PSM Veterinary Research ISSN(Online): 2518-2714

Research Article 2020 | Volume 5 | Issue 2 | 49-62

Article Info

Open Access

Citation: Valcárcel, F., Tercero, J.M., González, J., Aguilar, A., Sánchez, M., González, M.G., Olmeda, A.S., Landaluce, I., 2020. Cage-traps are Friendly and Informative in Predator Control Programs. PSM Vet. Res., 5(2): 49-62.

Running Title: Cage-traps are friendly and informative

Received: April 27, 2020

Accepted: May 22, 2020

Online first: May 31, 2020

Published: July 31, 2020

***Correspondence to:**
Felix Valcárcel
Email:
valcarcel.felix@inia.es
Tel: 0034 91 347 40 46

Cage-traps are Friendly and Informative in Predator Control Programs

Felix Valcárcel[1]*, Jose M. Tercero[2], Julia González[2], Ana Aguilar[1], María Sánchez[1], Marta G. González[2], Angeles Sonia Olmeda[3], Ignacio Landaluce[2]

[1]Instituto Nacional de Investigación y Tecnologías Agrarias y Alimentarias (INIA), Avda. Puerta de Hierro km 5,9, 28040 Madrid, Spain.
[2]Villamagna SA, Finca “La Garganta”, 14440 Villanueva de Córdoba, Córdoba, Spain.
[3]Departamento de Sanidad Animal, Facultad de Veterinaria, Universidad Complutense de Madrid, 28040 Madrid, Spain.

Abstract:
According to the World Wide Fund for Nature organization (WWF), hunting has been directly responsible for the extinction of 270 species. In consequence, people began to call for more rational control measures that could preserve all animal species, like the predator control. This study aimed to determine whether cage-traps are safe enough to be applied in rational predator management systems in rural areas with a stable population of endangered species. Trapping was undertaken for 18 months using 218 cage traps, which means 114,450 trap-nights. A total of 115 animals were caught (91 target species and 24 non-target species). Cage traps did not damage most animals; only six external trap-related injuries were detected, just in target species. Hence, the absence of damage was over the standard 80 % required by internationally agreed indicators. Our results seem to indicate that it is possible to develop and assess a rational predator management system on hunting reserves leading to a reduction in predator populations with the least possible impact on target and non-target animal species. These results have also been very useful in providing valuable information about the safety of these traps and their impact on animal welfare.

Keywords: Predator control, animal welfare, cage-traps, health monitoring, wildlife management.

INTRODUCTION

Spain is one of the most diverse European countries in terms of fauna and flora thanks to its orographic features, size, and geographical situation with nearly 80,000 classified taxa. There are 8,000 vascular plant species in Spain accounting for over 80 % of those existing in the European Union (EU) and 59 % of those on the entire European continent. 1,500 of those species are endemic. As regards fauna, the Iberian Peninsula possesses the greatest biotic wealth in Western Europe with a total of between 50,000 and 60,000 animal species, i.e. over 50 % of all species that exist in the EU. Of these, 770 are vertebrates, excluding marine fish. Spain is also the European country with the widest range of mammals and reptiles and the third European country in terms of amphibians and fish. Moreover, it possesses 121 different types of habitats accounting for 54 % of the EU total (Público, 2014).

Animal populations down through history have remained relatively stable in a 'self-balanced' way without excessive human intervention. However, as man began to consider predator animals as competitors, they designed different capture methods. According to the World Wildlife Fund (WWF 2015), over the last four centuries hunting has been directly responsible for the extinction of 270 species (150 bird and 120 mammal species). This disastrous outcome served to raise general awareness and in the second half of the 20th-century people began to call for more rational control measures. Fortunately today, predator control is more rational thanks to global awareness of the need to preserve all animal species, including predators, and to the modernization and redesign of traps with a view to enhance effectiveness and selectivity and to decrease the number of injuries caused to captured animals. In fact, the law prohibits the use of certain types of traps or capture systems (snares, nooses, bait, live birds as bait, recorders, and tape-recorders, poisoned bait, leg-hold traps, artificial light sources, non-selective traps or nets, and the way capture systems are used, gas or smoke asphyxiation, etc.).

The type of predator found in a given natural area is another aspect to consider when addressing the topic of predation. Some iconic species such as the Iberian lynx (*Lynx pardinus* Temminck, 1827) or the Imperial eagle (*Aquila adalberti* C. L. Brehhm, 1861) can be found in this category. These are predators that require high-density rabbit populations and very little human disturbance (Delibes-Mateos *et al.,* 2007). While the wide range of laws regulating these matters may make management systems more difficult and expensive, their purpose is to safeguard ecosystems and what they represent, i.e. the survival of the greatest possible number of animal and plant species over the long run [the Berne Convention, the Habitats Directive (Council Directive 92/43/EEC) and the Birds Directive (Directive 2009/147/EC), the International Agreement on Humane Trapping Standards, the Law on Conservation of Natural Habitats and Wild Fauna and Flora, the Spanish Act on Natural Heritage and Biodiversity (Law 42/2007), Agreements from the Environmental Sector Congress, Technical guidelines for the Capture of Predator Species: Standardization of Capture Methods and Certification of Users, Order 18/06/2013 of the Regional Department for the Environment, Food and Rural Affairs, etc.].

