol/L)	18 ± 4		20 ± 9
Total bilirubin (µmol/L)	2 ± 1		3 ± 1 (n = 8)
Cholesterol (mmol/L)	1.7 ± 0.2		1.7 ± 0.4
Triglycerides (mmol/L)	0.3 ± 0.1		0.3 ± 0.2
Free fatty acids (mmol/L)	0.2 ± 0.2	*	1.0 ± 0.3
ß-Hydroxybutyric acid (mmol/L)	0.3 ± 0.1		0.3 ± 0.1
Glucose (mmol/L)	8.4 ± 1.0		6.2 ± 0.9
Cortisol (nmol/L)	168 ± 76 (n = 7)		533 ± 113 (n = 5)
Aspartate aminotransferase (U/L)	99 ± 26		100 ± 27
Alanine aminotransferase (U/L)	32 ± 7	*	20 ± 6
Alkaline phosphatase (U/L)	251 ± 130		407 ± 276
Creatine kinase (U/L)	113 ± 30		99 ± 23
Lactate dehydrogenase (U/L)	835 ± 130		959 ± 202
ɣ-Glutamyltransferase (U/L)	16 ± 6		13 ± 4
Glutamate dehydrogenase (U/L)	4 ± 4 (n = 14)	*	1 ± 1
Amylase (U/L)	90 ± 23	*	118 ± 26
Lipase (U/L)	27 ± 20		47 ± 30
Inorganic phostphate (mmol/L)	0.8 ± 0.4	*	1.9 ± 0.6
Calcium (mmol/L)	2.5 ± 0.1	*	2.6 ± 0.2
Magnesium (mmol/L)	1.20 ± 0.17	*	1.40 ± 0.20
Sodium (mmol/L)	143 ± 3		143 ± 5
Potassium (mmol/L)	4.2 ± 0.5	*	4.9 ± 0.5
Chloride (mmol/L)	101 ± 2		99 ± 3
Iron (µmol/L)	21 ± 6		28 ± 7

* Significant difference ($p<0.05$) between groups.

re, the actual induction time is unknown for most of the animals in the present study. However, the fact that three individuals were seen going down and that all the other animals were completely immobilized when found, strongly indicates that the actual times from darting to recumbency were probably much shorter than the recorded «induction» times ($\bar{x}$=18.3 min).

Garner & Addison (1994) reported that the mean time from the first injection to recumbency for 22 free-ranging female moose immobilized with xylazine-ketamine in spring was 18.4 min and that

all animals required multiple injections. Although these authors concluded that xylazine-ketamine was suitable for the immobilization and capture of moose, my data clearly indicate that medetomidine-ketamine is a better combination.

There is no doubt that etorphine is an extremely safe drug for the immobilization of moose in winter. Approximately 970 captures of free-ranging individuals with etorphine have been carried out in Norway and only two drug-related fatalitites have occurred (M. Heim, pers. comm. 1995). However, a major side effect of etorphine is hyperthermia and Franzmann (1982) discouraged immobilization of moose at ambient temperatures above 10°C. Reports on the use of xylazine in August – September (Miller & Litvaitis, 1992) and of xylazine-ketamine in May – June (Garner & Addison, 1994) did not include information about the body temperature or other physiological parameters in immobilized moose, or the ambient temperature during the studies.

Although the normal body temperature in unmedicated free-ranging moose is not known, Franzmann *et al.* (1984) considered the safe range and the critical value for the rectal temperature in moose to be 38.4 – 38.9 and 40.2°C, respectively. In the present study, immobilization with medetomidine-ketamine did not produce critical hyperthermia in any of the animals, even on sunny days with an ambient temperature of up to 20°C.

Franzmann *et al.* (1984) reported the safe ranges and critical values for the heart and respiratory rates to be 70–91 and 103 beats/min, and 13–40 and 40 breaths/min, respectively. The bradycardia seen in all animals in the present study is probably a medetomidine-mediated effect (Jalanka, 1993). Although tachypnoea was recorded in a few individuals, a high relative arterial oxygen saturation was registered in all animals, indicating that ventilation is adequate during immobilization with medetomidin-ketamine.

