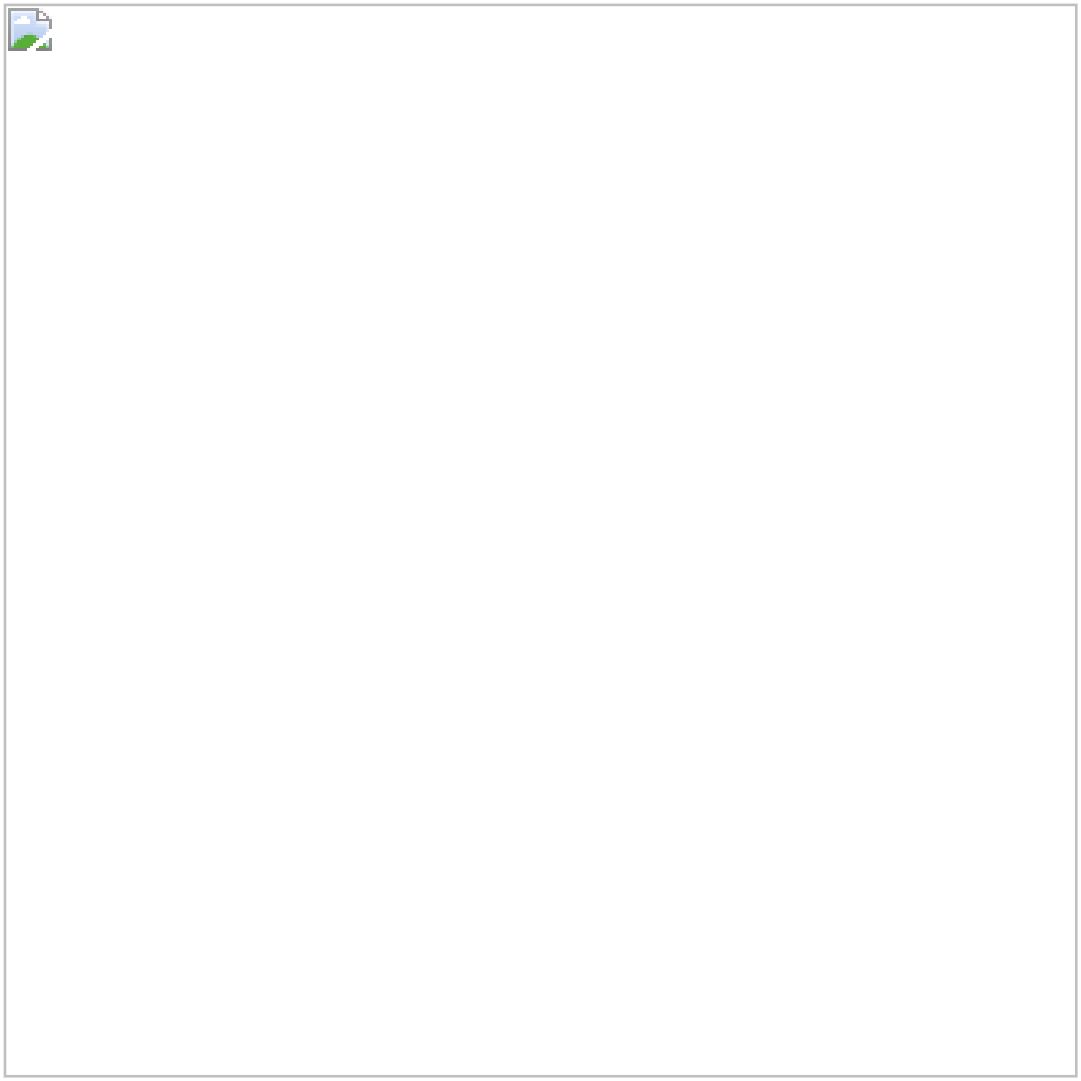

Immobilization of Wolves Using Ketamine in Combination with Xylazine or Promazine

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There were no lesions in the brain and optic nerves that might result in central blindness. We found that the rosettes in the falcon retina were not associated with other ocular changes and were of the primitive unilayer type which Lahav et al. (1973, op. cit.) found incidentally with no relationship to other ocular lesions. Although we did not demonstrate any viruses and the levels of common environmental pollutants measured were low, the morphologic lesions in the falcon were like those seen in other species secondary to injury by toxins or viruses.