Capture methods have many disadvantages, the most serious being direct or indirect injuries to animals (such as self-inflicted injuries when trying to escape). Therefore, "Technical Guidelines for the Capture of Cynegetic Predator Species: Standardization of Capture Methods and Certification of Users" were passed in 2011. According to the WWF (2015), these guidelines have some deficiencies: they do not clearly define when these techniques should be used and when other methods should take priority; they lack detail on the requirements and follow-up of authorizations; they authorize methods which have not been properly assessed and which cannot be regarded as selective itself; they use ISO 10990-5 as the reference standard to determine standardization criteria which, according to the WWF, is not applicable in some areas because it has been defined for commercial and not preservation purposes. Further analysis of the WWF report shows that most current systems are not selective in their own right because selectivity does not depend on the system itself but rather on how the user applies it. However, the WWF states that "none of the methods has been tested under the presence of certain protected species which are potentially more likely to be captured in those traps (wolf, Iberian lynx, mink and certain raptors)".

The aim of this study was to determine whether cage-traps are safe enough to be applied in rational predator management systems in rural areas with a stable population of endangered species, with the least possible impact on the welfare of target and non-target species.

MATERIALS AND METHODS

Study area

The study was conducted in a natural reserve in Ciudad Real (Central Spain: 37º24'78"N 42º59'101"E), representative of a meso-Mediterranean bioclimatic environment. The study site covered an area of 15,000 Ha at an altitude of between 500 and 1,266 meters above sea level; annual average rainfall is 650 mm and temperatures range from -4 to 43 ºC. The forest is mainly comprised of oaks (*Quercus ilex* L.), cork (*Quercus suber* L.), mastic (*Pistacia lentiscus* L.), eucalyptus (*Eucalyptus globulus* Labill) and pine (*Pinus pinea* L, *P. pinaster* Aiton). There is also limited farming activity: 265 ha of organically grown olive (*Olea europea* L.), 1,300 ha of cereals, and aromatic and native shrub species. It is a refuge for endangered species such as the Imperial eagle and the Iberian lynx, and many other species such as the Golden eagle (*Aquila chrysaetos* L.) and the Peregrine falcon (*Falco peregrinus,* L.), as well as owls (*Bubo bubo,* L.), black stork (*Ciconianigra*), black vulture (*Aegypius monachus* L.), partridge (*Alectoris rufa* L.), red fox (*Vulpes vulpes* L.), red deer (*Cervus elaphus* L.), roe deer (*Capreolus capreolus* L.), wild boar (*Sus scrofa* L.), Iberian wild goat (*Capra pyrenaica* Schinz, 1838), wild rabbit (*Oryctolagus cuniculus* L.), hare (*Lepus europaeus* L.) and wood mouse (*Apodemus sylvaticus* L.).

Capture procedures

In adherence to the instructions laid down in the authorized predator control program (Regional Department of Agriculture Resolution 24/06/2015 of the Directorate General for Woodlands and Natural Areas), trapping was undertaken for 18 months (from June 2015 to November 2016). A total of 218 cage traps (34 traps walk-in, 149 small and 35 big traps with bait) were used for the study which means a total of 114,450 trap-nights. In line with previous trapping experiences in the area, different sizes of metal cage traps with one or two chambers (with or without live pigeons as bait) and an entrance (0.45 m high x 0.30 m wide) were used (Muñoz-Igualada *et al*., 2008). Cage traps were manufactured at the natural reserve itself and their main characteristics are listed in Table 1.

All traps were placed close to a path and were georeferenced to facilitate daily checks by a specialist in predator control (checks were doubled in the summer months). The trapper used a monthly field book during checks to note all situations (animal captured or not, closed or open trap, target or non-target species, sex, alive or dead, conscious or unconscious, mobility, signs of attempts to escape, self-lesions, whether the animal was sacrificed, methods and a general overview) (Online resource 1).

Table 1. Trap classes used in the study. Dimensions are expressed in metres. Entrance dimensions are equal for all trap classes: 0.45 m high x 0.30 m wide.

Trap	Length	Width	High	Other dimensions	Trap rate	Trap rate TS	Trap rate NTS
Small metal trap with bait	1.50	0.30	0.45	Adjacent cage to keep alive the bait 1.5*1.0*0.5	0.36	0.29	0.08
Big metal trap with bait	2.00	2.00	2.00	Inside space to keep alive the bait 2.0*1.0*2.0	0.40	0.31	0.11
Small metal trap walk-in or zig-zag	1.50	0.30	0.45	No bait	0.21	0.06	0.15
				Total	0.34	0.26	0.10

Online resource 1. Monthly field book for trap revision during the predator control program

Captured animals

Red fox, wild dogs and feral cats (*Felis silvestris catus* L) were the target species (TS). Once annotations were made by the trapper in the monthly field book, red foxes were sacrificed by a captive bolt gun following the required protocol. Wild domestic predators, cats and dogs, were checked to determine whether they had an electronic microchip device. This was the case with two dogs that were taken care of until their owners came to pick them up.

After sacrifice, TS animals were identified with two non-removable plastic labels, one attached to the animal itself and the other to the plastic bag in which it was placed. Labels indicated the species, date, cage number and the number assigned to the trapped animal. Once identified, trapped animals were frozen at -20º C and transported to laboratory facilities.

