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EFFICIENCY OF UNPADDED AND PADDED STEEL FOOTHOLD TRAPS FOR CAPTURING COYOTES

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Steel foothold traps are widely used throughout North America to manage and harvest furbearers. Payne (1980) listed 6 incentives for furbearer harvest, 1 of which is to carry out "nuisance" control. The U.S. Fish and Wildlife Service (USFWS) has legislative responsibility for managing coyotes (*Canis latrans*) that cause damage to livestock (U.S. Fish and Wildl. Serv. 1978), and trapping is a primary method of achieving this objective. Steel traps are 1 of the most versatile techniques for controlling coyote damage; in 1980 trapping accounted for 36.3% of all coyotes taken by the USFWS Animal Damage Control (ADC) program (Connolly 1982). However, society has become increasingly opposed to steel traps and trapping. Not only have anti-trap legislative proposals increased at state levels but a 1984 Federal bill (H.R. 1797) aimed at prohibiting the interstate shipment and sale of traps and furs had the support of 25% of the U.S. House of Representatives (Hoyt 1985).

A major concern expressed by opponents of trapping is that foothold traps injure animals. The recent development and sale of padded-jaw traps have stimulated studies to determine the extent to which they reduce injury (Saunders and Rowsell 1984, Olsen et al. 1986, Tullar 1984). Although the above studies indicate that padded traps reduce foot injury of trapped foxes (*Vulpes vulpes* and *Urocyon cinereoargenteus*) and coyotes, the effectiveness of these traps is unknown. We studied the efficiency of padded traps so that USFWS managers and administrators could make informed decisions regarding their use.

METHODS

We tested traps in the laboratory and field. Laboratory tests made it possible to select and measure soil moisture and soil type, temperature, trap speed, and spring success rates under controlled conditions. Field trials by USFWS predator control specialists provided data on coyote capture rates and subjective assessments of field performance.

Trap Types

The Victor 3 NM[1] (Woodstream Corp., Lititz, Pa.) is the trap most widely used by the USFWS and cooperators for capturing coyotes that depredate livestock. We selected this trap as a "standard" for our tests. Characteristics of the Victor 3 NM and the other 4 trap types tested were as follows:

Unpadded jaws

- Victor 3 NM—double long spring trap with offset malleable jaws. Commercial model. Cannot be affixed with Soft Catch® jaw pads.
- Victor 3 NR—identical to 3 NM except for offset *stamped* jaws. Commercial model.
- Victor No. 3 OS—double coil spring trap with offset stamped jaws. Commercial model.

Padded jaws

- Victor 3 NR—Identical to unpadded 3 NR described above except for prototype stamped jaws

[1] Reference to trade names or companies does not imply U.S. Government endorsement of commercial products.

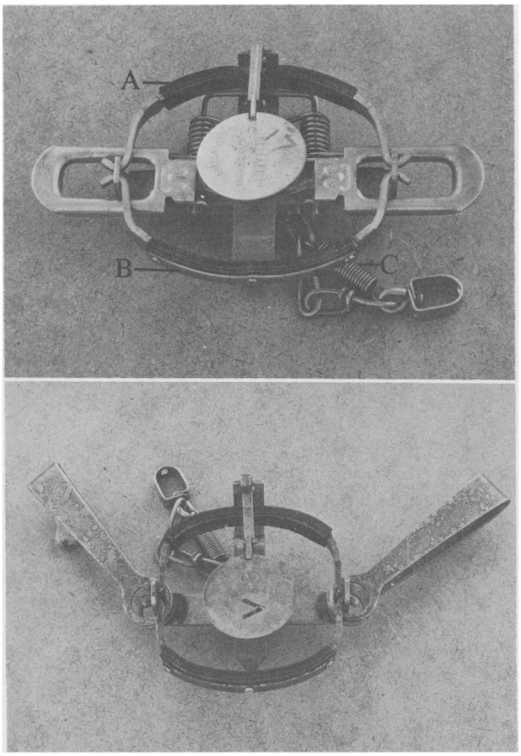

Fig. 1. Top, the Woodstream Victor No. 3 Soft Catch® trap (U.S. Patent 4,184,282). A = rubber-like jaw pad. B = steel pad retainer strip affixed to jaw by 3 screws. C = coil shock spring affixed to 15-cm center-mounted chain. Bottom, the Victor 3 NR affixed with identical system for reducing leg injuries.

