Tools and Technology Note

Evaluation of Cage-Traps and Cable Restraint Devices to Capture Red Foxes in Spain

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ABSTRACT A growing international concern for the welfare of animals, combined with the need to capture and handle specific species for conservation, management, or recreational purposes, is increasing the need for scientific evaluation of capture methods. We evaluated the efficiency, selectivity, and injury of cable restraint devices and cage-traps for capture of red foxes (*Vulpes vulpes*) in 4 sites of Castilla y León (Spain) during spring of 2006. All traps performed similarly at all sites, with no apparent site and trap interactions. Fox capture rates and mechanical efficiencies of the Belisle® (Edouard Belisle, Saint Veronique, PQ, Canada) and Collarum® (Wildlife Control Supplies, East Granby, CT; mention of product names does not infer endorsement) were similar, but both had higher capture rates than the cage-trap. Similar to previous studies, the Collarum was 100% selective for canids and had a selectivity of 94.4 overall, which was higher than that for the Belisle (63.4); both Collarum and Belisle were much more selective than the cage-trap (21.4). Fox injuries were statistically indistinguishable using injury scores, but the Collarum and the Belisle surpassed international standards for humane trapping; an insufficient number of animals were captured in cage-traps to allow evaluation. Both the Collarum and the Belisle may be useful for the capture of foxes in Spain, but training and experience with each may be necessary to ensure the highest efficiency while preventing injuries, especially to nontarget species. (JOURNAL OF WILDLIFE MANAGEMENT 72(3):830–836; 2008)

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Scientific evaluation of trapping methods is becoming more important due to growing international concern about animal welfare and impact on nontarget species (Harris et al. 2006). European laws emphasize trap selectivity and ban use of jawed traps and poisons (Council of Europe 1979, Council of the European Communities 1991, Consejo de las Comunidades Europeas 1992) and international agreements highlight the need for examining traps relative to animal-injury standards (European Union–Canada–Russian Federation 1998, United States of America–European Community 1998, International Organization for Standardization 1999). Therefore, thorough evaluations of traditional and new capture devices are needed.

The red fox (*Vulpes vulpes*), especially because it kills game species and livestock, comes into conflict with humans in Europe (Ruette et al. 2003, Sillero-Zubiri et al. 2004). Red fox in Spain are currently captured with snares and cage-traps but capture devices have not been thoroughly evaluated in Spain according to accepted international procedures (Herranz 1999, International Organization for Standardization 1999, Ferreras et al. 2003), as they have for other species in other countries (Shivik et al. 2000, 2005; Way et al. 2002). Some devices may be more efficient, but others may cause less injury or be more selective (Shivik et al. 2005). How should managers in Spain and Europe identify which devices to introduce or use? Information on newly available devices for capturing foxes is important in the context of potentially providing a larger variety of acceptable methods for capturing foxes, while minimizing potential impacts to sympatric endangered species. Our objective was to evaluate cage-traps, Collarums® (Wildlife Control Supplies, East Granby, CT), and Belisles® (Edouard Belisle, Saint Veronique, PQ, Canada) in terms of efficiency, selectivity, and injury to foxes and nontarget animals. Mention of product names does not infer endorsement.

STUDY AREA

We conducted our study at 4 sites in Spain in the provinces of Soria, Segovia, and León (within the Autonomous Community of Castilla y León), from April to June 2006 (Fig. 1). Site 1, Velasco Urbión (Soria), was characterized by continental Mediterranean climate with a mean rainfall of 50–65 cm. Topography was mountainous and semi-mountainous and vegetation consisted of grasslands and pine (*Pinus pinaster*), holm oak (*Quercus ilex*), and juniper (*Juniperus thurifera*) forests. Site 2, Estribaciones Guadarrama (Segovia), was characterized by continental Mediterranean climate with a mean rainfall of 30–50 cm. Lowland topography was covered with pine forests (*P. pinaster*) and croplands. Site 3, Valsemana (León), was characterized by a transitional climate between Mediterranean and temperate with mean rainfall of 70–90 cm. Topography was mountainous and semi-mountainous with a dominance of pines (*P. sylvestris*), bushes (*Cistus populifolius*), and pyrenaic oaks (*Q. pyrenaica*). Site 4, Mampodre (León), was characterized by

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Figure 1. Location of the study sites in Castilla y León, Spain, where we set Collarum, Belisle, and cage-traps for red foxes from April to June 2006.