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Immobilization of Wolves Using Ketamine in Combination with Xylazine or Promazine

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Wolves (*Canis lupus*) have been most commonly immobilized with phencyclidine and promazine (Mech, 1974, Proc. Intl. Congr. Game Biol. 11: 315–322) or with etorphine (Fuller and Keith, 1980, J. Wildl. Manage. 45: 271–273). Phencyclidine is not currently available and etorphine is a highly potent narcotic that must be used with extreme care. Ketamine, with subsequent injections of promazine, has been used to immobilize both captive and wild-caught wolves (U. S. Seal, L. D. Mech, and S. Fritts, pers. comm.), and xylazine has been used to restrain captive wolves (Philo, 1978, J. Am. Vet. Med. Assoc. 173: 1163–1166).

Ketamine acts primarily on the central nervous system and produces a dissociative anesthesia (Harthoorn, 1976, The Chemical Capture of Animals, Bailliere Tindall, London, England, 416 pp.). Muscle relaxation is generally poor when ketamine is used alone so we used it in combination with xylazine, a sedative and muscle relaxant, or promazine, a tranquillizer, to immobilize wild-caught wolves during telemetry studies in northcentral Minnesota.

Wolves were captured in No. 4 or 14 Newhouse steel traps during spring (April–May) or fall (August–October). Trapped wolves were immobilized initially with combinations of ketamine hydrochloride (ketamine [ketaset] Bristol-Myers Co., Syracuse, New York 13201, USA) and xylazine hydrochloride (xylazine [rompun] Haver-Lockhart Laboratories, Shawnee, Kansas 66201, USA), ketamine and xylazine with atropine sulphate (atropine [atropine sulphate] Med-tech Inc., Elwood, Kansas 66024, USA), or ketamine and promazine hydrochloride (promazine [sparine] Wyeth Laboratories, Inc., Philadelphia, Pennsylvania 19101, USA), injected intramuscularly in the hindquarters with a 2-m jab stick. Additional injections were administered similarly, if necessary. The wolves' legs were bound and their mouths were taped shut throughout handling. Animals were ear-tagged, weighed, measured, fitted with mortality-sensing radiocollars, inspected for injuries and general condition, and given an antibiotic (benzathine penicillin G and procaine penicillin G [bicillin fortified] Wyeth Laboratories, Inc., Philadelphia, Pennsylvania 19101, USA) in the case of trap damage to the foot. Blood samples were drawn from the femoral artery and were handled and analyzed as outlined by Karns and Crichton (1978, J. Wildl. Manage. 42: 904–908). Heart rates, respiration rates, and rectal temperatures were recorded for some wolves. Radiocollared wolves were subsequently located and observed from the air.

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During 5 September–17 October 1980, 22

TABLE 1. Total drug doses and immobilization statistics for 36 wolves captured in northcentral Minnesota during September–October 1980, April–May 1981, August–October 1981, and May 1982.

	Drug combination								
	Ketamine:xylazine[a]			Ketamine:xylazine:atropine			Ketamine:promazine		
	n	Mean	Range	*n*	Mean	Range	*n*	Mean	Range
Total drug dose (mg/kg)									
Ketamine	18	5.3	1.7–12.0	4	5.1	4.2–6.0	14	9.4	3.1–15.2
Xylazine	18	2.4	0.7–6.5	4	2.6	2.1–3.0			
Atropine				4	0.04	0.03–0.06			
Promazine							14	4.6	0.9–13.0
No. injections/wolf	18	1.1	1–3	4	1.0		14	2.8	2–6
Induction time (min)	6	4.3	2–7	4	5.5	3–10	13	30.6	8–98
Recovery time (min)[b]	16	40	18–75	4	39	20–60	14	63	24–123
Heart rate (per min)	5	79	60–138	4	141	114–160	12	186	91–272
Respiration rate (per min)	5	16	10–20	3	46	20–94	10	40	14–88
Rectal temperature (C)	1	38.6		3	40.4	39.3–41.5	6	40.0	38.3–41.5

[a] Includes one wolf which died <24 hr after a second large injection of drug. Does not include two wolves which died <15 min after drug injection.