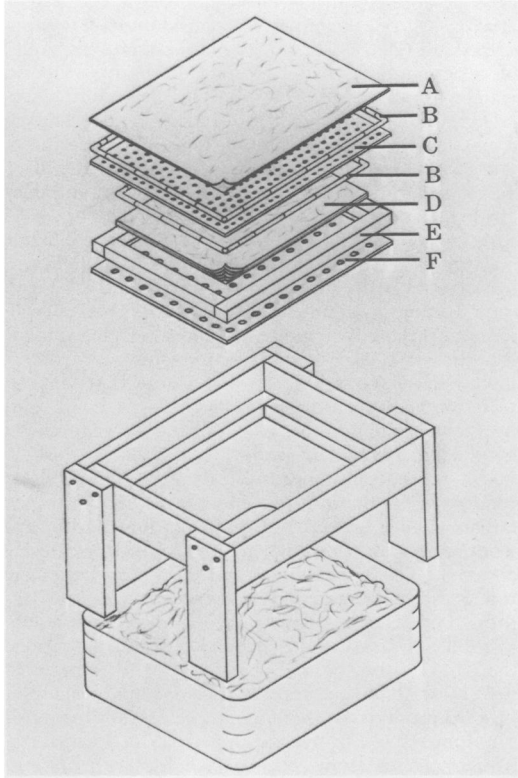

Fig. 2. Apparatus for trap tests in frozen soil. A drip stand (bottom) holding baffles of perforated hardboard and cloth was used to evenly disperse water into container of soil with buried trap. A = 2 layers of toweling. B = 0.7-cm diam rolled cheesecloth. C = 0.4-cm perforated soundboard. D = 12 layers of cheesecloth. E = 1.0 × 2.0-cm wooden spacer. F = 0.4-cm hardboard.

fabricated, coined (i.e., sharp edges smoothed by tumbling), and milled out to hold Woodstream pads and steel retainer strips (Fig. 1). Prototype model.

Victor No. 3 Soft Catch®—double coil spring trap with stamped jaws fabricated to hold Woodstream pads and steel pad retainer strips (Fig. 1). Commercial model.

All traps tested, except unpadded ones used in field trials, were new to reduce possible variations caused by deterioration of trap components.

Laboratory Tests

Closure speed of foothold traps is 1 measure of trap efficiency. Traps that operate slowly may have lower catch rates, particularly under marginal trapping conditions or when set for animals with rapid avoidance responses such as foxes and coyotes. We measured closure speeds in milliseconds (msec) (Johnson et al. 1986) for the 5 trap types described above. Set traps were sprung in a machinist's vise and in dry clay loam soil. Ten traps of each type were used for both vise and soil tests. In addition, 5 of the 10 traps in each type group were set and sprung 5 times in the vise to estimate within-trap variation. The data sets for traps sprung in the vise and in soil were each analyzed as a cell means model ANOVA for a 2-factor experiment. The specific comparisons of interest among trap types and padding were determined before analyses. Linear contrasts were used to test for differences in mean closure speeds.

The ability of traps to function under marginal conditions, such as in wet and frozen soils, is another measure of efficiency. We determined trap spring success rates in frozen soil for all 5 trap types. A homogeneous mixture of dry clay loam was placed in a plastic container (33.0 × 28.0 × 10.0 cm) to a depth of 6.5–7.5 cm and a trap was set and buried in the soil (Johnson

et al. 1986). The container was placed under a wooden drip stand (29.0 × 22.0 × 6.5 cm) containing baffles of alternating layers of perforated hardboard and water-saturated cloth (Fig. 2). This procedure simulated rainfall by slowly (30 sec) and evenly distributing a measured volume of water onto the soil. Experimentation was needed to establish the critical depth of water penetration. Too much water (e.g., 500 ml) penetrated too deeply so that none of the trap types would spring when trap pans were depressed after container and soil were frozen. When too little water (125 ml) was used, only the surface of the soil froze and all trap types sprung. A volume of 200 ml of water resulted in some trap types springing and others not; this amount was therefore used as a standard volume. To determine percentage soil moisture a sample of frozen soil was weighed, oven dried at 43 C for 24 hours, and reweighed to obtain the weight of the water removed by drying ([weight of water/weight of dry soil] × 100 = percent soil moisture). Use of 200 ml of water resulted in a soil moisture content of 24.8%. Trap containers were frozen at −10 C for 24 hours and traps were sprung by pressing on the frozen soil directly above the center of the pan with a 3-mm-diam steel rod. Pressure was applied until the pan was fully depressed and the dog was released from the pan notch. We did not measure the pressure required to depress the pan because the sole objective of this test was to determine if the released trap jaws would penetrate upward through the frozen soil. The extent of jaw closure for each test trap was assigned to 1 of 5 categories (A–E), varying from complete jaw closure to failure of the jaws to move when the pan was depressed.

