LEG-HOLD TRAPPING RED FOXES (VULPES VULPES) IN DOÑANA NATIONAL PARK: EFFICIENCY, SELECTIVITY, AND INJURIES

ALEJANDRO TRAVAINI

Estación Biológica de Doñana, Consejo Superior de Investigaciones Cientificas, Apartado 1056, 41080 Sevilla, Spain

RAFAEL LAFFITTE

Estación Biológica de Doñana, Consejo Superior de Investigaciones Cientificas, Apartado 1056, 41080 Sevilla, Spain

MIGUEL DELIBES

Estación Biológica de Doñana, Consejo Superior de Investigaciones Cientificas, Apartado 1056, 41080 Sevilla, Spain

Abstract: This paper reports on the performances of padded leg-hold traps for capturing and holding red foxes at Doñana National Park in Southwest Spain. Performance includes efficiency, failure, set quality, attractivity, boldness, and selectivity of five different trap sets: baited and blind sets, each with and without prebaiting, and dirt hole sets. A total of 2,378 trap-nights were activated between January 1990 and June 1992. Seventy three red foxes were captured. Prebaited sets were, on average, four times more efficient than nonprebaited ones. Prebaiting improves set quality and boldness and doubles trap-set selectivity. Dirt hole set performance felled between prebaited and non prebaited groups. Nontarget species caught are listed. We also examined red fox to evaluate injuries. No trap set type used in the present study showed any selectivity towards one sex. Based on our results we suggest one possible trap set sequence when trapping red foxes in protected areas or, in areas like in Doñana, when there are nontarget species, whose accidental capture must be avoided altogether.

Key words: body injures, leg-hold traps, red fox, Spain, trapping success.

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INTRODUCTION

Red foxes (*Vulpes vulpes*) are one of the most widely trapped carnivores. Pelt value (Voigt 1987), attempts to limit rabies outbreaks (Macdonald 1980, Macdonald and Bacon 1982), and competition with man (Sargeant and Arnold 1984, Harris and Saunders 1993) have been the main reasons to reduce the population of this canid. In 1985, an effort to reduce red fox population was initiated in Doñana National Park. This program arose out of concern for a remnant population of Iberian lynx (*Lynx pardina*).

In addition to increased opposition to trapping in Spain, foxes have to be trapped inside national parks, where they, and any other nontarget species are protected. Desirable trapping devices were therefore those that cause less injury to the restrained target and nontarget animals but are as efficient as standard models.

Here we report on the performance of padded traps for capturing and holding red foxes inside a protected area inhabited by an endangered species, the Iberian lynx. We also report on types and occurrences of trapping failures. Such data clarifies the interpretation of findings on comparative capture efficiency when maximizing the capture of targets as well as ensuring the safety of nontarget species.

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STUDY AREA AND METHODS

This study was carried out in the Doñana National Park in southwestern Spain from January 1990 to June 1992. The 500 km^2 area is at sea level on the southeast bank of the Guadalquivir river (73° 00' N, 06° 30' W). For a detailed description see Aguilar Amat et al (1986). Field trials were conducted during the autumn-winter season (October to March) and the spring-summer season (April to October). We excluded the spring-summer season from the analyses due to insufficient repetitions of the different trap sets.

We used unpadded No. 2 Victor coilspring traps (Woodstream Corp., Lititz, PA) with a handmade protection developed to reduce leg injuries to Iberian lynx. Each steel jaw was covered with a double layer of leather under a single layer of cloth. Each trap was anchored by a 60–70 cm center-mounted chain with an attached coil-spring to cushion the struggle of captured animals. All traps were staked (50–60 cm anchor-like stakes) in the sandy soil.

Three basic trap sets were used, including blind, baited and dirt hole sets. Blind sets were traps placed in trails or tracks traveled by target animals (Litvaitis et al. 1983). Baited sets included one or two traps placed adjacent to a piece of a chicken carcass. A dirt hole is a modification of the baited set that is frequently used with canids (Voigt 1987). Bait at

Table 1. Overall performance of 1,361 trap-nihgts conducted in Doñana National Park. TN – trap nights, RFC – red fox capture, RFV – red fox visit to the trap set, RFPO – red fox pulled out, TF – trap failure, I – trap intact, UV – unknown visit, OV – other visit.