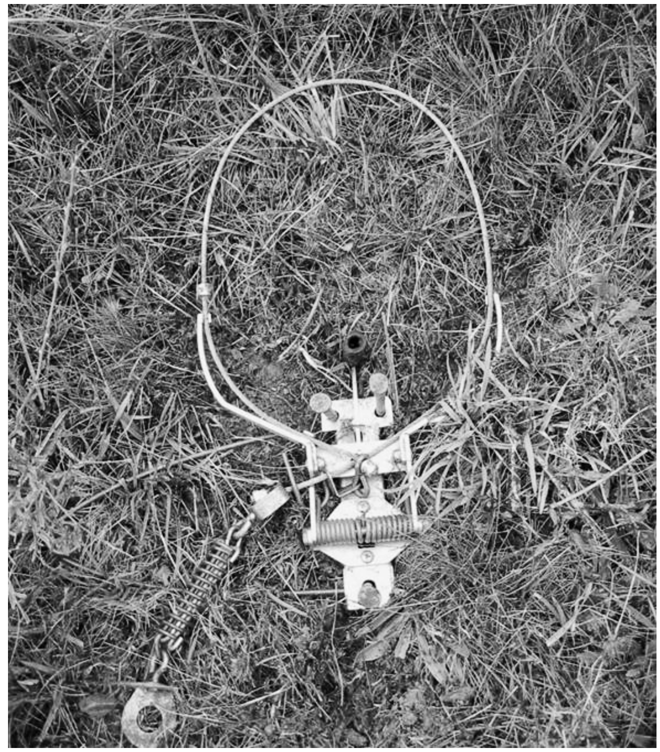

Figure 2. The Collarum® cable restraint produced by Wildlife Control Supplies (East Granby, CT), used in a comparative study of capture devices where we set Collarum, Belisle, and cage-traps for red foxes from April to June 2006 in Castilla y León, Spain.

temperate climate with mountainous topography and a mean rainfall of 100–120 cm. Vegetation consisted of pine forests (*P. sylvestris*), grasslands, and mountain bushes (*Cytisus scoparius, Genista polygaliphylla*). Detailed information on topographical and ecological features of each site can be found in Allué Andrade (1990) and Rivas-Martínez et al. (2002).

Red fox were abundant in all study sites but various other (potentially captured) species also inhabited the areas. Wolf (*Canis lupus*), European wildcat (*Felis silvestris*), Eurasian badger (*Meles meles*), stone marten (*Martes foina*), and small-spotted genet (*Genetta genetta*) were common in all study sites. Pine marten (*Martes martes*) were common in site 4, rare in site 3, and absent in the rest, brown bear (*Ursus arctos*) were rare in site 4 and absent in the rest, and otter (*Lutra lutra*) were absent in sites 1 and 2 and rare in the rest (Palomo and Gisbert 2002; F. G. Domínguez, Ministerio de Medioambiente, personal observation). Ungulates that occurred in the study area were wild boar (*Sus scrofa*; abundant in site 1 and common in the rest), roe deer (*Capreolus capreolus*; abundant in sites 1 and 3 and common in the rest), and red deer (*Cervus elaphus*; absent in site 2, rare in site 4, and common in the rest; Palomo and Gisbert 2002; F. G. Domínguez, personal observation). Lastly, Iberian hare (*Lepus granatensis*) were abundant in all the sites as were ravens (*Corvus* spp.) and raptors (*Buteo buteo, Milvus* sp., *Falco* sp., *Aquila* sp.; Palomo and Gisbert 2002; F. G. Domínguez, personal observation).

