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Evaluation of tranquilizer trap devices (TTDs) for foothold traps used to capture gray wolves

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Abstract Humaneness is an important issue associated with using foothold traps. Gray wolves (*Canis lupus*) captured with foothold traps frequently incur injuries to their feet, legs, and teeth during struggles to escape. Using tranquilizer trap devices (TTDs) on foothold traps reduces such injuries to coyotes (*C. latrans*). We collected data from 112 wolves (91 adults and 21 pups) killed in depredation control efforts in Minnesota during 1996 to determine whether TTDs would improve humaneness by reducing severity of injuries incurred by wolves. We also assessed the effects TTDs might have on other species caught during wolf-capture efforts by examining 114 animals from 9 other species. Radiographs and necropsies of foot and leg injuries of 37 adult wolves captured in traps equipped with TTDs containing propiopromazine hydrochloride revealed a significant reduction in severity of injuries compared to those among 48 wolves caught in traps without propiopromazine. None of 42 nontarget individuals captured in traps equipped with TTDs containing propiopromazine hydrochloride died from drug overdoses and injuries to these animals were less severe than among animals caught in traps without TTDs containing tranquilizer.

Key words animal capture, *Canis lupus*, Minnesota, necropsy, propiopromazine, tranquilizer trap device, trap injuries, TTD, wolf, wolves

Wolves (*Canis lupus*) captured in foothold traps frequently incur injuries to feet, legs, and teeth (Kuehn et al. 1986; Olsen et al. 1986, 1988; Onderka et al. 1990). Van Ballenberghe (1984) reported that 41% of 109 wolves captured in foothold traps incurred severe injuries to their feet and legs during struggles to escape. Kuehn et al. (1986) showed that the extent of injuries was related partially to the type of trap used and documented that wolves often damage teeth, especially premolars, when captured in foothold traps. Humane capture has become an important issue associated with using foothold traps.

Most mechanical modifications to foothold traps do not reduce foot and leg injuries to coyotes (Linhart et al. 1981, Olsen et al. 1986, Phillips et al. 1996), although laminated foothold traps (McAllister 1992, Houben et al. 1993) and padding trap jaws (Olsen et al. 1986; Linhart et al. 1988; Onderka et al. 1990; Linhart and Dasch 1992; Phillips et al. 1992, 1996) can reduce injuries.

Typically, animals captured in foothold traps immediately start biting and chewing on and around the trap. Balser (1965) demonstrated that when coyotes and other animals ingest tranquilizers from tabs (consisting of pieces of rolled cloth

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containing a powdered tranquilizing drug suspended in petroleum jelly) attached to the jaws of foothold traps, foot injuries can be reduced substantially (for the purposes of this study, tranquilizer tabs will be referred to as tranquilizer trap devices, or TTDs). Balser (1965) reduced injuries to coyotes by using TTDs containing diazepam, a controlled substance not registered for such use by the Drug Enforcement Administration (Savarie et al. 1993). Propiopromazine hydrochloride (PPZH), a tranquilizer which depresses the central nervous system at great doses, was tested on captive coyotes by Savarie and Roberts (1979). Linhart et al. (1981) reported reduced foot-leg injuries to wild coyotes captured in foothold traps with PPZH. In 1995, the United States Department of Agriculture's National Wildlife Research Center (NWRC) received approval from the Food and Drug Administration to use PPZH (CAS no. 7681-67-6) as an Investigational New Animal Drug in TTDs on foothold traps used to capture free-ranging canids.

An effective TTD would be especially useful in cases where wolves are captured for relocation, reintroduction, or research purposes. If TTDs act similarly on wolves as they do on coyotes, they would make foothold trapping more humane by reducing stress and injuries. In addition, animals might be less active, resulting in fewer escapes. We also anticipated that use of TTDs might reduce injuries to nontarget animals and facilitate their release. Our objectives were to assess whether TTDs containing PPHZ on foothold traps would reduce the severity of foot, leg, and tooth injuries sustained by captured wolves and assess effects of TTDs on nontarget species caught during wolf-capture operations.