Trap set	TN	RFC	RFV	RFPO	TF	I	UV	OV
Without prebaiting								
blind set	382	12	62	1	2	251	7	29
baited set	142	2	63	1	0	62	3	7
total	524	14	125	2	2	313	10	36
With prebaiting								
blind set	87	4	8	1	1	49	2	21
baited set	140	17	66	5	2	46	2	2
total	227	21	74	6	3	95	4	23
Dirt hole	610	22	192	3	1	313	10	65

Table 2. Efficiency, failure, boldness and selectivity of sets activated in Doñana National Park, 1990–1992.

Trap set	Efficiency	Failure	Set quality	Attractivity	Boldness	Selectivity
Without prebaiting						
blind set	29.70	7.69	16.88	23.48	–	41.94
baited set	58.70	33.33	4.55	51.56	43.94	42.86
total	40.04	12.50	9.93	31.36	–	42.11
With prebaiting						
blind set	21.75	20.00	35.71	22.22	–	83.33
baited set	8.24	22.73	24.44	66.18	77.78	100.00
total	10.81	22.22	25.96	52.26	–	96.43
dirt hole	27.73	12.00	11.47	41.44	81.65	73.53

dirt hole sets was hidden in a 45° shouldered slope hole 15 cm in front of the trap (Baker and Dwyer 1987). Thirty to 40 dirt hole sets were placed along dirt roads and fire cuts spaced at a regular distance of 300 meters. All sets were installed in moist sandy soil and considered to be available to red foxes. Baited and blind sets were installed either with or without prebaiting. Prebaiting consisted of leaving (and replacing when stolen) a piece of bait for two to four days in the place where baited sets would be installed or in easily recognizable trails used by foxes to reach the bait. Traps were set only after bait was repeatedly stolen by red foxes. Sites were abandoned if used by a nontarget species. In accord with the preceding descriptions, we have 5 different trap sets: baited and blind sets, with and without prebaiting and dirt hole sets, always without prebaiting. In all cases we left the trapping area after a variable period of 15–25 days to avoid any bias in the trapping effort. Such bias would arise from a combined effect of reduction of red fox density and increase of red fox awareness (promoted by the extractions).

Traps were checked daily. All carnivores were physically restrained and transported to the laboratory where, after immobilization, they were measured, weighed and examined for trap injuries. Nontarget species other than carnivores were either immediately released when found unhurt or sacrified when injuries were so serious as to make their survival impossible, as in the case of small birds or rabbits. Daily site activity data were collected under the following categories: red fox (RFC) or nontarget species caught (NTC); fox caught but pulled out (RFPO); fox tracks on the trap pan, but trap not sprung (TF); fox sign at trap set (RFV) (subclassified as fox in close proximity to the trap set (A), stole the bait without detecting the trap (B) detected trap without springing it (C), or trap sprung by a fox, but animal not caught (D). Differences between (D) and (RFPO) might in some cases be subjective; individual of an identifiable nontarget species visited the set (VO); individual of an unidentifiable nontarget species at the trap set since the last check (I).

These data were used to calculate six indices.

Capture efficiency was defined as the number of trap-nights necessary to capture a red fox. A trap set was deemed lees efficient if it took more trap-nights to capture a red fox. When calculating this figure for blind and baited sets without prebaiting we included 597 trap-nights (152 blind and 445

Table 3. Total numbers of non-target species captured, grouped by trap set type. In brackets: total trap-nights necessary to capture one individual.

Species	Blind set	Baited set	Dirt hole set
Without prebaiting			
Milvus milvus	2 (191)	0	1 (610)
Milvus migrans	0	0	2 (305)
Pica pica	2 (191)	2 (71)	0
Turdus phylomelos	0	1 (142)	0
Alectoris rufa	1 (382)	0	1 (610)
Herpestes ichneumon	4 (96)	1 (142)	4 (153)
Meles meles	5 (76)	0	3 (203)
Lynx pardina	1 (382)	0	0
Genetta genetta	1 (382)	0	0
Canis familiaris	0	0	1 (610)
Sus scrofa	0	0	1 (610)
Oryctolagus cuniculus	2 (191)	0	0
Elyomis quercinus	0	0	1 (610)
Rattus rattus	0	0	1 (610)
With prebaiting			
Meles meles	1 (87)	0	0

Table 4. Leg injuries evaluated through cursory examination and X-ray radiographs, as a number and percentage of occurrences, for red foxes trapped in steel foothold traps with padded jaws.

Injury categories by cursory examination	n	%
Apparently normal	48	53
Swelling without cutaneous laceration	26	29
Swellind, cutaneous laceration and hemorrhage	13	14
Fracture below carpus but not visible	2	2
Exposed fracture below carpus or tarsus	2	2
Injury categories by X-ray radiographs	**n**	**%**
No fracture	28	85
With fracture	5	15
(1 metacarpal)	(2)	—
(2 metacarpals)	(3)	—

baited sets) for which we only know the total number of foxes captured. These 597 trap-nights were excluded from other calculations.