A strict protocol was followed in the case of non-target species (NTS). First of all, all NTS were checked by a veterinary doctor specialized in animal welfare to determine whether they had been injured by the cages or attempts to escape that could reduce their survival rate once they were set free. According to this protocol, injured animals should be sent to a recovery centre run by the local Government until they recovered while animals with no observed injuries were immediately released.

Necropsies

A total of 81 necropsies were performed; for that, animals were thawed at room temperature and then a complete veterinarian necropsy was achieved on each one following the international scale of traumas (Annex C, International Organization for Standardization 1999). Reports were drawn up with a description of the nature and extent of all tissue damage in the area of the body examined and was classified as NK (not known), NA (not applicable), NI (not inspected) or NS (not submitted). The following parameters were observed during necropsy procedures: general descriptive data, examination of head, body and limbs, and trap-related injuries (Online resource 2).

Online resource 2. Details of the parameters to be observed during necropsy procedures

Data analysis

The five age classes set out in the capture authorization protocol were maintained for descriptive purposes. However, to minimize the effect of individual differences, we grouped by two ranges, *juvenile* (cubs and young) and *adult* (sub-adult, adult and old). We analysed the following parameters:

Trap rate = number of traps with at least one animal trapped /total number of traps set.

Trap rate TS = number of traps with at least one animal TS trapped /total number of traps set.

Trap rate NTS = number of traps with at least one animal NTS trapped /total number of traps set.

Capture efficiency = number of TS captures during a trapping effort of 1000 trap nights.

Negative efficiency = number of NTS captures during a trapping effort of 1000 trap nights.

ISO 10990-5 selectivity = number of TS captures / total number of captures (TS + NTS)

Trappability = total number of captures for one animal in a given season + 1 / number of trap-nights.

Homologation threshold: in compliance with EU standards, traps must not cause injury to more than 20 % of the animals captured, with a minimum of 20 animals of the same species captured.

We used Chi-square test to detect a relationship between categorical variables (age group, sex and season) and *t*-test to compare the difference of trappability. All statistical analyses and graphs were performed by software IBM SPSS Statistics 20 (SPSS 2011).

RESULTS

A total of 115 animals (91 TS: 63 red foxes and 28 feral cats; and 24 NTS) were captured during 114,450 trap-nights, what reflected a global capture efficiency of 0.79 (Table 2). Trap rate was 0.34, although it varied between trap classes; traps with bait showed similar values, being higher trap rates TS than rates NTS, in contrast to results of traps walk-in (Table 1). The most of species (92.17 %) were captured in traps with live bait, what demonstrate a higher capture efficiency and lower negative efficiency than other trap class (Table 2). We analysed the selectivity of traps through negative efficiency and ISO index; a value of ISO index close to 1 indicating selectivity. In this sense, the global ISO selectivity was 0.79 (Table 2) being higher in the case of traps with live bait (0.83) than in the case of traps walk-in (0.33) because most of species captured with this last trap class (66.67 %) were non-target species.

Table 2. Summary of trapping effort in trap-nights, number of target and non-target captures, capture efficiency, negative efficiency and selectivity (ISO index) for each trap class used during the study.

Trap	Target species captures	Non-target species captures	Trap-nights	Capture efficiency	Negative efficiency	ISO selectivity
Small (bait)	63	14	78,225	0.8054	0.1790	0.8182
Big (bait)	25	4	18,375	1.3605	0.2177	0.8621
Small (walk-in)	3	6	17,850	0.1681	0.3361	0.3333
	91	24	114,450	0.7951	0.2097	0.7913

Regarding target species captured, sex proportion was equal in red foxes (31 females and 32 males) and cats (14 females and 14 males); also, we did not find a significant difference between age groups (χ^2 = 2.05, df = 1, P > 0.05). Nutritional status of the most of target species was considered normal, except to five captures (one fat adult and two juvenile foxes, and one juvenile and one adult fat cats); body measurements varied in both species, although in general, males were taller and heavier than females (Tables 3 and 4). Results about total captures showed that trapping of foxes commenced in spring with the maximums of capture in summer (July), and then we observed a progressive decrease in autumn until a slight increase in November. In contrast, there were few captures of cats in summer, trapping showed maximums in March and two peaks during autumn (Figure 1). We found evidence of a significant difference in the proportion of seasonal captures between age groups of target species (χ^2 = 14.20, df = 3, P < 0.01) (Figure 2).

Trappability graphs reflected these results (Figure 3). In foxes, mean trappability in summer was significant higher from winter and autumn (t = 2.84, df = 6, P < 0.05; t = 2.96, df = 6, P < 0.05), while we found just an evidence of a statistically significant effect on mean trappability of feral cats between autumn and summer (t = 2.90, df = 6, P < 0.05).

Table 3. Weight and measures from red foxes captured using cage-traps during a predator control program.

			Wrist (mm)			**Neck (mm)**			**Back of the skull (mm)**		
Red fox	**n**	**weight (kg)**	mean	min	max	mean	min	max	mean	min	max
Females											
Young	16	3.49	18.06	13	23	37.19	20	59	49.50	31	72
Sub-adults	1	3.47	20.00	20	20	36.00	36	36	59.00	59	59
Adults	11	4.43	17.91	11	23	47.00	30	60	60.64	41	78
Global	28	3.86	18.07	11	23	41.00	20	60	54.21	31	78
Males											
Cubs	1	3.50	21.00	21	21	43.00	43	43	50.00	50	50
Young	15	4.22	19.73	12	24	42.47	29	58	56.27	35	76
Sub-adults	4	4.54	20.25	16	24	39.50	33	46	51.00	47	58
Adults	7	4.45	19.43	15	24	44.43	28	66	57.57	45	79
Old	1	4.87	20.00	20	20	51.00	51	51	73.00	73	73
Global	28	4.32	19.79	12	24	42.86	28	66	56.21	35	79

Table 4. Weight and measures from feral cats captured using cage-traps during a predator control program.

