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Immobilization of Free-ranging Red Foxes (*Vulpes vulpes*) with Tiletamine Hydrochloride and Zolazepam Hydrochloride

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ABSTRACT: We evaluated Zoletil on free-ranging red foxes (*Vulpes vulpes*) in Spain. Twenty-two pup and 49 adult wild-caught red foxes (*Vulpes vulpes*) were immobilized with a combination of tiletamine hydrochloride and zolazepam hydrochloride in a 1:1 proportion (Zoletil). Mean (\pm SE) Zoletil doses were 10.57 (\pm 0.41) mg/kg (range = 7.58–15.39 mg/kg, n = 22) for pups and 10.51 (\pm 0.33) mg/kg (range = 5.88–16.67 mg/kg, n = 45) for adults. Mean induction and first recovery times for pups were 2.3 (\pm 0.2) minutes (range = 1 to 5 minutes) and 35.5 (\pm 3.28) minutes (range = 18 to 78 minutes), respectively. Mean induction and first recovery times for adults were 3.7 (\pm 0.21) minutes (range = 2 to 8 minutes) and 35.4 (\pm 2.22) minutes (range = 13 to 90 minutes), respectively. We recommend Zoletil doses of 10 mg/kg for red foxes. For wild adult red foxes of unknown weight, an initial dose of 60 to 70 mg Zoletil should be administered. This dose should allow about 40 minutes of handling time.

Key words: Immobilization, red fox, *Vulpes vulpes*, Spain, tiletamine, zolazepam, zoletil.

Tiletamine hydrochloride is a cyclohexane that produces a cataleptic state in which the eyes remain open with intact corneal and light reflexes (Domino, 1964; Seal and Kreeger, 1987). It is unavailable as a single product and usually is combined in equal proportions (1:1) with the diazepam tranquilizer zolazepam (Gray et al., 1974). Tiletamine and zolazepam (Zoletil, Virbac S.A., Esplugues de Llobregat, Barcelona, Spain) anesthesia is characterized by retention of cranial, spinal, laryngeal, and pharyngeal reflexes. Zoletil has been used successfully to immobilize a wide variety of wild and captive animals (Shobert, 1987), including captive red foxes (*Vulpes vulpes*) (Kreeger et al., 1990a). However, the effectiveness and safety margins of Zoletil doses developed for captive red foxes have not been tested on wild foxes, which represent a wide spectrum of nutritional, physiological and also trapping stress conditions during immobilization (Kreeger et

al., 1990b; White et al., 1991). Our objective was to evaluate Zoletil for immobilizing red foxes in the wild and to recommend effective Zoletil doses.

Twenty-two red fox pups (11 males, 11 females) and 51 adult red foxes (22 males, 29 females) were immobilized at Doñana National Park (37°00'N, 06°30'W) from November 1990 through November 1992. Pups were excavated from their dens when they were 6 to 18 wk old. Adults were captured using unpadded No. 2 Victor coil spring traps (Woodstream Corp., Lititz, Pennsylvania, USA) that were modified by protecting the steel jaws with soft material to reduce leg injuries. Recaptured animals were not included in the analyses in order to avoid pseudoreplication (Hurlbert, 1984). Captured foxes were placed in special cages and transported to the laboratory. Two to five hours after capture, pups and adults were physically restrained and injected intramuscularly in the hindquarters with a single dose of Zoletil. The dose chosen for each animal, following the recommendations of Kreeger et al. (1990a) for captive red foxes, was based on visual assessment of the individual's size and weight. After anesthetic induction, foxes were weighed and placed in right lateral recumbency. The eyes were covered with a cloth to avoid corneal damage and rectal temperature, respiration rates (breaths/min), and heart rate (beats/min) were monitored throughout the immobilization period. For comparison, reference values of red fox respiration and heart rate were estimated from their body weights (Stahl, 1967). Body temperature and heart rate reference values also were obtained from Kreeger et al. (1989). Ambient temperatures during immobilization ranged from 14 to 17 C during autumn and winter, and from 18 to 23 C during spring and sum-

mer. Animals were left to recover in covered containers in dark, quiet areas. Induction time was defined as the time from injection of the anesthetic to loss of consciousness. First recovery time was defined as the time from loss of consciousness to first head movements. Foxes were released at the same place of capture the evening after the initial anesthetic. We used the two-sample *t*-test (Zar, 1984) for all comparisons. Acceptance of significant differences was set at $P < 0.05$.