METHODS

The Collarum restraint device used a baited (Collarum-bait®, Wildlife Control Supplies) pull-tab that triggered a pair of coil-spring powered throw-arms that propelled a 0.466-cm (diam) cable loop over the head onto the neck of a fox. We tested the commercially available fox-size version (Fig. 2).

The Belisle consisted of a throwing device similar to a long-spring foot-hold trap (Fig. 3). The device, however, incorporated breakaway springs and a 0.20-cm steel cable (with a 3-cm plastic coat at its end) with a one-way lock that was looped over the device's frame. When triggered, the frame closes and places the cable on the fox's leg. As the fox pulls away from the device, the cable tightens and restrains the limb. Struggle engages the breakaway springs, which causes the frame to open and fall away. We adjusted the pan tension of each Belisle so that 900 g of force was required before the device would activate. We also used Collarum bait for Belisle traps but placed it in a hole approximately 10 cm behind the trap.

We tested metal cage-traps with 2 chambers, one for holding a captured fox and the other for holding a dove as an attractant (each chamber was 155 × 28 × 45 cm). Cage-traps were constructed by local blacksmiths. We set and baited traps as they are commonly used in Spain, with live doves placed in the annex chamber as an attractant (Fig. 4).

We instructed 4 teams of 2 rangers in the use of each of the traps before work began (Manitoba 2007). Because the Belisle and Collarum were commercially available, we were able to set equal numbers of traps at each site (i.e., all sites used 10 Belisles and 10 Collarums). The locally fabricated cage-trap, however, was more difficult to obtain and, thus,

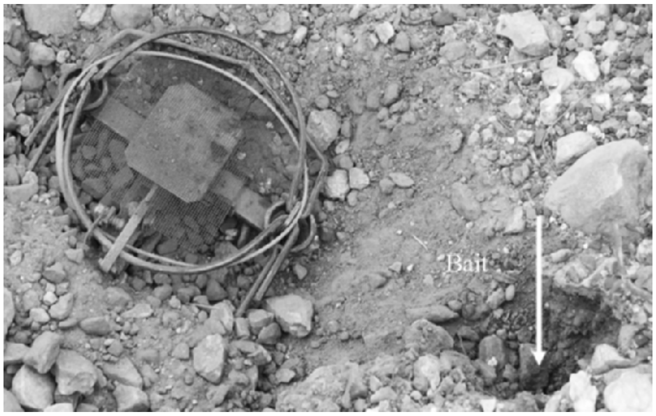

Figure 3. The Belisle® device manufactured by Belisle Traps, Inc. (Saint Veronique, PQ, Canada), used in a comparative study of capture devices where we set Collarum, Belisle, and cage-traps for red foxes from April to June 2006 in Castilla y León, Spain.

we had <10 cage-traps at some sites (i.e., we used 10 cage-traps at site 1, 9 traps at site 2, 5 traps at site 3, and 4 traps at site 4).

Trapping occurred simultaneously during the spring of 2006, but there was some staggering of start-dates. All trapping was completed on 17 June 2006, but work began on 19 April on sites 1 and 2, then on 8 May for site 3, and on 17 May for site 4. Trappers established trap lines along unimproved ranch roads and checked traps each morning, which limited the amount of time an animal could be held in a trap to 24 hours. The setting procedure was as follows: 1) trappers chose trap locations based on fox sign and habitat features, 2) after a site was identified, the trapper randomly selected a restraining device for placement, and 3) trappers then continued 300 m along the road before looking for a new trap site and repeating the process.

We used fox capture rate (fox captures/1,000 trap-nights) to determine trapping system efficiency. Mechanical efficiency was the proportion of fox captures relative to total number of potential captures for each device; a potential capture occurred when a fox triggered the trap (and either escaped or was held). Trappers examined tracks and signs at the capture site to identify potential captures.

We studied selectivity using 2 measures: selectivity was the percentage of foxes captured relative to total number of animals captured and nontarget capture rate was the number of nonfox captures per 1,000 trap-nights (International Organization for Standardization 1999).