Procedures

We collected data from wolves trapped by Wildlife Services (WS) personnel during routine depredation control efforts in 15 counties in the northern forested region of Minnesota. At the time, wolves in that area were classified as "threatened" but were subject to trapping and removal from areas where losses of livestock or pets to wolves occurred (Fritts et al. 1992). In accord with WS protocols, traps were set in response to requests from cooperators after losses of domestic or companion animals were documented. About 160 wolves are killed annually in such activities (William Paul, Wildlife Services, personal communication). Data for this study were collected between mid-April and October of 1996, with nearly all captures occurring when temperatures were above freezing. This study was conducted under the guidance and approval of the Institutional Animal Care and Use Committees of the National Wildlife Research Center (Protocol number QA-433) and Utah State University (Approval #738). References to company names, products, or trade names do not imply endorsement of the companies or their products by the federal government.

TTD production and attachment

We conducted preliminary tests with Dasch "B" balloon-type TTDs with a petroleum jelly carrier (Linhart et al. 1981), but encountered several shortcomings (Sahr 1997). We subsequently selected the McBride TTD (Ranchers Supply Company, Alpine, Tex., USA) for evaluation. The device (Figure 1) consists of a molded rubber base with a 1.5-cm-diameter × 3.2-cm-tall nipple that can be filled with an appropriate drug and attached to the trap jaw. Previous attempts to use McBride TTDs with powdered PPZH and no carrier proved unreliable for capturing coyotes because the dry powder frequently spilled without being ingested when the nipple of the TTD ruptured (Zemlicka and Bruce 1991). We resolved this by mixing the powdered PPHZ with a viscous, sugar-based syrup to take advantage of canid preference for sugar (Mason and McConnell 1997).

We had 4 treatments: traps with no TTD (I) and traps with TTDs containing 0.0 mg PPZH (II), 500 mg PPZH (III), and 1,000 mg PPZH (IV). The doses selected were extrapolated from previous studies with captive coyotes (Savarie and Roberts 1979)

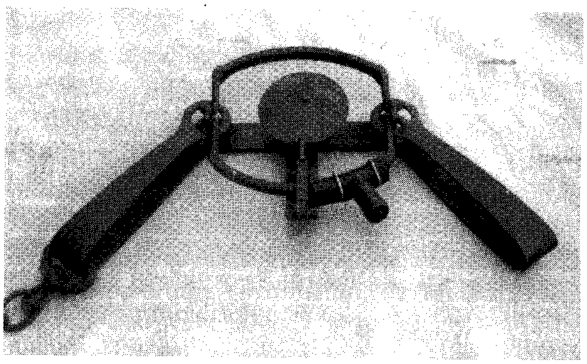

Figure 1. Photograph of a #3 foothold trap shows the McBride tranquilizer trap device (TTD) attached to the jaw on the detente side of the trap and on the side away from the chain attachment (#4 traps were used in wolf-capture efforts in Minnesota in 1996). Photo by D. E. Zemlicka.

Table 1. Formulations for loading 12 tranquilizer trap devices (TTDs) for each of 4 treatments used for wolf capture during 1996 in Minnesota.

Treatment	Propiopromazine (g)	Syrup (ml)	Pectin (g)
I (No TTD)	—	—	—
II (0 mg PPZH)	0	12	20
III (500 mg PPZH)	6	12	13
IV (1,000 mg PPZH)	12	14	0

and field experience with wild coyotes (Linhart et al. 1981, Windberg and Knowlton 1988, Windberg 1995). We varied the amounts of syrup and pectin (Table 1) combined with the powdered propiopromazine in the 3 TTD treatments to produce mixtures of a uniform consistency and volume. We also added sufficient tartrazine (a yellow food dye) to the 0.0-mg treatment to provide a yellow stain similar to that created by propiopromazine. All mixtures were fluid enough to be injected into the nipple of the TTD when warmed, but thick enough at room temperature so they would not flow from the TTD when it was torn open.

We mixed the appropriate PPZH, pectin, and syrup combination in a 100-ml syringe and warmed the syringe by immersion in hot water for one to 2 minutes until the mixture softened sufficiently to be injected into the TTD nipples. Approximately 6 ml of the mixture was injected into each of 12 empty TTDs, a rubber stopper was inserted into the open end of the TTD nipple, and the TTD was sealed with 2 coats of 3M black super weatherstrip adhesive (part no. 08011). The first coat of adhesive was allowed to dry overnight before the second coat was applied, which also was allowed to dry overnight before the TTD was handled.