			Wrist (mm)			**Neck (mm)**			**Back of the skull (mm)**		
Feral cat	**n**	**weight (kg)**	mean	min	max	mean	min	max	mean	min	max
Females											
Cubs	1	0.30	13.00	13	13	15.00	15	15	47.00	47	47
Young	7	2.39	12.29	8	16	29.57	23	35	43.14	27	64
Sub-adults	3	2.51	12.33	9	14	33.00	26	43	48.67	30	68
Adults	3	3.22	16.33	16	17	39.00	30	44	54.00	48	59
Global	14	2.44	13.21	8	17	31.29	15	44	46.93	27	68
Males											
Young	2	1.08	12.00	9	15	19.50	16	23	34.00	28	40
Sub-adults	3	2.69	17.00	16	18	37.67	33	41	56.67	40	67
Adults	6	3.63	16.00	13	18	37.50	34	45	51.33	45	64
Global	11	2.91	15.55	9	18	34.27	16	45	49.64	28	67

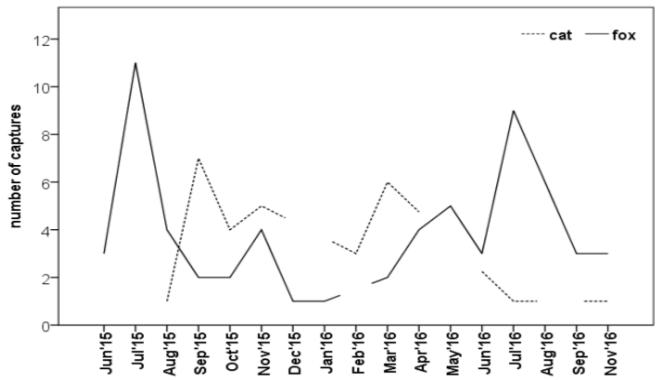

Fig. 1. Monthly number of targeted species captured in a predator program in a reserve located in a meso-Mediterranean from June 2015 to November 2016.

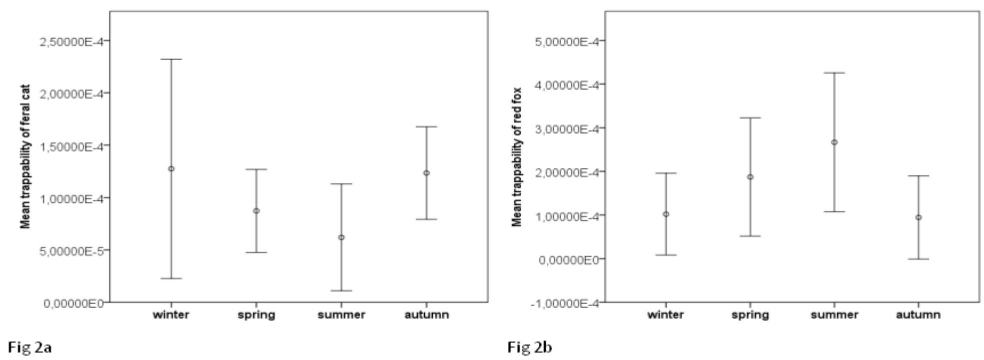

Fig. 2. Seasonal number of captures of targeted species according to age groups. Error bars: 95 % CIF. a) feral cat trappability b) red fox trappability

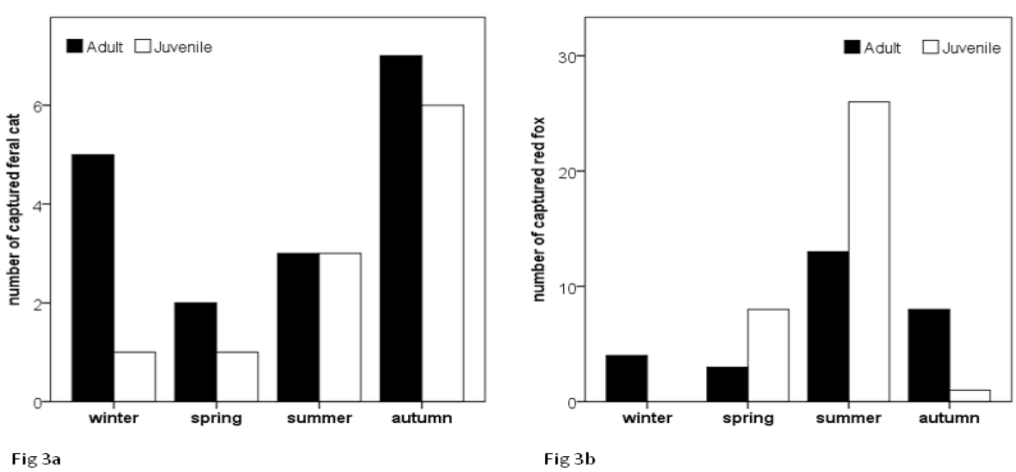

Fig. 3. Seasonal trappability of targeted species in a predator program in a reserve located in a meso-Mediterranean; a) feral cat captures b) red fox captures.