[b] Time of first injection to time wolf is first on its feet or sitting up.

April–15 May 1981, 26 August–7 October 1981, and 8–22 May 1982, 11 adult (≥1.0 yr) male wolves (mean weight = 38 kg), 17 adult females ($\bar{x}$ = 30 kg), six male pups ($\bar{x}$ = 24 kg), and four female pups ($\bar{x}$ = 17 kg) were captured and immobilized. Twenty wolves were immobilized with ketamine (*K*) and xylazine (*X*), four with ketamine, xylazine and atropine (*A*), and 14 with ketamine and promazine (*P*). There were no significant differences ($P > 0.13$) in mean drug doses between sex or age classes, or in seasonal response to drug doses. Thus, data were pooled for each drug combination.

Injections of ketamine and xylazine ($\bar{x}$ = 5.2 mg/kg *K*:2.4 mg/kg *X*) immobilized 18 wolves successfully within about 4 min and allowed for handling that lasted an average of 36 min (Table 1). Wolves given lighter doses of both ketamine and xylazine generally became active sooner ($r^2 = 0.49$; $P < 0.005$); two would have escaped had they not been restrained. Most wolves lay quietly during handling and ran off when released. One wolf trapped <10 min before drugging required three injections totaling 8.9 mg/kg *K*:2.7 mg/kg *X* over a 21-min period before it could be handled. Rectal temperature of one wolf was 38.6 C. Five wolves immobilized with the ketamine:xylazine mixture had a mean respiration rate of 16/min and heart rate of 79/min. All five wolves had irregular heart beats.

Six of the 18 wolves required additional injections to allow for continued handling. Five of these were redrugged with 1.4–4.8 mg/kg *K*:0.6–1.4 mg/kg *X* after initial doses of 2.8–5.8 mg/kg *K*:0.8–3.3 mg/kg *X*, and remained immobilized for another 18–38 min. Recovery time for two was not noted and two recovered in 17–18 min. Another wolf stayed down for 150 min, was given a third injection (4.3 mg/kg *K*:1.4 mg/kg *X*) and recovered after a further 130 min. The sixth wolf, an adult female captured 8 September, was initially given 11.5 mg/kg *K*:3.4 mg/kg *X* and was redrugged after 75 min with 7.7 mg/kg *K*:2.7 mg/kg *X*. It remained immobilized and vomited once during the next 190 min, and subsequently died. This wolf was thin (26 kg) and had a count of 54 nucleated red cells/100 white cells in the blood (normal <1%). This possibly indicates chronic hemorrhaging, neoplastic disease, or congestive heart disease (Wintrobe, 1967, Clinical Hematology. Lea and Febiger, Philadelphia, Pennsylvania, 1287 pp., K. Kerr, pers. comm.). Blood values indicating possible dehydration (Schlam, 1975, Veterinary Hematology, 3rd ed. Lea and Febiger, Philadelphia, Pennsylvania, 807 pp.) and trap stress (Seal et al., 1975, J. Mammal. 56: 64–75) included high hemoglobin and high serum enzyme values, respectively (T. Fuller and P. Karns, unpubl. data). It appears that this individual was moribund before capture, and that trapping and handling hastened its death.

Two other wolves, a 29-kg adult female captured 13 May and a 15-kg female pup captured 29 August, died 5 to 10 min after injection ($\bar{x}$ = 4.5 mg/kg *K*:3.4 mg/kg *X*). The rapid deaths

of these two animals and the cardiac arrhythmia found in five other wolves drugged with ketamine and xylazine suggest cardiac arrest was the cause of death. Blood parameters for the two dead wolves were similar to those of successfully-drugged animals (T. Fuller and P. Karns, unpubl. data).

Philo (1978, op. cit.) immobilized captive wolves with xylazine and atropine, and noted no cardiac abnormalities; he suggested this was possibly due to the injection of atropine. Thus, in May 1982, we immobilized four wolves with a mean dose of 5.1 mg/kg *K*:2.6 mg/kg *X*:0.04 mg/kg *A*. Induction occurred in about 5 min and drug doses allowed for handling lasting about 39 min (Table 1). No cardiac abnormalities were noted, but heart rates ($\bar{x} = 141$/min) and respiration rates ($\bar{x} = 46$/min) were elevated in comparison with ketamine:xylazine immobilized wolves. The wolves were not as submissive during handling either. One wolf given a low ketamine dose (4.2 mg/kg) required additional injections to complete handling.