Subsequently, we randomly assigned a unique number to each TTD and attached an aluminum tag on which the number was stamped. TTDs from all treatments were then combined and sent to Minnesota for field tests and data collection. This allowed personnel to run a blind test of efficacy in the field.

Trappers used #4 traps (Livestock Protection Company, Alpine, Tex., USA) with smooth, offset jaws and equipped with drags. The TTDs were attached to the jaw on the trigger side of trap, opposite the chain attachment. The slotted base of the TTD was inserted over the trap jaw from the inside of the jaw, so the open slot of the base faced the outside of the jaw. TTDs were attached using 2 Blair-type, hog-size hog rings (Decker Manufacturing Company, Keokuk, Ia., USA) clamped around the base of the TTD and trap jaw, one on each side of the nipple (Figure 1). The hog rings were installed with the open ends toward the outside of the jaw. A hole drilled in the end of the numbered aluminum tag allowed it to be transferred from the TTD and wired to the trap chain, approximately 30 cm from the trap drag. This eliminated a problem encountered previously when tags attached to the chain near the trap base were destroyed by trapped wolves. Each set trap was checked daily according to WS protocols.

Wolf captures

When a wolf was captured, trappers recorded their assessment of the degree of tranquilization of the wolf in one of 6 categories (modified from Zemlicka and Bruce 1991). After euthanizing the wolf by gunshot according to WS and American Veterinary Medical Association protocols (Andrews et al. 1993), field personnel recorded the WS wolf number, the TTD number (from the aluminum tag), and the condition of the TTD (Zemlicka and Bruce 1991), and assigned foot and leg injuries within one of 7 categories (modified from Kuehn et al. 1986). The trapped limb of the euthanized wolf was severed at the distal end of the humerus (front leg) or femur (rear leg). The head was skinned and removed. The head and leg were placed in separate plastic bags, labeled with the wolf and TTD numbers, and refrigerated on ice until they could be frozen.

We evaluated tooth injuries sustained by wolves by assigning each animal to one of 5 injury categories developed by Onderka et al. (1990). Frozen legs were shipped to the United States Department of Agriculture (USDA) Predator Research Facility in Millville, Utah, for more detailed evaluation of injuries.

We used radiographic procedures to evaluate bone injuries and necropsies to assess bone and soft-tissue trauma without knowing the treatment group from which animals came. Radiographs also made a permanent record of bone injuries which might not be evident in the dissections used to assess soft-tissue trauma. Radiographs were taken under the supervision of Dr. Robert Miller (Cache Meadows Veterinary Clinic, Logan, Ut.) with lateral and anterior–posterior views of each leg radiographed side by side on 36- × 43-cm film. We assigned sequential numbers to radiographs and cross-referenced them to the WS wolf number for each leg. Developed radiographs were taken to the Veterinary Hospital at Washington State University and evaluated by radiologist Dr. John Alexander. For each radiograph, we recorded its number, age of the animal (pup or mature), limb that was radiographed, degree of soft-tissue trauma (swelling, lacerations, or joint injuries), presence or absence and class of fractures, and quality of the radiographic exposure.

Following analysis of radiographs, we took a sample of 15 frozen legs, along with the corresponding radiographs, to Dr. Elizabeth Williams at the University of Wyoming, where they were used as specimens to train us in necropsy procedures for soft-tissue injury assessment. Leg and foot injuries were evaluated according to injury and trauma criteria recognized by the International Organization for Standardization (ISO) Technical Committee 191 (Jotham and Phillips 1994), abridged to include only foot and leg injuries. The same criteria were used by Phillips et al. (1996) in assessing trap-related injuries to coyotes. Radiographs of each leg and their interpretations were referenced during necropsy to insure that hard-tissue injuries were not overlooked. We then evaluated remaining wolf legs for injuries using procedures demonstrated by Dr. Williams. After we calculated an injury score for each leg, we sorted the data by treatment to allow comparisons of injury scores (severity).

Captures of other species

When nontarget species were captured, field personnel recorded the degree of tranquilization, TTD number, condition of the TTD, the foot–leg injury category to which they were assigned in the field, and fate of the animal. Because nontarget animals are typically released at the trap site if injuries are not severe, injury categories were reduced to 4 for field evaluations to accommodate working with live animals as well as to minimize animal handling.