The non-target species most frequently trapped were the Iberian lynx followed by the beech marten (*Martes foina*, Erxleben 1777), wildcat (*Felis silvestris* Schreber, 1777) and the northern goshawk (*Accipiter gentilis* L.) (11, 6, 2 and 2, respectively). A single specimen of the common genet (*Genetta genetta* L.), Egyptian mongoose (*Herpestes ichneumon* L.) and European badger (*Meles meles* L.) were also captured. With a view to avoiding undue stress arising from manipulation, all non-target species were immediately released once visual veterinary inspection indicated no external lesions or symptoms of distress. There is therefore very little data on these animals.

Trap-related injuries

Only six external trap-related injuries (listed in table 5) were detected throughout the study. We also observed other external injuries such as a superficial chest wound and wounds to the left axilla, bilateral periocular alopecia, facial lacerations and an ulcer in the inner lip area, all occurring before the animals were trapped. This low number indicates that capture devices had a low impact on animal welfare. In other words, a very high percentage of animals were not damaged by traps, well over the standard 80 % required by internationally agreed indicators (European Union–Canada–Russian Federation 1998, United States of America–European Community 1998) (Figure 4).

Table 5. Relation of damages observed in the necropsies related to cage-traps during a predator control program.

	Wild cat	Red fox	Total
broken canine	1	2	3
broken fang	1	1	2
broken incisor	1		1

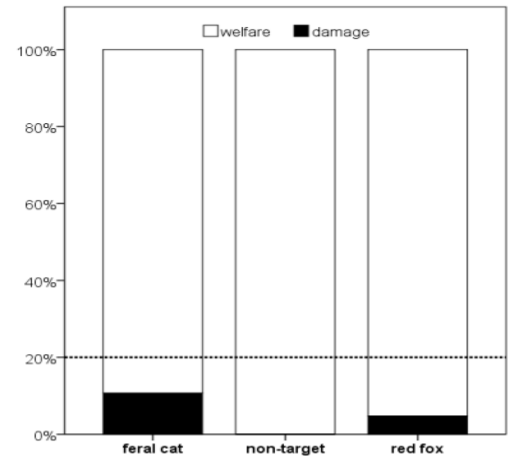

Fig. 4. Percentage of trap related injuries in a predator program in a reserve located in a meso-Mediterranean. The line indicates the threshold of homologation to comply with indicators of welfare (European Union–Canada–Russian Federation 1998, United States of America–European Community 1998).

DISCUSSION

A number of questions needs to be posed when applying a delicate management system such as a predator control program: Is it effective? Is it financially profitable? Does it entail risks to fauna? What is its effectiveness when compared to other actions? Does it really reduce the number of predators? Do territories become recolonized after extractions cease? And Where, when, how and for how long must it be carried out? While these questions are not easy to answer, there are numerous scientific works in this regard (Herranz *et al.*, 2000; Duarte and Vargas, 2001; Leopold and Chamberland, 2002; Loveridge *et al.*, 2006; Bolton *et al.*, 2007; Reynolds *et al.*, 2010; Smith *et al.*, 2010, 2011; Brook *et al.*, 2012; Delibes-Mateos *et al.*, 2013; Díaz-Ruiz and Ferreras, 2013; Barrull *et al.*, 2014; Eason *et al.*, 2014; Allen, 2015; Kirkwood *et al.*, 2014; Vucetich and Nelson, 2014; Underwood *et al.*, 2014; Norbury and Jones, 2015) Although this study lasted only 18 months, we had the human and material resources needed to assess the situation and were therefore able to provide current data that shed light on some of these questions.

Predation naturally helps regulate prey populations (Murdoch and Oaten, 1975) but is also considered the most important cause of mortality for many endangered species (Stringham and Robinson, 2015) and should therefore be controlled using different methods. Our results appear to indicate that it is possible to develop and assess a rational predator management system on hunting reserves with the least possible impact on target and non-target animal species. Predator control considerably increases the likelihood of survival of prey populations. However, it does not necessarily reduce predator populations nor does it prevent recolonization or, if it does, this reduction is normally temporary (Smith *et al*. 2010). In fact, if aggressive predator control programs lead to predator extinction, natural mechanisms such as increased reproduction rates (Underwood *et al*. 2014) or colonization by predators from neighbouring areas (Mosnier *et al*. 2008) are triggered which help such populations to recover. There are large wild rabbit and red partridge populations in the study area, enough to maintain a great number of predators (mainly red fox). Our results showed that regular trapping of red fox throughout the year, plus the fact that we trapped all age groups, especially juvenile individuals, what others authors have associated with inquisitiveness and/or naivety (Baker *et al*. 2001); this was more evident in summer. It appears to indicate that the red fox population is well established and that possible colonizers are coming from bordering areas. It is therefore safe to assume that the predator control program applied will not lead to its extinction at least in the short or medium term. The lower trapping of young feral cats is probably due to the fact that there is not a regular established wild population and kitten remain in human houses. When they growth to be adult and escape to explore the field they are easily trapped. Other studies have reached results similar to ours, i.e. no effective decrease in the fox population (Heydon and Reynolds, 2000; Baker and Harris, 2006), or an isolated decrease (Harding *et al*. 2001). The efficiency of large scale predator control has been successfully examined for other endangered species (Whitehead *et al*. 2008). We share the view of these and other authors (Barrull *et al*, 2014) that for plans to be effective and profitable, they must always be considered for the longest possible period of time and the largest possible area.