Twenty traps of each type were tested and a spring success rate for each type was the number of traps that sprung (A and B categories) divided by 20. The success rate for each trap type was individually compared to that for each of the other trap types. The normal (Z-tests) approximation to the binomial was used for testing differences between spring rates. The Bonferroni inequality (Graybill 1976:360) was used to insure that the overall error rate for all comparisons was at the 0.05 level.

Field Tests

Predator control specialists supervised by the ADC program conducted field tests in fall 1984 and winter and spring 1985 to evaluate the efficiency of unpadded and padded traps. All were experienced trappers selected by their supervisors as well qualified to collect and record data. Six men (1 each in Colo., Idaho, Nebr., N.M., Nev., and Okla.) were assigned to test traps in predominantly dry weather with night temperatures usually above freezing. Two men on the Gulf Coast of Texas and 2 in northwestern Oregon were assigned to measure trap efficacy in muddy conditions.

Each trapper was supplied with equal numbers of padded Victor 3 NR and Victor No. 3 Soft Catch® traps. The Soft Catch® had a 15-cm chain center-mounted to a swivel on the cross and bottom of the trap. A 4-cm-long coil spring was affixed to the middle of the chain to absorb the shock of struggling animals. A second swivel for holding the trap stake was located on the free end of the chain (Fig. 1). The identical system of center-mounted chain, coil spring, and swivels was used on the padded Victor 3 NR. Trappers were instructed to set a trap line alternating the above traps with the unpadded traps they normally used for responding to coyote damage. The unpadded traps (as used operationally by ADC) were either Victor 3 NM or Newhouse No. 4 and had the customary 91-cm kinkless chain mounted by a swivel to 1 of the trap springs. All traps were always staked and set out in triplicate (i.e., Soft Catch®, padded 3 NR, and unpadded ADC trap) with each trapper selecting the most likely trap locations and using his preferred trap sets and odor lures or baits. Trappers checked trap lines daily, removed any coyotes caught, and completed a daily field data sheet with the following information:

1. Maximum-minimum temperatures and prevailing weather for the previous 24 hours (clear, cloudy, windy, rain, muddy, snow).
2. Coyote activity at each set: (a) coyote tracks on the trap pan but trap not sprung, (b) trap sprung by a coyote but animal not caught, (c) coyote caught but pulled out, or (d) coyote caught.
3. Point on leg where caught: toe(s), foot pads, above foot pads.
4. Conditions of trap lines in muddy situations: soil type and whether soil and sprung traps were dry, damp, wet, muddy, frozen, or covered by snow.

We visited each trapper before his field trial and reviewed conduct of the trial and recording of field data. Each man was encouraged to record observations on trap performance and each was interviewed by telephone at the completion of the test.

We pooled catch-rate data from individual trappers to obtain adequate samples for statistical analyses. We compiled 2 data sets: 1 from trappers working in moderate conditions and 1 from those working in muddy conditions. Catch rates for each trap type were derived by dividing the number of coyotes caught by the sum of the numbers that stepped on trap pans, sprung traps, were caught but pulled loose, or were actually caught. The same analytical methods were applied to the catch-rate data as used for the trap spring success rate data.

RESULTS AND DISCUSSION

Closure Speed

Mean closure speed differed between unpadded and padded traps, whether sprung in a vise or in dry clay loam (Tables 1 and 2). The padded Victor 3 NR was 19% slower in the vise and 20% slower in soil than the un-

Table 1. Mean closure speed (milliseconds) of unpadded and padded steel foothold traps sprung in vise and in dry clay loam soil.

Trap type	In vise[a]		In soil[a]	
	$\bar{x}$	Range	$\bar{x}$	Range
Victor 3 NM	17.5	15.0–21.5	21.7	20.0–23.5
Victor 3 NR	19.8	17.0–23.5	21.9	18.0–25.0
Victor No. 3 OS	17.6	16.5–20.0	21.2	19.0–23.0
Padded Victor 3 NR	24.5	21.0–29.0	27.4	23.5–30.0
Soft Catch® No. 3	21.7	21.0–25.0	25.6	24.0–28.0

[a] n = 10 traps of each type.

padded 3 NR. The Victor No. 3 Soft Catch® was 19% slower than the unpadded Victor No. 3 OS in the vise and 17% slower when sprung in soil. We believe differences in the closure speed between the unpadded and padded 3 NR were a result of increased jaw weight caused by the pads and retainer strips and/or increased surface area on the padded jaws. The above 2 factors, and the weakened coil springs placed on the Soft Catch® by the manufacturer, most likely caused the slower speed of the Soft Catch®. The Soft Catch® trap was significantly faster ($\bar{x}$ = 21.7 msec) than the padded 3 NR ($\bar{x}$ = 24.5 msec) in the vise test (P = 0.0006).