Statistical analyses

We used chi-square tests of independence (Feinberg 1994) to assess differences among treatments in the degree of tranquilization for wolves and nontarget species and field evaluations of foot–leg and tooth injuries to wolves. This enabled us to determine whether severity of injury and degree of tranquilization were associated with treatments. We used one-way analysis of variance (ANOVA) to compare foot and leg injuries among treatments, and Tukey's post-hoc tests to isolate differences among means. We used a significance level of 0.05.

Results

We used data from 112 gray wolves (91 adults and 21 pups) and 114 animals of other species captured by WS for this study. Data from wolf pups were handled separately. The small number of pup captures, which were distributed among the 4 treatments, was insufficient for formal statistical treatment and permitted only calculation of descriptive statistics. Other species captured included 41 red foxes (*Vulpes vulpes*), 21 raccoons (*Procyon lotor*), 17 striped skunks (*Mephitis mephitis*), 16 coyotes, 6 bobcats (*Lynx rufus*), 5 black bears (*Ursus americanus*), 5 domestic dogs, 2 white-tailed deer fawns (*Odocoileus virginianus*), and one fisher (*Martes pennanti*). Failure to collect some samples or record all information resulted in differing sample sizes for comparisons of degree of tranquilization, field evaluations of injuries, tooth damage, and laboratory evaluations of foot–leg injuries.

Degree of tranquilization

Adult wolves. Degree of tranquilization was assessed for 85 captured adult wolves (Table 2). Because the nipple of the TTD was torn from its base in all cases of adult wolf capture, we were unable to accurately assess the frequency with which TTDs were punctured or the contents ingested. To avoid small counts within some cells during statistical comparisons of treatments I (no TTD) and II (placebo TTD), the 6 categories were reduced to 2: no apparent tranquilization (category 1) and possible tranquilization (categories 2–6). Chi-square analysis revealed no difference in the degree of tranquilization of captured wolves between treatments I and II ($\chi^2_1=0.80, P=0.37$). For comparison of treatments III (500 mg TTD) and IV (1,000 mg TTD), tranquilization categories 4, 5, and 6 were combined to adjust for small cell counts and no difference in tranquilization of captured wolves was detected ($\chi^2_3=4.57, P=0.21$). We detected a difference when treatments I and II (no tranquilizer) were combined and compared with combined tranquilizer treatments III and IV ($\chi^2_3=15.87, P=0.001$), with wolves captured in PPZH treatments more tranquil than wolves captured without tranquilizer. This reflects a "detected" tranquilization of 23 of 47 wolves in treatments III and IV (Table 2). Tranquilization among the 24 other wolves in these treatments was not readily evident.

Table 2. Distribution of animals among tranquilization categories[a] by treatment, based on field evaluations of animals captured during 1996 in Minnesota.

	Number of animals in each tranquilization category (1–6)[b]					
Treatment (PPZH)	1	2	3	4	5	6
Adult wolves (n=85):						
I (No TTD)	19	3	0	0	0	0
II (0 mg)	12	3	1	0	0	0
III (500 mg)	14	4	2	4	0	0
IV (1,000 mg)	10	1	3	7	2	0
Nontarget species (112 individuals of 9 species):						
I (No TTD)	44	1	0	0	0	0
II (0 mg)	19	4	1	1	0	0
III (500 mg)	10	4	1	5	1	0
IV (1,000 mg)	8	2	3	7	1	0

[a] Modified from Zemlicka and Bruce (1991).

[b] Categories of tranquilization: 1=alert, active, no apparent drug effect; 2=quiet, unable to maintain attention; 3=eyes dull, animal drowsy; 4=sleepy, but could be aroused; 5=could not be aroused; 6=dead (probably drug related).

Wolf pups. All pups captured in TTD-equipped traps punctured the nipple portion of the TTD and were exposed to the contents. None succumbed to drug overdose from consumption of TTD contents. Among pups captured in tranquilizer treatments and released (n=5), all immediately left the capture site, although 2 may have been heat-stressed. The 16 wolf pups captured after 1 August were euthanized and ranged in weight from 9 to 20 kg (20 to 44 lb).