First doses of ketamine and promazine averaged only 4.2 mg/kg *K*:1.8 mg/kg *P* for 13 of 14 wolves, and these animals all required one or more additional injections within 10–50 min to maintain adequate sedation. Total injections for all 14 wolves averaged 9.4 mg/kg *K*:4.6 mg/kg *P* (Table 1). Wolves were immobilized sufficiently to allow for handling that lasted an average of 32 min, but 10 wolves struggled throughout handling despite mean total doses of 9.7 mg/kg *K*:3.9 mg/kg *P*. Wolves given higher doses of ketamine were generally immobilized longer, as with the ketamine:xylazine mixture.

Rectal temperatures of six wolves immobilized with ketamine:promazine (40.0 C) were similar to the wolves immobilized with ketamine:xylazine:atropine (Table 1). Mean respiration rate for 10 wolves (40/min) and heart rate for 12 wolves (186/min) immobilized with ketamine:promazine were significantly higher ($P < 0.05$) than for wolves immobilized with ketamine:xylazine, but similar to values for wolves immobilized with ketamine:xylazine:atropine.

Ketamine alone in doses of 12–25 mg/kg *K* provided adequate immobilization lasting 20–45 min (recovery: 45–100 min) for a number of canid species (Kaplan, 1972, Vet. Med. Small An. Clin. 67: 631–634; Ramsden, Coppin, and Johnston, 1976, J. Wildl. Dis. 12: 221–225; Baer, Severson, and Linhart, 1978, J. Wildl. Manage. 42: 452–454; Harthoorn, 1976, op. cit.; Rowe-Rowe and Green, 1980, S. Afr. J. Wildl. Res. 10: 153). Mean doses of 5.5–12.3 mg/kg *K*:1.8–5.5 mg/kg *X* immobilized coyotes (*Canis latrans*) (Mulder, 1978, J. Wildl. Dis. 14: 501–502; Cornely, 1979, J. Wildl. Manage. 43: 577–579) and dogs (Stephenson, Blevins, and Christie, 1978, Vet. Med. Small An. Clin. 73: 303–306) for 30–50 min (recovery: 30–120 min), and no mortalities were reported. Our data indicated that doses of about 5–6 mg/kg *K*:2–3 mg/kg *X*, with or without 0.04 mg/kg *A*, adequately immobilized wolves and allowed for handling lasting an average of 35–40 min. Recovery was usually rapid and wolves not given atropine seemed submissive rather than sedated and ran off at the first opportunity. With the ketamine:xylazine mixture, however, two wolves died and all five others that were monitored showed cardiac arrhythmia, a common problem in dogs immobilized with xylazine alone or in combination with atropine (Klide, Calderwood, and Soma, 1975, Am. J. Vet. Res. 36: 931–935). Four wolves were subsequently immobilized with ketamine:xylazine:atropine and showed no signs of cardiac abnormalities, but had higher heart and respiration rates.

Adult wolves injected first with 10–12 mg/kg *K*, then with 3–5 mg/kg *P* 15–20 min later, were immobilized for an additional 10–20 min (U. S. Seal, L. D. Mech, and S. Fritts, pers. comm.). In this study, high cumulative doses of the ketamine:promazine mixture were administered to wolves, but the animals struggled throughout a short (32 min), often interrupted, handling period and had elevated heart and respiration rates. The animals might have been incompletely sedated because the metabolism of ketamine is fairly rapid and initial doses were low.

We suggest that a 33-kg adult wolf be initially immobilized (intramuscular injection) either with a combination of 200 mg ketamine, 100 mg xylazine, and 1.3 mg atropine, or with 300 mg ketamine and 100 mg promazine. Using either combination, a followup injection (intravenously) of 50–100 mg ketamine should give rapid relaxation to allow for additional handling lasting 10–15 min. Prior to immobilization, consideration should be given to the physical condition of the animal and the ambient

temperature. Heart and respiration rates, and body temperatures of immobilized wolves should be monitored as well. Properly administered, either of these drug combinations should provide for adequate immobilization of wild-caught wolves.

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