We found significant differences among closure speeds of unpadded trap types tested in the vise, but not when tested in soil (Table 2). These results suggest that data on closure speed should be obtained from traps sprung in a vise. The vise test is easier and quicker to perform than setting traps in soil, and the data appear less variable and, therefore, more sensitive to statistical analyses. With the much greater variability associated with testing in the soil, a much larger sample size may be needed to detect a fundamental difference between trap types that would easily be displayed by vise testing. Much of the variability in soil testing occurs due to the difficulty in uniformly setting each trap and applying the same amount of soil over the trap. We reiterate that comparisons of trap closure speed are useful only when considered with other measurements of efficiency such as capture rates and spring success rates under specified conditions.

Performance in Frozen Soil

Fewer padded Victor 3 NR traps sprung in frozen soil than did the unpadded model (P < 0.05, Table 3). The spring success rate of the Soft Catch® was also lower (P < 0.05) than its unpadded equivalent, the Victor No. 3 OS. Failure of both types of padded-jaw traps to close was primarily due to a higher percent of traps having frozen soil (mean thickness of 24

Table 2. Results of comparisons on closure speeds among trap types in vise and in dry clay loam soil.[a]

Comparisons[b]	P-value[c]	
	Vise	Soil
Victor 3 NR-U vs. Victor 3 NR-P	0.0001	0.0001
Victor No. 3 OS-U vs. Victor 3 Soft Catch-P	0.0001	0.0001
Victor 3 NR-U vs. Victor 3 NM-U	0.0029	NS
Victor 3 NR-U vs. Victor 3 OS-U	0.0075	NS
Victor 3 NM-U vs. Victor 3 OS-U	NS	NS

[a] Test results were generated as single degree of freedom linear contrasts in analysis of variance.
[b] Trap labels ending in "-U" denote unpadded traps and those ending in "-P" denote padded traps.
[c] "NS" in a P-value column indicates that the test was not significant (P > 0.20).

Table 3. Spring success rates and extent of jaw closure for unpadded and padded traps sprung in frozen soil.

Trap type	Percent springing[a]	Jaw closure category[b]				
		A	B	C	D	E
Victor 3 NM	45	7	2	2	1	8
Victor 3 NR	65	12	1	3	1	3
Victor No. 3 OS	70	14	0	5	0	1
Padded Victor 3 NR	20	4	0	8	3	5
Soft Catch® No. 3	10	1	1	7	2	9

[a] Sum of jaw closure categories A and B divided by the sum of categories A through E.

[b] Jaw closure categories are defined as: A = jaws closed completely, trap would capture coyote; B = jaws nearly completely closed, <5 mm of soil lodged between jaws, trap would capture coyote; C = jaws partially closed, closure prevented by 10–45 mm frozen soil between jaws, capture of coyote unlikely; D = jaw(s) broke through soil but did not close, capture of coyote impossible; E = jaws did not move when pan was depressed, capture of coyote impossible.

mm) caught between the jaws (category C), or having jaws that failed to move (category E) after the dog was released from the pan notch.

We believe that spring success rate tests in frozen soils were a good measure of trap performance. Similar laboratory tests in mud, and in crusted-over soils caused by heat or wind evaporating moisture from the soil, need to be developed and standardized. Such tests would simulate common problems encountered by trappers attempting to use traps under marginal operating conditions.

Efficiency under Moderate Trapping Conditions

We obtained data from 153 days of trapping and the capture of 111 coyotes by 6 trappers. All trappers worked under predominantly moderate trapping conditions; 2 had frequent below–freezing night temperatures, and 1 reported mud or snow during 42% of the days he trapped. All 6 trappers averaged muddy or snowy conditions only 16% of the time they operated traps. We found no differences between the catch rates of the 4 trappers using unpadded Victor 3 NM and the 2 trappers using unpadded No. 4 Newhouse (75 vs. 72%), and therefore pooled the data from all 6.

The coyote catch rate (Table 4) for unpadded traps was higher ($P < 0.05$) than for either the padded Victor 3 NR or the Soft Catch®. Unpadded traps sprung more frequently than padded traps when coyotes stepped on trap pans. We speculated that pressure from the jaw pad on the underside of the dog on set traps might have required more pressure on the pan to release the dog from the pan notch. However, the mean ($n = 5$) pan pressures (measured with a Chattillon DPP-25 push-pull pressure gauge) required to spring the 3 different trap types were 1.0 kg for the unpadded 3 NM, 0.6 kg for the Soft Catch®, and 0.4 kg for the padded 3 NR. We were therefore unable to explain why padded traps sprung less frequently. More coyotes pulled out of padded than unpadded traps, and the number of toe-caught coyotes was higher for the padded 3 NR than for the Soft Catch® or unpadded traps. We did not test these various coyote activities (Table 4) for differences because of the small samples in each category (i.e., "tracks on pan, traps not sprung," "traps sprung," etc.). We report the above results only to suggest that other investigators may wish to more thoroughly study these possible sources of variation in trap performance.