Captures of other species. None of the other animals caught in TTD-equipped traps are known to have died. For statistical comparisons (Table 2), we combined data from all species. We also reduced the categories of tranquilization from 6 to 2 (original categories 1 and 2–6) during chi-square analysis to eliminate small numbers in some cells. An apparent difference in tranquilization between treatments I and II (χ^2_1=4.63, P=0.03) among nontarget animals was not related to PPZH. While no difference was evident between treatments III and IV (χ^2_1 =0.39, P=0.53), there was a difference in degree of tranquilization (χ^2_1=25.70, P<0.001) between tranquilizer treatments (III and IV combined) and nontranquilizer treatments (I and II combined). Overall, animals captured in tranquilizer treatments were more placid, but only half of the animals captured were noticeably affected.

Tooth injuries

We evaluated tooth injuries for 69 adult wolves (Table 3) but combined injury categories 4 and 5 to adjust for small cell counts. Chi-square analysis revealed no difference in tooth injuries between treatments I and II (χ^2_3= 1.65, P=0.65), between treatments III and IV (χ^2_3= 3.02, P=0.39), or between combined treatments I and II compared to combined treatments III and IV (χ^2_3=3.60, P=0.31). However, 68% of wolves captured in the 2 tranquilizer treatments (III and IV) were placed in tooth-injury categories 1 or 2 (Table 3) compared to only 47% of wolves captured in nontranquilizer treatments (I and II).

Foot and leg injuries of wolves

Field evaluations. Injuries were recorded in the field for 85 adult wolves (Table 4). For chi-square analysis, we combined injury categories 1 and 2 and categories 5, 6, and 7 to avoid small counts in some categories. There was no difference in severity of injuries between nontranquilizer treatments I and II (χ^2_3=4.57, P=0.21) or between tranquilizer treatments III and IV (χ^2_3=3.07, P=0.38). However, we noted a significant reduction in injury when nontranquilizer treatments (I and II) combined were compared with tranquilizer treatments (III and IV) combined (χ^2_1=0.80, P<0.001).

Table 3. Severity of tooth injuries[a] to 69 adult wolves captured during 1996 in Minnesota.

	Number in each injury category (1–5)[b]				
Treatment	1	2	3	4	5
I (No TTD)	3	8	3	2	1
II (0 mg PPZH)	2	7	5	1	0
III (500 mg PPZH)	3	12	1	3	0
IV (1,000 mg PPZH)	1	13	3	1	0

[a] Modified from Onderka et al. (1990).

[b] Categories of tooth damage: 1=no apparent damage; 2=slight (loss of incisors or premolars #1 or #2, chipped tips of any teeth); 3=mild (loss or breakage of #3 premolar); 4=moderate (canines or molars broken or ground over halfway to gumline); 5=severe (complete loss, or wear of several canines, premolars, and molars to the gumline, or abrasion of the bone).

Table 4. Field evaluations of foot–leg injuries[a] to 85 adult wolves captured during 1996 in Minnesota.

	Number in each injury category (1–7)[b]						
Treatment	1	2	3	4	5	6	7
I (No TTD)	2	1	4	8	5	1	1
II (0 mg PPZH)	1	1	8	3	3	0	0
III (500 mg PPZH)	9	2	12	0	0	1	0
IV (1,000 mg PPZH)	6	4	11	2	0	0	0

[a] Modified from Kuehn et al. (1986)

[b] Categories of injury: 1=no obvious damage; 2=swelling (at or below trap jaw); 3=minor cut (<2.54 cm long); 4=major cut (>2.54 cm long); 5=swollen joint (above trap jaw), broken toes, tendon damage; 6=simple fracture above toes; 7=compound fracture above toes.

Among nontarget animals captured, there was no difference in severity of injuries between nontranquilizer treatments I and II (χ^2_3=3.52, P=0.32) or between tranquilizer treatments III and IV (χ^2_3= 0.98, P=0.81), but injuries among tranquilizer treatments (III and IV) combined were significantly less severe (χ^2_1=16.76, P<0.001) than injuries among nontranquilizer treatments (I and II) combined (Table 5). Only 3 of 42 (7%) nontarget animals captured in tranquilizer treatments III and IV had obvious fractures (injury category 4), whereas 30 of 72 (42%) nontarget animals in treatments I and II had category 4 injuries.