Our results show a low cage trapping rate, although trap rate of Targeted species was higher than NTS, what demonstrate the efficiency of traps used during study. The low trap rate TS of traps walk-in as we expected because they are located in areas with access limitation and no bait whilst traps with baits are allocated to trap those predators seeking actively a prey. We agree to other authors that reported that traps using live baits are more efficient (Muñoz-Igualada *et al*. 2008, Díaz-Ruiz *et al*. 2016).

Our low number of NTS captured, showed through negative efficiency, could be indicative of selectivity of traps (Muñoz-Igualada *et al*. 2008). According to the National authorities we used ISO selectivity index although we believe that other indexes considering relative species abundance could be better indicator as it has been reported before (Virgós *et al*. 2016). The different systems to estimate abundance of populations (Martella *et al*. 2012) are extremely reliable in areas as this because of the big size of area and low human intervention. Then, in our study global ISO index resulted also marked a higher capture proportion of target species. We observed a very small impact on animal welfare as has been previously reported (Shivik *et al*. 2005). The number of injuries was much lower compared to the use of restraint devices by Collarum or Belisle (Muñoz-Igualada *et al*. 2008, 2010). These authors warned about a possible negative impact on NTS related to the inappropriate use of cage traps and we agree with this assessment. However, if cage traps are used correctly, this disadvantage can become a strength as is the case here. Different predator species were regularly trapped during the study as the entrance to the traps was large enough to let them through. This reduced selectivity and, considered jointly with the low number of trap related injuries, could constitute one of the strengths of cage traps. Following this reasoning, it is important to note that when trappers went to the field to check the traps, they first observed captured animals from a distance to avoid being detected by them. In most cases they were calm inside the trap. Of course it is not natural for these animals to be held captive but this was a source of information that would be impossible to obtain otherwise.

Predator programs are usually assessed in terms of the number of predators eliminated and not the rise in prey populations (WWF 2015). Predator control has regularly been performed in the study area for quite some time resulting in a large European wild rabbit population. Under these circumstances, the very specialized and endangered Iberian lynx was able to survive and the population grew. In fact based on these results, considered jointly with other observations using trap cameras, it has been determined that approximately 10 % of the world's Iberian lynx population lives in the study area (Jara y Sedal, 2017). Throughout the study we saw them in the field on eleven occasions which is significant considering that this emblematic feline was not detected in a similar study conducted ten years earlier in the same area (Muñoz-Igualada *et al*. 2010).

The main objective of predator control is usually to improve prey populations but is has proved very interesting in preserving endangered species as well (Whitehead *et al*. 2008; Underwood *et al*. 2014) insofar as it provides a great deal of information about population dynamics, characteristics of the fauna and health indicators that are very difficult to obtain otherwise. In fact, predator control is actively recommended to preserve endangered species (Layman, 2014). It has provided us with very interesting secondary health information of both TS, red fox and feral cat (Checa *et al*. 2017; Montoya-Matute *et al*. 2017; Valcárcel *et al*. 2018) but only limited information about Iberian lynx because we did not handle this endangered species to obtain other parameters or diagnose possible diseases affecting them. We agree with the authors mentioned and others (Underwood *et al*. 2014; Norbury and Jones, 2015) that support the idea that predator control could be a key management strategy to promote the recovery of endangered species and implement disease monitoring programmes.

CONCLUSION

In conclusion, our results seem to indicate that it is possible to develop and assess a rational predator management system on hunting preserves leading to a reduction in predator populations with the least possible impact on target and non-target animal species. These results have also been very useful in providing valuable information about the safety of these traps and their impact on animal welfare. Moreover, they have also provided population and health information on the target species. It would be useful to continue these studies over longer periods in order to obtain new data, especially in cases of endangered species in which the use of anaesthetics or other authorized methods would be very useful in taking measurements and samples for the purpose of health analyses.

ACKNOWLEDGEMENTS

The authors are especially grateful to his Grace the Duke of Westminster for his support during all the studies.

FUNDING

This study was funded by Villamagna SA and the INIA (CON15-064).

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

ETHICAL APPROVAL

All procedures performed in studies involving animals were in accordance with the ethical standards of the institution or practice at which the studies were conducted.

REFERENCES

Allen, B.L., 2015. Top-predator Control-induced Trophic Cascades: An Alternative Hypothesis to the Conclusion of Colman *et al*. (2014). Proc. Biol. Sci., 282(1799): 20141251.

Baker, P.J., Harris, S., Robertson, C.P.J., Saunders, G., White, P.C.L., 2001. Differences in the capture rate of cage-trapped red foxes *Vulpes vulpes* and an evaluation of rabies control measures in Britain. J. App. Eco., 38: 823-835.