Following laboratory and field tests, the Woodstream Corporation reviewed our results and informed us their staff had discovered that an unknown number of the padded traps supplied to us had improperly cured pads. They also determined that equipping the Victor No. 3 double-coil trap with pads (i.e., Soft Catch®) resulted in upward pressure being exerted on the dog causing pan "creep," or a slow upward movement of the pan after the trap had been set in the ground. Woodstream attributed the lessened efficiency of padded traps to the above factors and subsequently made unspecified changes to pads, instituted a quality control regime, and repositioned the fulcrum point of the pan shank on the Soft Catch® trap. The latter modification was reportedly to correct the pan "creep" problem. Future

Table 4. Capture performance and locations of captures of coyotes for unpadded and padded steel foothold traps based on field trials in 6 states, 1984–1985.

		Fate of trap set (%)				Location of catch (%)		
Trap type	*n*	Tracks on pan, not sprung	Sprung	Coyotes pulled out	Coyotes caught[a]	Toe(s)	Foot pads	Above foot pads
Unpadded	60	20.0	3.3	3.3	73.3	4.5	9.1	86.4
Padded Victor 3 NR	65	33.3	3.1	12.3	50.8	18.2	12.1	69.7
Soft Catch® No. 3	70	31.4	4.3	15.7	48.6	5.9	2.9	91.2

[a] Catch rate for unpadded traps exceeded the rate for either padded trap or Soft Catch® ($P < 0.05$).

tests of Woodstream padded traps may therefore produce results that differ from ours.

Trapper Evaluation

Five of the 6 trappers who conducted field evaluations disliked the center-mounted chain and attached shock-absorbing coil spring on padded traps because their location beneath the trap made it difficult to set and properly bed the traps. Two men felt a better swivel on the trap end of the chain was needed. One trapper stated that the shorter chain made it easier to remove animals from the traps. Three of 6 liked the short chain and 3 preferred longer chains or the kinkless chain used on ADC traps. The trappers had no consensus of opinion as to why coyotes that stepped on trap pans failed to spring traps, or why coyotes pulled out of some traps but not others. Five men said that padded traps worked well in dry soil but 3 of the 6 were critical of Soft Catch® operation in wet soils, stating that they were too slow. Five of the 6 said that padded traps reduced foot damage; 2 mentioned that an unspecified number of coyotes taken in padded traps had swollen feet (i.e., edema). All 6 men said that the jaw pads on both types of padded traps were not damaged by coyotes but 2 reported that raccoons (*Procyon lotor*), badgers (*Taxidea taxus*), and striped skunks (*Mephitis mephitis*) chewed and destroyed pads.

Several suggestions were made for modifying padded traps. The repositioning of the center-mounted chain, a different swivel, and use of stronger trap springs were most commonly suggested. One individual urged us to hold captured coyotes in captivity for a period of time to see if foot damage worsened over time. Five of 6 men did not feel that changes to unpadded ADC traps were needed. The sixth suggested that the chain be shortened to facilitate removal of animals. Following field trials several of the shock-absorbing coil springs on padded traps that held coyotes had partially straightened out or pulled loose from the trap chain, suggesting that a stronger spring and better attachment were needed.

Because of unseasonally dry, snowy, or freezing weather conditions we were not able to obtain adequate data on trap performance in muddy conditions other than the trapper comments mentioned above.

SUMMARY AND CONCLUSION

We compared the efficiency of unpadded- and padded-jaw foothold traps in the laboratory and field. The padded Victor 3 NR and Victor No. 3 Soft Catch® traps had slower closure speeds when sprung in a vise or in dry soil, rates of springing of both padded traps were lower in frozen soil, and rates of catching coyotes in the field were lower than with the unpadded traps normally used by ADC personnel. While the padded-jaw traps were somewhat less efficient, they were able to capture and hold coyotes under moderate trapping conditions. According to the manufac-

turer, some of the problems causing lessened efficiency have been corrected.

We believe that research is needed to develop standard tests for foothold traps to permit comparative analyses and that development of test procedures be under the auspices of a recognized organization such as the American Society for Testing and Materials or American National Standards Institute.

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