Red fox was the only nontarget species captured in sufficient numbers for independent evaluation. Twelve of 16 (75%) foxes captured in the tranquilizer treatments were assigned to the 2 least-injury categories; whereas only 6 of 25 (24%) captured in the nontranquilizer treatments were in these injury categories. No fox captured in the tranquilizer treatments sustained category 4 injuries (obvious fractures), whereas 15 of 25 foxes (60%) from the nontranquilizer treatments had category 4 injuries.

Table 5. Field evaluations of foot–leg injuries to 114 nontarget animals captured in Minnesota during 1996.

	Number in each injury category (1–4)[a]			
Treatment	1	2	3	4
I (No TTD)	6	11	7	23
II (0 mg PPZH)	3	10	5	7
III (500 mg PPZH)	5	10	4	2
IV (1,000 mg PPZH)	4	13	3	1

[a] Injury categories: 1=no injury evident; 2=slight swelling or small cut; 3=moderate, open, or bleeding cut; 4=severe (obvious fracture).

Laboratory analysis of foot and leg injuries. We used necropsy procedures to evaluate severity of foot and leg injuries to 75 adult wolves (Figure 2). There was an effect among treatments ($F_{3, 71}$= 6.18, P=0.001). Subsequent post-hoc analysis with Tukey's two-way comparison among treatments failed to reveal a difference in injuries between treatments I and II or between treatments III and IV, but did recognize a difference in injuries between treatments I and III, treatments I and IV, and treatments II and IV. The difference in severity of injury was not significant between treatments II and III (P =0.08), even though the median injury scores for the 2 treatments were quite different (Figure 2). Two injury scores in each of treatments II and III, which were very high compared to the other scores in the respective treatments, increased the variance and affected results of the ANOVA. A subsequent chi-square test used to compare treatments II and III, after injury scores were categorized as low (0–50), moderate (51–100), and high (>100), resulted in a detectable difference in injuries between treatments II and III (χ^2_2=9.72, P=0.008), suggesting the difference between treatments II and III was real.

Laboratory evaluations of foot and leg injuries of the 14 euthanized pups suggested that foot and leg injuries were generally less severe than among adults. Mean injury score for 10 pups captured in nontranquilizer treatments (I and II) was 47 and the mean score for 4 pups captured in the tranquilizer treatments (III and IV) was 39.

Discussion

Using TTDs reduces severity of foot and leg injuries to captured animals, as detected in field evaluations and in detailed laboratory assessments. Tooth damage to wolves was not reduced. We acknowledge that data for this study were collected between mid-spring and mid-fall, with nearly all captures occurring when ambient temperatures were above freezing. While TTD function, as well as trap-related injuries under freezing conditions, remain to be investigated, our experiences with PPZH in TTDs lead us to speculate that the potential hypothermic action of PPZH may not become critical if traps are checked daily and ambient temperatures remain above 20°F.

Although precise comparisons of our results with those of other studies are difficult because different evaluation criteria were used, broad comparisons