Escapes represents the percentage of foxes that were able to free themselves from a trap.

$$Escapes = \frac{RFPO}{RFPO + RFC} \times 100$$

Attractivity measures the capacity of a trap set to attract a fox, independent of whether a fox is actually captured.

$$Attractivity = \frac{RFV + RFC + RFPO + TF}{TN - (UV + NTC + OV)} \times 100$$

where "TN" is total number of trap-nights.

Boldness evaluates the fox confidence to take the bait from the trap once the set was detected. This was estimated only for baited and dirt hole sets.

$$Boldness = \frac{B + C + RFPO + TF}{RFV + RFC + RFPO + TF} \times 100$$

Quality was obtained as the relative effectiveness of a site in capturing foxes (i.e., the percentage of foxes approaching the set that were captured).

$$Quality = \frac{RFC + RFPO}{RFC + RFPO + RFV + TF} \times 100$$

Selectivity was defined as the percentage of all captures that were red foxes.

$$Selectivity = \frac{RFC + RFPO}{RFC + RFPO + NTC} \times 100$$

X-ray radiographs of the captured extremity and cursory examinations of trap-related injuries to the target species were made to detect fractures. results from cursory analyses were classified into five categories:

1. No injury.
2. Swelling in the captured extremity but no cutaneous laceration.
3. Swelling and cutaneous laceration with hemorrhage.
4. Fracture below carpus or tarsus, detectable by palpation.
5. Compound fracture below the carpus or tarsus.

We tested selectivity by sex by comparing total males versus females captured by each set type, irrespectively of prebait.

We also evaluated the strength of our handmade protection after removing the captured animal. Traps were examined and classified into one of three ways:

1. No damage. The trap could be reused in its present condition.
2. Slightly damaged. One or more small portions of the steel jaw were visible. The leather protection had to be repaired before the trap could be reused.
3. Completely damaged. Protection nearly or completely removed. The extremity caught was in full contact with the trap steel jaw.

Chi-square test (Zar 1984) was used in all comparisons. Differences were considered significant at $p < 0.05$.

RESULTS

Trapping was conducted for 1958 trap-nights from October 1990 to March 1992 and 73 red fox were captured. Complete calculations of all indices described above were performed using only that set for which a complete record was available. Complete calculations were performed on 1,361 trap-nights distributed among all trap set types (597 trap-nights were discarded because of incomplete records) (Table 1).

Prebaited sets were four times more efficient than nonprebaited ones ($\chi^2 = 13.99$, $df = 1$, $p < 0.01$) (Table 2). This difference was primarily attributable to baited sets ($\chi^2 = 9.78$, $df = 1$, $p < 0.01$), because blind set efficiency was not significantly improved by prebaiting ($\chi^2 = 0.11$, df $= 1$, $p = 0.75$).

Prebaiting improved set quality, set boldness ($\chi^2 = 17.37$, $df = 1$, $p < 0.01$), attractivity ($\chi^2 = 24.89$, $df = 1$, $p < 0.01$) and doubled trap-set selectivity ($\chi^2 = 18.63$, $df = 1$, $p < 0.01$). Maximum selectivity was observed in baited sets with prebaiting (Table 2).

Dirt hole sets had intermediate performance between prebaited and nonprebaited groups (Table 2). They were as efficient as nonprebaited sets ($\chi^2 = 0.49$, $df = 1$, $p = 0.49$) but less than prebaited sets ($\chi^2 = 9.69$, $df = 1$, $p < 0.01$). Dirt hole sets are significantly more attractive than nonprebaited sets ($\chi^2 = 11.83$, $df = 1$, $p < 0.01$), but less than prebaited sets ($\chi^2 = 5.81$, $df = 1$, $p < 0.05$). Taking set selectivity into account, dirt hole sets have the same indices as nonprebaited ones ($\chi^2 = 2.48$, $df = 1$, $p = 0.11$) and smaller indices than prebaited ($\chi^2 = 8.74$, $df = 1$, $p < 0.01$). Finally, red fox escape values are a minimum with non-prebaited blind sets and a maximum with non-prebaited baited sets (Table 2).

Fifteen nontarget species were caught (Table 3). All carnivores other than red foxes were captured without injuries and released within 24 hours from capture at the same site. Red kites (*Milvus milvus*) and black kites (*Milvus migrans*) were measured, ringed and immediately released. The wild boar (*Sus scrofa*) was liberated immediately without injuries. Some small birds, rabbits and small mammals were found dead or killed by us when checking the trap. One magpie (*Pica pica*) was released unharmed.