Trappers euthanized captured animals with a captive bolt to the head (American Veterinary Medical Association 2001). We euthanized all animals captured with Collarum and Belisle, except 3 domestic dogs that we released, but given consensus on the low level of injures suffered by animals trapped with cage-traps, we released nontarget species caught in cage-traps in situ after checking for external, visible injuries (Harris et al. 2006). All work was performed following approval by the competent authority (Castilla y León Regional Government).

We immediately froze and shipped collected carcasses to

Figure 4. Cage-traps used in a comparative study of capture devices where we set Collarum, Belisle, and cage-traps for red foxes from April to June 2006 in Castilla y León, Spain. We chose cage-traps from a design typical to the area and manufactured by local blacksmiths.

the University of León (León, Spain), where whole-body necropsies were performed by a veterinary pathologist. The veterinarian necropsied animals by skinning and examining the entire body for injury in accordance with international recommendations (International Organization for Standardization 1999).

For each euthanized animal we summarized veterinarian necropsy data in terms of accepted international scale of traumas (Annex C [International Organization for Standardization 1999]). Injury data are categorical and the relative degree of pain experienced by an animal cannot be realistically transformed into quantitative variables; also, systems that subjectively assign scores to injuries are not appropriate for statistical analysis (Engeman et al. 1997). However, injury scores are ubiquitous in the literature (Onderka et al. 1990, Phillips et al. 1996, Hubert et al. 1997). Therefore, we also scored injuries based on the International Organization for Standardization (1999). Finally, we assessed injuries using internationally agreed-upon indicators of poor welfare (European Union–Canada–Russian Federation 1998, United States of America–European Community 1998). That is, we regarded the following categories as indicators of poor welfare: fracture, joint luxation proximal to the carpus or tarsus, severance of a tendon or ligament, major periosteal abrasion, severe external hemorrhage or hemorrhage into an internal cavity, major skeletal muscle degeneration, limb ischemia, fracture of a permanent tooth exposing pulp cavity, ocular damage including corneal laceration, spinal cord injury, severe internal organ damage, myocardial degeneration, amputation, or death. A device exceeded the standards if ≥80% of

Table 1. Summary of trapping effort in trap-nights (TN), number of foxes and nontarget (NT) captures, values of mechanical efficiency (ME), fox capture rates (FCR), selectivity (S), and nontarget capture rates (NTC) in each study site for each trapping method during the study in Castilla y León, Spain, from April to June 2006.

	Trap																				
	Collarum[a]							Belisle[b]							Cage-trap						
Site	TN	Foxes	NT	ME	FCR	S	NTC	TN	Foxes	NT	ME	FCR	S	NTC	TN	Foxes	NT	ME	FCR	S	NTC
1	535	10	1	48.8	18.8	93.8	1.9	538	13	5	91.7	24.2	69.0	9.3	515	0	13	0	0	0	25.6
2	562	8	1	47.6	14.3	91.7	1.8	574	10	2	75.0	17.3	89.3	3.4	540	3	2	100.0	5.6	60.0	3.7
3	359	2	0	40.0	5.6	100.0	0.0	406	3	4	75.0	7.3	41.7	9.9	140	0	1	0	0	0	7.1
4	297	2	0	66.7	7.7	100.0	0.0	317	1	2	33.3	3.1	33.3	6.4	127	0	1	0	0	0	7.8

[a] Wildlife Control Supplies, East Granby, CT.
[b] Belisle Traps, Inc., Saint Veronique, PQ, Canada.

a sample of 20 captured animals showed none of these indicators.

We used a 2-factor (site and trap) fixed-effects analysis of variance (ANOVA; Type III Sum of Squares; Quin and Keough 2002) to detect differences in trap efficiency and selectivity, using the individual trap as the sample unit. In injury analyses, the captured animal was the sampling unit. We verified assumptions of normality by means of probability plots and variance homogeneity by means of plots of studentized residuals against groups of means. Due to violations of these assumptions, fox capture rate and capture rate of nontarget species required square-root transformation before statistical analysis; injury scores required log-transformation. We made multiple comparisons with Tukey's honestly significant difference tests (Quinn and Keough 2002).