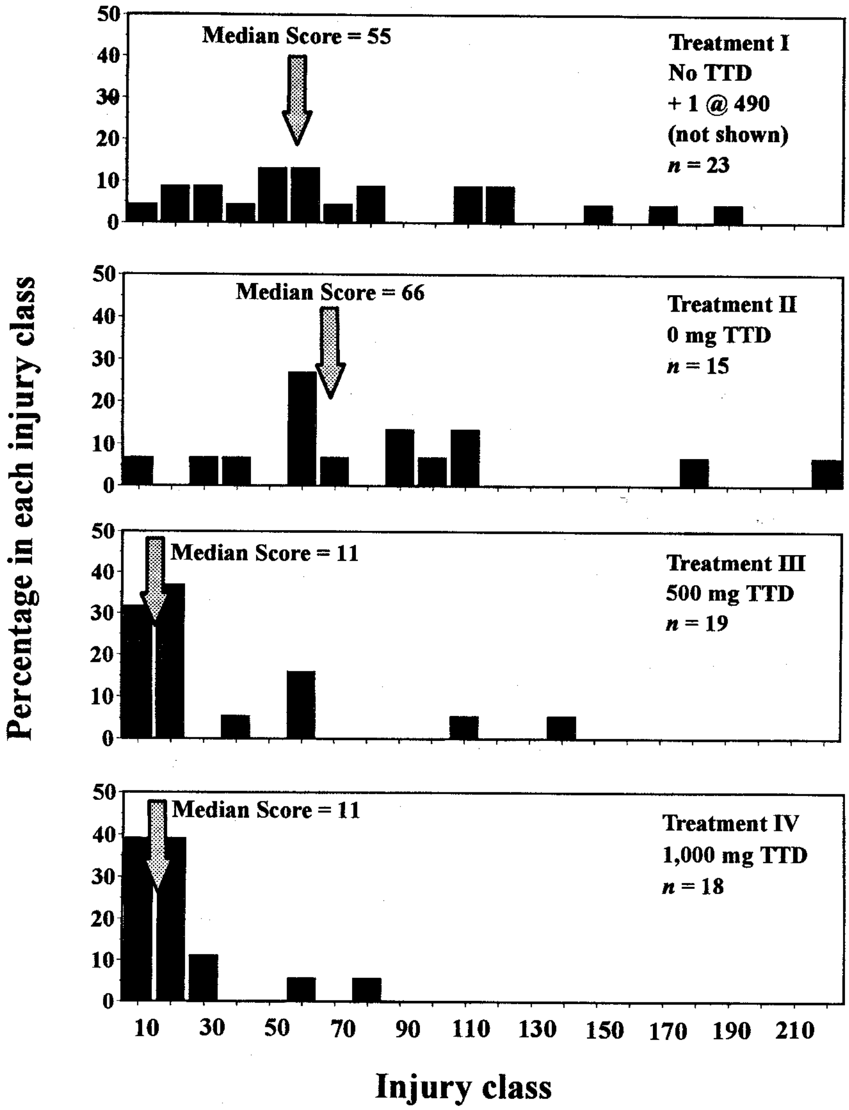

Figure 2. Relative distribution of foot and leg injuries to wolves, based on necropsy, among injury classes for 4 experimental treatments used in 1996 in Minnesota. Median injury scores of respective treatments are indicated by arrows. Injury scale modified from Phillips et al. (1996).

are possible. Van Ballenberghe (1984) reported 56% of 73 adult wolves captured in foothold traps sustained severe injuries. His definition of "severe" injuries approximates category 4 and greater in our field assessments of injuries. Similarly, Kuehn et al. (1986) reported 38% of 81 adult wolves sustained injuries comparable to our category 4 and greater. These are consistent with our results. Of 38 adult wolves captured in treatments I and II (nontranquilizer treatments), 53% sustained injuries of category 4 or greater. TTDs dramatically reduced severity of injuries, because only 6% of 47 adult wolves captured in treatments III and IV (tranquilizer treatments) sustained category 4 or greater injuries.

Phillips et al. (1996) evaluated trap-related injuries sustained by coyotes captured in 3 types of foothold traps, including the Sterling MJ600 trap with offset jaws. Using similar necropsy procedures and injury scale, Phillips et al. (1996) reported coyotes captured in the Sterling trap had a mean injury score of 103.3, close to the mean score of 90.13 for wolves captured in treatment I (no TTD) in this study (we recognize mean values are inappropriate for categorical data but use them here to permit comparisons with prior studies). Wolves captured in treatments III (500 mg PPZH) and IV (1,000 mg PPZH) in this study had mean injury scores of 28.2 and 18.4, respectively. These scores approximate the injury scores for the padded No. 3½ EZGrip trap (mean injury score = 29.0) tested by Phillips et al. (1996), suggesting TTDs may reduce injury severity as effectively as padded-jaw traps. Hence we consider TTDs a humane and cost-effective alternative to padded-jaw traps.