Baker, P.J., Harris, S., 2006. Does Culling Reduce Fox (*Vulpes vulpes*) Density in Commercial Forest in Wales, UK?. Eur. J. Wild Res., 52: 99-108. DOI: 10.1007/s10344-005-0018-y

Barrull, J., Mate, I., Salicrú, M., Palet, J., Casanovas, J.G., Gosàlbez, J., Ruiz-Olmo, J., 2104. Differential Response of a Carnivore Community to Predator Control: A Spatiotemporal Observational Study. Italian J. Zool., 81(2): 271-279. DOI: 10.1080/11250003.2014.893378

Bolton, M., Tyler, G., Smith, K., Bamford, R. 2007. The Impact of Predator Control on Lapwing *Vanellus vanellus* Breeding Success on Wet Grassland Nature Reserves. J. Appl. Ecol., 44(3): 534-544. DOI: 10.1111/j.1365-2664.2007.01288.x

Brook, L., Johnson, C.N., Ritchie, E.G., 2012. Effects of Predator Control on Behaviour of an Apex Predator and Indirect Consequences for Mesopredator Suppression. J. Appl. Ecol., 49: 1278-1286. DOI: 10.1111/j.1365-2664.2012.02207.x

Checa, R., González, J., Valcárcel, F., González, F., Sánchez, M., González, M., Montoya, A., Gálvez, R., Marino, V., Miró, G., 2017. Estudio preliminar sobre las parasitosis intestinales y pulmonares de la fauna silvestre procedente de la región central de la Península Ibérica. Proceedings of the XX Congreso de la Sociedad Española de Parasitología, La Laguna (Tenerife, Spain). Page 233

Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora: http://data.europa.eu/eli/dir/1992/43/oj

Delibes-Mateos, M., Redpath, S.M., Angulo, E., Ferreras, P., Villafuerte, R., 2007. Rabbits as a Keystone Species in Southern Europe. Biol. Conserv., 137: 149-156. DOI: 10.1016/j.biocon.2007.01.024

Delibes-Mateos, M., Díaz-Fernández, S., Ferreras, P., Viñuela, J., Arroyo, B., 2013. The Role of Economic and Social Factors Driving Predator Control in Small-Game Estates in Central Spain. Ecol. Soc., 18(2): 28. DOI: 10.5751/ES-05367-180228

Díaz-Ruiz, F., Ferreras, P., 2013. Conocimiento científico sobre la gestión de depredadores generalistas en España: el caso del zorro (*Vulpes vulpes*) y la urraca (*Pica pica*). Ecosistemas, 22(2): 40-47. Doi.: 10.7818/ECOS.2013.22-2.07

Díaz-Ruiz, F., Delibes-Mateos, M., Ferreras, P., 2016. Can Cage-Trap Performance in Capturing Red Foxes Be Improved by Using Different Baits and Scent Attractants? Ann. Zool. Fennici., 53: 91-102.

Directive 2009/147/EC of 30 November 2009 on the conservation of wild birds: http://data.europa.eu/eli/dir/2009/147/oj

Duarte, J., Vargas, J.M., 2001. Mamíferos predadores de nidos de perdiz roja (*Alectoris rufa* Linnaeus, 1758) en olivares del sur de España. Galemys 13 (especial issue): pages 47-58.

Eason, C.T., Miller, A., MacMorran, D.B., Murphy, E.A., 2014. Toxicology and Ecotoxicology of Para-aminopropiophenone (PAPP) – A New Predator Control Tool for Stoats and Feral Cats in New Zealand. N. Z. J. Ecol., 38(2): 177-188.

Harding, E.K., Doak, D.F., Albertson, J.D., 2001. Evaluating the Effectiveness of Predator Control: the Non-native Red Fox as a Case Study. Conserv. Biol., 15(4): 1114-1122

Herranz, J., Yanes, M., Suárez, F., 2000. Relationships between the abundance of small game species, their predators and the habitat structure in Castilla-La Mancha (Spain). Ecol., 14: 219-233

Heydon, M.J., Reynolds, J.C., 2000. Demography of Rural Foxes (*Vulpes vulpes*) in Relation to Cull Intensity in Three Contrasting Regions of Britain. J. Zool., 251: 265-276. DOI: 10.1111/j.1469-7998.2000.tb00609.x

Jara y Sedal, editor, 2017. Un coto privado de caza alberga la mayor población de lince de España: https://revistajaraysedal.es/coto-caza-lince/. Accessed 10 November 2017

Kirkwood, R., Sutherland, D.R., Murphy, S., Dann, P., 2014. Lessons from Long-term Predator Control: A Case Study with the Red Fox. Wild Res., 41: 222-232. DOI: 10.1071/WR13196

Layman report, 2014. "Conservación de especies prioritarias del monte mediterráneo en Castilla-La Mancha" Informe final divulgativo. LIFE+ 07NAT/E/000742 Priorimancha.

Leopold, B.D., Chamberland, M., 2002. Predator Control: Here We Go Again. Proceedings of the Annual Conference of the Southeast Association of Fish and Wildlife Agencies 56: 239–254.

Loveridge, A., Reynolds, J.C., Milner-Gulland, E.J., 2006. Does Sport Hunting Benefit Conservation? Macdonald/Key Topics in Conservation Biology 1405122498_4_015: pages 224-240.

Ley 42/2007, 2007. Ley del Patrimonio Natural y de la Biodiversidad https://www.boe.es/buscar/pdf/2007/BOE-A-2007-21490-consolidado.pdf

Martella, M.B., Trumper, E., Bellis, L.M., Renison, D., Giordano, T.S., Bazzano, G., Gleiser, R.M., 2012. Manual de Ecología. Poblaciones: Introducción a las técnicas para el estudio de las poblaciones silvestres. Reduca (Biología). Serie Ecología, 5 (1): 1-31.