The diuretic effect of alpha-2 adrenoceptor agonists is well established (Maze & Tranquilli, 1991; Jalanka, 1993) and explains why all the animals in the present study passed copious amounts of urine shortly after reversal.

Reference ranges for some blood values in moose have been reported by Franzmann & LeResche (1978). However, results from their study should be interpreted with caution, because pooled data from animals immobilized with different drugs and from animals killed during hunting were used. According to Wesson *et al.* (1979), it is undesirable to combine and compare blood samples obtained by different methods such as shooting, immobilizing drugs or physical restraint.

Several blood stress parameters were significantly lower in animals treated with medetomidine-ketamine than in animals treated with etorphine. An increase in the haematocrit, red blood cell count, and hameoglobin and cortisol concentrations is part of the animal's normal stress-response (Franzmann *et al.*, 1975; Arnemo *et al.*, 1994) and may indicate that etorphine-immobilization is more stressful to the animal. The hyperglycaemia found in animals treated with medetomidine-ketamine is a well-knwon alpha$_2$-adrenoceptor-mediated effect (Jalanka, 1993). Low levels of aspartate aminotransferase, creatine kinase and lactate dehydrogenase indicate that physical stress associated with capture was minimal in both groups of animals, and that muscle damage did not occur (Spraker, 1993).

Significant differences in some of the other blood parameters are probably unrelated to the drug effects: nutritional factors and body condition may influence the serum levels of proteins, minerals and metabolites (Franzmann & LeResche, 1978), while the difference in eosinophilic cell counts may indicate different parasitic burdens (Jain, 1986). Although Franzmann & LeResche (1978) did not find any sex differences in blood values during the summer/autumn season, the skewed sex distribution between animals treated with medetomidine-ketamine (mostly females) and those treated with etorphine (mostly males) may have influenced som of the results in the present study.

It is highly desirable that an effective reversal agent is available to shorten the recovery in captured wildlife, especially in ruminants which may develop life-threatening bloat and regurgitation while recumbent. In the present study, atipamezole rapidly remobilized the moose, both after i.v./s.c. and i.m./s.c. administration, and side effects were not seen. Because i.v. administration of atipamezole may cause ataxic recovery (Jalanka, 1993), I suggest that the i.m./s.c. route should be used on a routine basis.

Garner & Addison (1994) used yohimbine to reverse xylazine-ketamine immobilization in moose. Although yohimbine was given partly intravenously, the recovery was slow, the mean time from injection to standing being 22.8. min. The authors did not include information on side effects such as resedation. Yohimbine is a less potent and selective

alpha$_2$-adrenoceptor antagonist than atipamezole, especially in ruminants (Arnemo & Søli, 1993; Jalanka & Roeken, 1990), and may cause heavy resedation after the initial arousal effect (Jalanka & Roeken, 1990).

In conclusion, the present study showed medetomidine-ketamine and atipamezole to be excellent drugs for the reversible immobilization of free-ranging moose under the described circumstances.

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References

Arnemo, J. M., Negard, T. & Søli, N. E. 1994. Chemical capture of free-ranging red deer (*Cervus elaphus*) with medetomidine-ketamine. – *Rangifer* 14 (3): 123–127.

Arnemo, J. M. & Søli, N. E. 1993. Reversal of xylazine-induced sedation in dairy calves with atipamezole: a field trial. – *Vet. Res. Commun.* 17 (4): 305–312.

Booth, N. H. 1988. Clinical stages of anesthesia. – *In:* Booth, N. H. & McDonald, L. E. (eds.). *Veterinary Pharmacology and Therapeutics.* Ames: Iowa State University, pp. 171–180.

Doherty, T. J. & Tweedie, P. R. 1989. Evaluation of xylazine hydrochloride as the sole immobilizing agent in moose and caribou – and its subsequent reversal with idazoxan. – *J. Wildl. Dis.* 25 (1): 95–98.