RESULTS

We collected information on Collarums, Belisles, and cage-traps during 4,910 trap-nights in the 4 sample areas (Table 1). Given that cage-traps only captured foxes in site 2, analyses of mechanical efficiency and injury scores were limited; that is, for these variables, we tested for interactions between site and trap using a model with 2 levels of the factor trap: Collarum and Belisle. We compared measurements of the cage-trap in a single-factor (trap) ANOVA within site 2, which was the only site with captures in cage-traps.

Fox capture rate varied between trap types ($F_{2,107} = 6.694$, $P = 0.002$) and sites ($F_{3,107} = 5.191$, $P = 0.002$), but there was no evidence of a significant interaction between sites and traps ($F_{6,107} = 0.992$, $P = 0.426$). Specifically, fox capture rate for the Collarum ($\bar{x} = 11.6$, SE = 2.26) and Belisle ($\bar{x} = 13.0$, SE = 3.16) were similar ($P = 0.998$), but both the Collarum ($P = 0.004$) and Belisle ($P = 0.004$) had greater capture rates than the cage-trap ($\bar{x} = 1.8$, SE = 0.98). Fox capture rate at site 1 ($\bar{x} = 14.3$, SE = 3.87) and site 2 ($\bar{x} = 12.6$, SE = 2.58) were similar ($P = 0.998$). Fox capture rate at site 2 ($P = 0.02$) and at site 1 ($P = 0.31$) was higher than at site 4 ($\bar{x} = 4.5$, SE = 2.53). Fox capture rate at site 3 ($\bar{x} = 5.1$, SE = 2.1) was intermediate to site 1 ($P = 0.084$), site 2 ($P = 0.058$), and site 4 ($P = 0.976$).

Mean mechanical efficiency of the Belisle was 73.9 (SE = 9.08), and the Collarum was 48.8 (SE = 7.3). The cage-trap failed to capture any foxes in sites 1, 3, and 4 and, thus, we could not calculate mean mechanical efficiency and include it in the site and trap comparisons (Table 1). Mean mechanical efficiency was 67.1 (SE = 8.20), 68.9 (SE = 8.44), 55.6 (SE = 17.57), and 50.0 (SE = 22.37) at sites 1, 2, 3, and 4, respectively. Overall, mechanical efficiency was similar for all capture devices ($F_{1,44} = 2.031$, $P = 0.163$) and all sites ($F_{3,44} = 0.429$, $P = 0.734$), without evidence of a site and trap interaction ($F_{3,44} = 1.401$, $P = 0.258$).

Cage-traps captured 17 nontarget species: 2 goshawks (*Accipiter gentilis*), 1 buzzard (*Buteo buteo*), 8 European wildcats, 4 stone martens, 1 small-spotted genet, and 1 domestic dog. The Collarum captured 2 nontarget species: 2 domestic dogs. The Belisle captured 13 nontarget species: 8 Eurasian badgers, 1 stone marten, 1 Iberian hare, 1 domestic dog, 1 raven (*Corvus corax*), and 1 western hedgehog (*Erinaceus europaeus*; Table 2).

Selectivity varied between traps ($F_{2,54} = 13.536$, $P < 0.001$) and sites ($F_{3,107} = 2.990$, $P = 0.041$) but there was little evidence of an interaction between trap and site ($F_{6,54} = 1.574$, $P = 0.178$). Specifically, selectivity for the Collarum ($\bar{x} = 94.4$, SE = 3.82) was higher than for the Belisle ($\bar{x} = 63.4$, SE = 9.09, $P = 0.013$) and the cage-trap ($\bar{x} = 21.4$, SE = 11.39, $P < 0.001$). Selectivity for the Belisle was also higher than that for the cage-trap ($P = 0.002$). Multiple comparisons of selectivity among sites were less conclusive, with site 2 ($\bar{x} = 81.9$, SE = 8.04) somewhat higher than sites 1 ($\bar{x} = 56.1$, SE = 10.08, $P = 0.102$), 3 ($\bar{x} = 50.0$, SE = 16.67, $P = 0.102$), and 4 ($\bar{x} = 50.0$, SE = 22.37, $P = 0.191$). Estimates of selectivity for site 1 were similar to those for site 3 ($P = 0.967$) and site 4 ($P = 0.979$), and site 3 had the same selectivity as site 4 ($P = 1.000$).