A total of 124 red foxes were examined for injuries. For this evaluation the same traps and handmade trap protections were used in all captures. Ninety one of the foxes were subjected to a cursory examination; 33 were examined through X-ray radiographs (Table 4). Cursory examinations in some cases underestimated leg injuries. Simple fractures were observed in 4% and 15% of cursory and X-ray examinations, respectively.

Sex ratio of captured red foxes was not significantly different from 1:1 in blind sets (32 males, 33 females, $\chi^2 = 0.296$, $df = 1$, $p = 0.90$), baited sets (25 males, 29 females, $\chi^2 = 0.296$, $df = 1$, $p = 0.59$), and dirt hole sets (34 males, 31 females, $\chi^2 = 3.462$, $df = 1$, $p = 0.69$). A total of 61 leg hold traps were examined for damage. Those selected for the examination had effectively held a red fox after capture. On 36 occasions (59%) our jaw padding showed no damage, while on 20 (33%) and 5 (8%) occasions the damage was slight and complete, respectively. No damage was evident after nontarget species were captured. This difference could be attributable to the common chewing activity of red foxes when captured. This behaviour is similar to that of other canids (e.g., coyote *Canis latrans*) and was a consideration in trap jaws to reduce or eliminate trap injuries (Balser 1965, Linhart et al. 1980).

DISCUSSION

Steel leg hold traps are one of the most versatile techniques for capturing canid species (Payne 1980, Linhart 1986). Nevertheless, their use in an area like Doñana has been strongly discouraged because of the presence of numerous nontarget species, two of which (Iberian lynx and the imperial eagle *Aquila adalberti*) are endangered. The use of our handmade trap protection was initiated in 1980 when capturing Iberian lynx for radiotracking studies. Our ability to capture lynx and non-target carnivores with minimal injury encouraged the use of this type of protection before commercially padded leg hold traps were available.

Trap set comparison should be interpreted with caution because their performance is affected by factors such as red fox absolute density, trap density, trapper experience and ability, season, and so on. Nevertheless, our results suggest some performance differences among trap set types.

The most significant result was the improvement in all performance indices when prebaiting was used, reaching a maximum in prebaited, baited sets. This set is highly efficient for capturing red foxes and reducing the accidental capture of non target species, which is often the case with blind sets (Litvaitis et al. 1983). Blind sets without prebait, however, had a similar efficiency to dirt hole sets, and when set exclusively at sites with red fox tracks, capture of nontarget species could be reduced. The minimum frequency of escape obtained using by blind sets without prebaiting could be due to the fact that red foxes in normal movement walk more confidently (and spring the trap more strongly) than when they are near or approaching food places. Set quality and attractivity was doubled by prebaiting while dirt hole sets reached intermediate values (Table 2). Boldness was also doubled by prebaiting but in this case the dirt hole set has the highest index values.

Injuries to foxes in this study differed slightly from those obtained by Olsen et al. (1988) with commercially protected traps and were notably lower than those reported by Englund (1982) using plastic hand-made jaw padding. In neither case was any estimation of changes in capture efficiency due to trap protection provided. In our case, a comparison of efficiency and general trap performance between padded and unpadded traps is completely impossible. Anyway, our combined leather and cloth trap protection could affect performance in at least three ways. Closure speed could be slowed by the padding (Linhart et al. 1986), leather and cloth could increase the olfactory detectability of the traps, or red foxes captured could have an extra opportunity to pull out of the trap and escape. Results obtained previously using commercially padded traps (Olsen et al. 1986, 1988) should be considered in future trapping efforts in Doñana. These traps should be tested in Doñana because they could increase efficiency by decreasing escapes and olfactory detection. What is more, commercial padding does not have to be replaced after each use.

Trap padding deterioration was acceptable considering animal safety. In only 8% of captures were steel jaws in direct contact with the caught leg. Based on these results we offer the following suggestion for trapping red foxes in protected areas like Doñana, where incidental capture of nontarget species must be avoided.

1. Activation of dirt hole sets along regularly spaced trails.

2. Prebaiting of selected places where blind and baited sets will be placed.
3. Placing of blind sets as trapping progresses. This way, the area will be better known by the trapper and some exclusive red fox tracks will be detected. Furthermore, if trapping reduces red fox density significantly, dirt hole sets become less efficient and could be abandoned, concentrating trapping effort on prebaited sets and carefully selected blind sets.

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