Franzmann, A. W. 1982. An assessment of chemical immobilization of North American moose. – *In:* Nielsen, L., Haigh, J. C. & Fowler, M. E. (eds.). *Chemical immobilization of North American wildlife.* Milwaukee: The Wisconsin Humane Society, pp. 393–407.

Franzmann, A. W., Flynn, A. & Arneson, A. D. 1975. Serum corticoid levels relative to handling stress in Alaskan moose. – *Can. J. Zool.* 53: 1424–1426.

Franzmann, A. W. & Lance, W. R. 1988. Chemical immobilization of wildlife: recent advances. – *In:* Nielsen, L. & Brown, R. D. (eds.). *Translocation of Wild Animals.* Milwaukee/Kingsville: The Wisconsin Humane Society & the Caesar Kleberg Wildlife Research Institute, pp. 99–109.

Franzmann, A. W. & LeResche, R. E. 1978. Alaskan moose studies with emphasis on condition evaluation. – *J. Wildl. Manage.* 42 (2): 334–351.

Franzmann, A. W., Schwartz, C. C. & Johnson, D. C. 1984. Baseline body temperatures, heart rates, and respiratory rates of moose in Alaska. – *J. Wildl. Dis.* 20 (4): 333–337.

Garner, D. L. & Addison, E. M. 1994. Postpartum immobilization of adult female moose using xylazine, ketamine and yohimbine hydrochlorides. – *J. Wildl. Dis.* 30 (1): 123–125.

Haigh, J. C. & Hudson, R. J. 1993. – *Farming Wapiti and Red Deer.* St. Louis: Mosby-Year Book, Inc., pp. 83–98.

Jain, N. C. 1986. – *Schalm's Veterinary Hematology.* Philadelphia: Lea & Febiger, pp. 747–749.

Jalanka, H. H. 1993. New alpha$_2$-adrenoceptor agonists and antagonists. – *In:* Fowler, M. E. (ed.). *Zoo and Wild Animal Medicine: Current Therapy 3.*

Jalanka, H. H. & Roeken, B. O. 1990. The use of medetomidine, medetomidine-ketamine combinations, and atipamezole in nondomestic mammals: a review. – *J. Zoo Wildl. Med.* 21 (3): 259–282.

Maze, M. & Tranquilli, W. 1991. Alpha$_2$-adrenoceptor agonists: defining their role in clinical anesthesia. – *Anesthesiology* 74: 581–605.

Mikalsen, R. & Arnemo, J. M. 1993. Immobilization of moose with Rompun®. – *Nor. Vet. Tidsskr.* 105 (12): 1230–1231 (in Norwegian).

Miller, B. K. & Lirvaitis, J. A. 1992. Habitat segregation by moose in a boreal forest ecotone. – *Acta. Theriol.* 37 (1–2): 41–50.

Sandegren, F., Petterson, L., Ahlqvist, P. & Röken, B.-O. 1987. Immobilization of moose in Sweden. – *Swedish Wildlife Research Suppl.* 1: 785–791.

Schwab, F. E., Schwab, S. W. & Pitt, M. D. 1984. Moose immobilization program in northcentral British Columbia. – *Alces* 20: 209–221.

Spraker, T. R. 1993. Stress and capture myopathy in artiodactylids. – *In:* Fowler, M. E. (ed.). *Zoo and Wild Animal Medicine: Current Therapy 3.* Philadelphia: W. B. Saunders Co., 481–488.

Tyler, N. J. C., Hotvedt, R., Blix, A. S. & Sørensen, D. R. 1990. Immobilization of Norwegian reindeer (*Rangifer tarandus tarandus*) and Svalbard reindeer (*R. t. platyrhynchus*) with medetomidine and medetomidine-ketamine and reversal with atpamezole. – *Acta Vet. Scand.* 31 (4): 479–488.

Wesson, J. A., Scanlon, P. F., Kirkpatrick, R. L. & Mosby, H. S. 1979. Influence of the time of sampling after death on blood measurements of the white-tailed deer. – *Can. J. Zool.* 57: 777–780.

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