Montoya-Matute, A., Checa, R., Rodríguez, E., López, A.M., Carmena, D., Fidalgo, L., González, J., Valcárcel, F., González, M., Gálvez, R., Marino, V., Fuentes, I., Miró, G., 2017. Caracterización molecular de aislados de *Giardia duodenalis* y *Cryptosporidium* spp. procedentes de heces del zorro rojo (*Vulpes vulpes*) en la Península Ibérica. Proceedings of the XX Congreso de la Sociedad Española de Parasitología, La Laguna (Tenerife, Spain). Page 225

Mosnier, A., Boisjoly, D., Cortois, R., Ouellet, J.P., 2008. Extensive Predator Space Use Can Limit the Efficacy of a Control Program. J. Wild. Manag., 72: 483-491

Muñoz-Igualada, J., Shivik, J.A., Domínguez, F.G., González, L.M., Aranda Moreno A., Fernández Olalla, M., Alves García, C., 2010. Evaluation of Cage-Traps and Cable Restraint Devices to Capture Red Foxes in Spain. J. Wild. Manag., 72(3): 830–836. DOI: 10.2193/2007-198

Muñoz-Igualada, J., Shivik, J.A., Domínguez, F.G., Lara, J., González, L.M., 2008. Traditional and New Cable Restraint Systems to Capture Fox in Central Spain. J. Wild. Manag., 74(1): 181-187. DOI: 10.2193/2008-603

Murdoch, W.W., Oaten, A., 1975. Predation and Population Stability. Adv. Ecolog. Res., 9: 1-131. DOI: 10.1016/S0065-2504(08)60288-3

Norbury, G., Jones, C., 2015. Pest Controlling Pests: Does Predator Control Lead to Greater European Rabbit Abundance in Australasia? Mam. Rev., 45(2): 1-9. DOI: 10.1111/mam.12034

Público, 2014. Biodiversidad en España: http://www.vidasostenible.org/informes/biodiversidad-en-espana/. Accessed 21 November 2017.

Reynolds, J., Stoate, C., Brockless, M.H., Aebischer, N.J., Tapper, S.C., 2010. The Consequences of Predator Control for Brown Hares (*Lepus europaeus*) on UK Farmland. Eur. J. Wild. Res., 56(4): 541-549.

Shivik, J.A., Martin, D.J., Pipas, M.J., Turnan, J., De Liberto, T.J., 2005. Initial comparison: jaws, cables and cage-traps to capture coyotes. Wild. Soc. Bull., 33: 1375–1383.

Smith, R.K., Pullin, A.S., Stewart, G.B., Sutherland, W.J., 2010. Effectiveness of Predator Removal for Enhancing Bird Populations. Conserv. Biol., 24(3): 820-829. DOI: 10.1111/j.1523-1739.2009.01421.x

Smith, R.K., Pullin, A.S., Stewart, G.B., Sutherland, W.J., 2011. Is Nest Predator Exclusion an Effective Strategy for Enhancing Bird Populations? Biolog. Conserv., 144(1): 1-10. DOI: 10.1016/j.biocon.2010.05.008

Stringham, O.C., Robinson, O.J., 2015. A Modelling Methodology to Evaluate the Efficacy of Predator Exclosures versus Predator Control. Anim. Conserv., 18(5): 451-460. DOI: 10.1111/acv.12197

Underwood, J.G., Sibernagle, M., Nishimoto, M., Uyehara, K.J., 2014. Non-native Mammalian Predator Control to Benefit Endangered Hawaiian Waterbirds. Proceedings from the 99th Ecological Society of America Annual Meeting, August 10-15. Page 24.

Valcárcel, F., González, J., Aguilar, A., Sánchez, M., González, M.G., Suárez, R., Tercero, A.M., Tercero, J.M., Nieto, J.M., González-Guirado, A.M., Olmeda, A.S., 2018. Spirocercosis in red fox (*Vulpes vulpes*) in a natural reserve located in a meso-Mediterranean area. Vet. Parasitol. Reg. Stu. Rep., 115-119. doi: 10.1016/j.vprsr.2018.05.002..

Virgós, E., Lozano, J., Cabezas-Díaz, S., Macdonald, D.W., Zalewski, A., Atienza, J.C., Proulx, G., Ripple, W.J., Rosalino, L.M., Santos-Reis, M., Johnson, C.J., Malo, A.F., Baker, S.E., 2016. A poor international standard for trap selectivity threatens carnivore conservation. Biodivers. Conserv., 25: 1409-1419.

Vucetich, J., Nelson, M.P., 2014. Wolf Hunting and the Ethics of Predator Control. Oxford Handbooks Online. DOI:

10.1093/oxfordhb/9780199927142.013.007.

Whitehead, A., Edge, K.A., Smart, A.F., Hill, G.S., Williams, M.J., 2008. Large Scale Predator Control Improves the Productivity of a Rare New Zealand Riverine Duck. Biol. Conserv., 141: 2784-2794. DOI: 10.1016/j.biocon.2008.08.013

WWF Spain report, 2015. El Control de predadores: consideraciones y peticiones: http://www.wwf.es/que_hacemos/especies/nuestras_soluciones/-acciones_sobre_el_terreno/proyecto_lince_iberico/. Accessed 21 November 2017