Nontarget capture rate was different among traps ($F_{2,107} = 6.047$, $P = 0.003$), and sites ($F_{3,107} = 2.564$, $P = 0.059$), but there was little evidence for an interaction between site and trap ($F_{6,107} = 1.566$, $P = 0.165$). Specifically, the nontarget capture rate of the Collarum ($\bar{x} = 0.9$, SE = 0.63) was lower than that for the Belisle ($\bar{x} = 7.2$, SE = 1.98, $P = 0.029$) and the cage-trap ($\bar{x} = 12.7$, SE = 3.59, $P = 0.001$). In contrast, the nontarget capture rate for the Belisle and cage-trap were similar ($P = 0.277$). The sites that differed the most in nontarget capture rate were site 1 ($\bar{x} = 12.3$, SE = 3.47) with

Table 2. Injury data (i.e., no. of animals that sustained each injury) from whole-body necropsies of animals captured with restraining devices intended for red foxes in Castilla y León, Spain, from April to June 2006. Data reported are only for those injuries that were observed and are not a complete list of all injuries that we looked for as listed in International Organization for Standardization (1999).

	Species[a]							
	Red fox							
Pathological observations	Belisle (n = 27)	Collarum (n = 22)	Cage (n = 3)	Eurasian badger (n = 8)	Iberian hare (n = 1)	Stone marten (n = 1)	Weatern hedgehog (n = 1)	Raven (n = 1)
Oedematous swelling or haemorrhage	20	19	2	8	1	0	1	1
Minor cutaneous laceration	4	1	0	1	0	0	0	0
Major cutaneous laceration, except on foot pads or tongue	4	1	0	0	1	0	0	1
Severance of minor tendon or ligament (each)	1	0	0	0	0	0	0	0
Fracture of a permanent tooth exposing pulp cavity	0	3	1	1	0	0	0	0
Minor skeletal muscle degeneration	1	1	2	0	0	0	0	0
Simple fracture at or below the carpus or tarsus	1	0	0	0	0	0	0	0
Any fracture or joint luxation on limb above the carpus or tarsus	2	0	0	0	1	0	0	1
Any amputation above digits	0	0	0	0	0	1	0	0

[a] Injured Eurasian badgers, Iberian hare, stone marten, western hedgehog, and raven reported here were captured with the Belisle device.

site 2 ($\bar{x} = 3.0$, SE = 1.23, $P = 0.060$) and site 4 ($\bar{x} = 3.9$, SE = 2.18, P = 0.077), but few of the other multiple comparisons indicated large differences in nontarget capture rates; site 1 was similar to site 3 ($\bar{x}$ = 5.4, SE = 2.24, P = 0.250), site 2 was similar to site 3 (P = 0.939), and sites 2 and 3 were similar to site 4 ($P > 0.94$).

In terms of humane trapping standards, most (86.4%) foxes captured in the Collarum device (n = 22) showed no indicators of poor welfare, although 3 foxes suffered permanent tooth fracture (Table 2). Most injuries caused by the Belisle device were minor, but there was a broader array of injuries than with the Collarum, and 24 of 27 (88.9%) foxes showed no indicators of poor welfare. Finally, 1 of the 3 foxes captured with cage-trap showed an indicator of poor welfare by having a permanent tooth fracture exposing pulp cavity.