Overall, wolves captured in the tranquilizer treatments appeared more tranquil than those captured in nontranquilizer treatments. However, this varied among individuals, with effects not always apparent. Among wolves captured in treatments III and IV, respectively, 58% and 43% were assigned to tranquility category 1 (alert, active, no drug effect). However, necropsies indicated injuries were reduced among these wolves. There are several possible explanations. External stimuli, including noises, vehicles, and approaching humans, can arouse animals from PPZH tranquilization. Because trappers were interested in dispatching the animals as quickly as practical and were only superficially trained in assessing degree of tranquilization, they may not have taken the time to accurately assess degree of tranquilization. In addition, time of capture was not known. Wolves may have been in traps for a few minutes or as long as 24 hours. Zemlicka and Bruce (1991) indicate that onset of tranquilization of coyotes begins within 15 minutes of capture and starts to wane after 12 to 18 hours. Thus, if a wolf had just been captured, the tranquilizer may not yet have taken effect, or the effect may have begun to dissipate if a wolf was in the trap for a long period. Furthermore, results could be confounded if captured wolves did not consume the entire tranquilizer dose. Although wolves may not exhibit noticeable tranquil behavior, decreased intensity of struggling may prevent more severe injuries.

Tooth injury was the only criterion among wolves that showed no statistically significant effect of PPZH (comparing treatments I and II with treatments III and IV). Initially, we were uncertain whether the immediate response of wolves to capture in foothold traps would be to lunge from the trap location or to attack the trap in an effort to remove it. Because pieces of rubber, yellow dye, etc. were found within a few feet of the trap sets in several instances, we speculate that captured wolves began biting the trap and TTD immediately upon capture. This would be consistent with observations of coyotes in pen-tests of TTDs, which showed that they initially attack the trap and only later attempt to retreat from the location. This could explain why little or no difference in tooth injuries occurred between the nontranquilizer and tranquilizer treatments. We suspect most tooth injuries occur shortly after capture, and we anticipate that use of PPZH in TTDs is unlikely to reduce tooth injuries to wolves captured in foothold traps. However, 71% of the 69 wolves evaluated for tooth damage incurred "no" or only "slight" tooth injury, a level of injury we suspect would have few long-term effects on the health of wolves.

In addition to reducing severity of foot and leg injuries, TTDs can prevent escape of trapped animals. In one instance, a sedated wolf was recovered from a trap in which the anchoring stakes were partially pulled from the sandy soil, with only 15 cm of the stakes remaining in the ground. A few additional tugs could have freed the stakes and allowed the wolf to escape. In a similar incident, a comatose red wolf (*C. rufus*) that pulled out of a foothold trap was recovered only a few feet away (R. McBride, personal communication). Operationally, preventing the escape of one or 2 wolves could offset the costs of TTD use for an entire season.

Use of TTDs frequently makes locating trapped wolves easier. Because wolves appear to bite the tab soon after capture, several tranquilized wolves were found within a few feet of the trap site, in some cases without pulling the trap drag from the set. On the other hand, a sedated wolf can be more difficult to locate in dense cover.

Selecting an appropriate dose of tranquilizer for the TTD must simultaneously consider degree and duration of sedation desired, acceptable levels of injury to target and nontarget species, and risks posed by the TTD, especially to smaller animals. Based on reports in the literature (Savarie and Roberts 1979) and prior experience with 600-mg PPZH TTDs in capturing wild coyotes (Linhart et al. 1981, Windberg and Knowlton 1988, Windberg 1995), we planned tests of TTDs with 500 to 1,500 mg PPZH. Preliminary tests with 1,500-mg TTDs in 1995 resulted in some wolves becoming sedated to the point that they did not defend themselves from flies, which laid eggs in and around their eyes and mouths. Consequently we eliminated the 1,500-mg treatment from the study. Because no difference in performance was demonstrated between the 500-mg and 1,000-mg treatments for any of the criteria used in our evaluations, we see little reason to use the 1,000-mg dose of PPZH for wolf captures. Although no data are available on recovery times for wolves tranquilized with propiopromazine, the lesser dose should keep recovery time relatively short, perhaps reduce risks to animals in situations where they are to be released, and presumably pose less risk of overdosing smaller animals. We did not evaluate other doses of PPZH that may be as effective in reducing foot and leg injuries as the 500-mg dose.

We demonstrated that TTDs containing propiopromazine hydrochloride can effectively reduce injuries to limbs of wolves captured in foothold traps, but likely will not reduce severity of tooth injury. TTDs containing propiopromazine hydrochloride also reduce severity of injuries to nontarget animals and posed little risk of overdosing smaller animals. Reduced injuries associated with use of TTDs substantially increased the percentage of nontarget animals that could be released.

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