Zoletil doses ranged between 5.88 and 16.67 mg/kg. For four adult females (two of them pregnant) a mean Zoletil dose of 8.99 (± 0.48) mg/kg (range 7.61 to 9.78 mg/kg) was insufficient for total immobilization and complementary dosages of one half the initial dose were given. No other females in the sample were pregnant. There were no significant differences in mean Zoletil doses between sexes (pups: $P = 0.31$; $t = 1.03$; adults: $P = 0.21$, $t = 1.26$) or age classes (males: $P = 0.88$, $t = 0.15$; females: $P = 0.90$, $t = 0.13$; Table 1). Mean induction times were significantly shorter for pups than for adults (males: $P = 0.01$, $t = 2.73$, females: $P < 0.01$, $t = 3.07$), were similar between sexes (pups: $P = 0.84$, $t = 0.23$; adults: $P = 0.44$, $t = 0.77$, Table 1). We detected no significant differences in first recovery times between sexes (pups: $P = 0.83$, $t = 0.22$; adults: $P = 0.30$, $t = 1.05$) or age classes (males: $P = 0.61$, $t = 0.52$; females: $P = 0.57$, $t = 0.58$; Table 1).

We did not detect any excessive hypothermia or hyperthermia. Mean rectal temperature just after induction was 38.2 (± 0.3) °C for pups (range = 37.3 to 39.7 °C) and 38.8 (± 0.3) °C for adults (range = 38.2 to 39.3 °C). Mean rectal temperatures were about 1 °C lower than those of sleeping and active adult red foxes (Kreeger et al., 1989). Respiration rates increased slightly after immobilization (pups: $\bar{x} = 51.8 \pm 3.6$ breaths/min, range = 26 to 96 breaths/min; adults: $\bar{x} = 38.7 \pm 2.4$ breaths/min, range = 18 to 74 breaths/min) but declined to theo-

retical reference levels (pups: 48 breaths/min, adults: 35 breaths/min) within 75 min after induction (pups: $\bar{x} = 45.7 \pm 10.6$ breaths/min, range = 25 to 60 breaths/min; adults: $\bar{x} = 30 \pm$ breaths/min, range = 22 to 38 breaths/min). Heart rates after immobilization had a similar pattern, initially averaging 232 and 218 beats/min for pups and adults, respectively, but declining to theoretical reference values (pups: 220 beats/min, adults: 163 beats/min) within 40 min after induction (pups: $\bar{x} = 217 \pm 4.6$ beats/min, range = 209 to 228 beats/min; adults: $\bar{x} = 198 \pm 10.4$ beats/min, range = 180 to 216 beats/min). Heart rates of adult foxes after 40 min induction were higher than those of sleeping and hunting foxes, similar to those of feeding foxes, and lower than those of running foxes (Kreeger et al., 1989).

In contrast to captive studies, the animals we used were free-ranging; thus, they probably represented a wide spectrum of nutritional and physiological conditions during immobilization. Additionally, stress due to capture and handling could affect induction and recovery times as well as heart rates, respiration rates, and body temperatures (Kreeger et al., 1990b; White et al., 1991). In spite of this, the combination of tiletamine hydrochloride and zolazepam hydrochloride achieved quick inductions and acceptable recovery times in free-ranging red foxes. In fact, dosages, induction times, and first recovery times were similar to those reported for captive red foxes (Kreeger et al., 1990a). This drug combination also provided good cardiac and respiratory support compared to the potential bradycardic and respiratory depressant effects of xylazine hydrochloride (Clark et al., 1982). This wide safety factor is valuable in field work, where animals rarely can be weighed or examined extensively before immobilization. We recommend a dose of 5 mg/kg tiletamine hydrochloride combined with 5 mg/kg zolazepam hydrochloride (10 mg/kg Zoletil) for adult and pup red foxes. For un-

TABLE 1. Statistics associated with red fox immobilization with a mixture of tiletamine hydrochloride and zolazepam hydrochloride (Zoletil) in Spain, 1990 to 1992.

	Number of foxes	Mass (kg)		Drug dosage* (mg/kg)		Induction time (min)			First recovery time (min)		
		Mean	SE	Mean	SE	Mean	SE	Range	Mean	SE	Range
Adult females	25	4.46	0.18	10.88	0.46	3.5	0.23	2-7	33.3	2.54	14-63
Adult males	22	5.31	0.23	10.05	0.45	3.8	0.38	2-8	37.9	3.85	13-90
Adults combined	47	4.84	0.16	10.51	0.33	3.7	0.21	2-8	35.4	2.22	13-90
Pup females	11	1.57	0.31	10.99	0.80	2.4	0.20	2-4	36.3	5.36	18-78
Pup males	11	1.27	0.26	10.14	0.20	2.3	0.36	1-5	34.8	4.05	24-78
Pups combined	22	1.42	0.20	10.57	0.41	2.3	0.20	1-5	35.5	3.28	18-78
Total	69	3.72	0.23	10.53	0.26	3.2	0.17	1-8	35.4	1.82	13-90

* Dosage is expressed as mg Zoletil/kg body mass.

weighed, adult red foxes we recommend an initial dose of 60 to 70 mg Zoletil. This should allow for a handling time of about 40 min, sufficient to conduct most routine field procedures.

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