Examining foxes using the International Organization for Standardization (ISO) injury scale, the Belisle caused higher mean injury values ($\bar{x}$ = 21.7, SE = 6.93) than did the Collarum ($\bar{x} = 13.4$, SE = 2.47), but the Belisle's scores were lower than those for the cage-trap ($\bar{x}$ = 40.0, SE = 5.02). Overall, we detected no statistically significant differences in injury scores among the different capture devices ($F_{1,48}$ = 0.119, $P = 0.731$). In regards to differences in injury scores between sites, site 1 ($\bar{x} = 24.6$, SE = 7.88), site 2 ($\bar{x} = 17.6$, SE = 3.56), site 3 ($\bar{x} = 6.0$, SE = 0.98), and site 4 ($\bar{x} = 11.7$, SD = 6.64) were all similar ($F_{3,48} = 0.410$, $P = 0.747$), and we did not detect evidence of an interaction between site and trap ($F_{3,48} = 0.677$, $P = 0.571$). Within site 2, which was the only site where foxes were captured in cage-traps, we did not detect differences in injury scores between the Belisle ($\bar{x}$ = 11.5, SE = 4.65), Collarum ($\bar{x}$ = 16.9, SE = 4.91), or cage-trap ($F_{2,18} = 2.020$, $P = 0.159$).

We were also able to examine the injuries sustained by some nontarget species that were captured (Table 2). We returned the 3 domestic dogs (without visible injuries) that we trapped with the Collarum and the Belisle devices to their respective owners. All of the nontarget species captured with a cage-trap and then released appeared to behave normally. Only one goshawk and one European wildcat showed cuts on their heads, possibly from scraping or knocking against the wall of the cage. Of the 8 Eurasian badgers captured with the Belisle, 7 showed no indicators of poor welfare. One individual exhibited one poor welfare indicator due a permanent tooth fracture exposing pulp cavity (Table 2). In terms of International Organization for Standardization injury scores, badger injuries were similar between sites ($F_{2,7}$ = 2.796, P = 0.173) and similar to the scores of foxes ($F_{1,34} = 0.074$, $P = 0.789$). The Iberian hare that was captured was unable to release the breakaway springs and its necropsy showed an open and complete fracture of the metatarsus as well as edematous swelling and hemorrhage. Similarly, the raven was unable to release the breakaway springs and its necropsy showed and open-fractured (almost amputation at the tibia–tarsus joint) forelimb. The stone marten was unable to release the springs and its forelimb was amputated at the carpus joint. Lastly, although the western hedgehog was also unable to open the springs, it only showed minor injuries (edematous swelling) but had quills present in the larynx, which were probably ingested postcapture. Because only one individual per species was captured for the raven, hare, stone marten, and hedgehog, we could not perform a statistical comparison of their injury scores.

DISCUSSION

One strength of our study is the absence of significant interactions between sites and traps. Thus, our results and conclusions about the different trap types should be applicable to any of our study sites as well to other similar areas.

Our results of efficiency with the Collarum (49%) were higher than earlier versions of Collarum devices (without the secondary throw-arm), which had efficiency of 41% with coyotes (*Canis latrans*; Shivik et al. 2000), but lower than a later Collarum design, which incorporated a secondary throw-arm and showed 87% efficiency for coyotes (Shivik et al. 2005). Differences in our measurements of mechanical efficiency from those reported in previous studies using coyotes could be because coyotes are more susceptible to Collarums than are foxes, but it is probably more likely that soil conditions, or our relative inexperience with the devices, resulted in lower efficiency. The Belisle showed similar efficiency to that reported by other authors with coyotes (Shivik et al. 2000).

Our results show that efficiency of the cage-traps we used was less than in other studies, where capture rates were near 18 foxes per 1,000 trap-nights, but were similar to other studies in Spain, which had capture rates ranging between 1.2 and 5 foxes per 1,000 trap-nights (Herranz 1999, Baker et al. 2001, Ferreras et al. 2003). As in previous studies, cage-traps performed poorly with respect to selectivity (Way et al. 2002, Shivik et al. 2005). Nevertheless, the selectivity we measured (21.4%) was higher than that reported by other authors in Spain, who reported selectivity between 3% and 12.5% (Herranz 1999, Duarte and Vargas 2001, Ferreras et al. 2003).

We measured 100% selectivity for canids using the Collarum, exactly as reported in previous studies (Shivik et al. 2000, 2005). The Collarum device appears to present the lowest risk of interfering with nontarget species, even in the case of erroneous or malicious use.

The Belisle device was intermediately selective between Collarum and cage-traps and could possibly be improved by identifying a more species-specific lure; the Eurasian badger will be the wild species most difficult to avoid capturing when trapping foxes in areas similar to ours. Captures of species lighter than foxes, such as martens (0.5–2.0 kg; Powell 2001) or the Iberian hare (2.0–2.5 kg; Carro and Soriguer 2002), could possibly be avoided by ensuring that the pan tension of the Belisle be 0.9–1 kg. It is important to note that during our work we observed that pan tension of the Belisle sometimes lost its initial 0.9-kg calibration after being triggered, which could have resulted in an inflated nontarget capture rate in our data. For example, captures of the raven and hedgehog which both weighed approximately 0.5 kg, were caused by an erroneous pan-tension calibration. If used correctly, the Belisle presumably can be used with minimal impact on nontarget species.

Although the cage-trap seemed to produce minimal impact on the welfare of animals held in the short-term, the capture of high numbers of nontarget animals makes this device highly susceptible to malicious or inappropriate use; new cage-trap designs or modifications should be explored that account for fox behavior and wariness and that will preclude nontarget species captures. Important advances can be achieved by improving mesh size (Arthur 1998, Powell and Proulx 2003), incorporating new or natural materials (Copeland et al. 1995), using more selective attractants (Shivik et al. 2005), or monitoring and managing cages with electronic devices (Kaczensky et al. 2002, Potocnik et al. 2002).

We measured the short-term impact of capture devices on animal welfare, but long-term effects of capture should also be accounted for (Independent Working Group on Snares 2005). Studies that investigate postcapture differences in survival or behavior may be useful.

According to our results, the Collarum and Belisle surpassed current international standards for humane trapping. Most important injuries from the Collarum involved fractured teeth, which probably resulted from animals chewing on the cable or other hard elements around it. If tooth damage could be prevented, the Collarum device would be extremely useful for capturing foxes (in terms of minimizing injury). Perhaps a coated cable, or a chew-tab that would encourage noninjurious displacement behavior could be attached to the cable and prevent tooth injury. In regard to the Belisle, Shivik et al. (2000) did not find poor welfare indicators in only 31% of the 16 coyotes necropsied and they reported a higher injury scale value (50.9). However, the Belisle is a trap certified by the Canadian government to meet humane international standards to trap coyotes (Fur Institute of Canada 2006). In our study the Belisle produced a broader array of injuries both for foxes and nontarget species. Most severe injuries (bone fractures) were caused to small animals that were unable to release the breakaway springs. Similarly, foxes that showed poor welfare indicators were juveniles unable to release the springs. It may be useful to develop structural modifications to the current form of the Belisle that would allow the breakaway springs to release more easily.

Management Implications

The Collarum is in many ways a preferred device because it is unlikely to capture many nontarget animals and it can be an efficient device for capturing foxes. No capture device is without risk, but we believe that the Collarum could be used to capture red foxes in areas with presence of endangered nontarget species, such as Iberian lynx (*Lynx pardinus*). The Belisle has the potential to be the most efficient and easiest trap to use, however, because it is a less complicated device than the Collarum. Although, without good training and setting techniques (fox-specific lures and appropriate pan tension), the Belisle could be more prone to capture and injure small nontarget animals. Thus, we recommend proper training before use of this device and that it normally not be used near fox dens during puppy emergence (mid-May–mid-Jun in Spain). The cage-trap was the most likely to capture the fewest foxes and the most nontarget species and, thus, improvements in its design or method of use are needed.

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