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Short note

Survival of injured Iberian lynx (*Lynx pardinus*) and non-natural mortality in central-southern Spain

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Dedicated to the memory of Luis de la Cuesta

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Abstract

Captures and observations of handicapped carnivores living in the wild have been occasionally reported, but no information has been found in the scientific literature about survival or reproductive success of such individuals. In this study, a sample of 44 Iberian lynx (*Lynx pardinus*), collected from central-southern Spain between 1960 and 1983, has been analyzed. Evidence is presented of several lynx that had recovered in the wild from serious physical injuries, and causes of non-natural mortality are described. Results indicate that some lynx were even able to produce offspring, despite suffering physical limitations such as an amputated limb. Results suggest that, as in Doñana National Park, trapping (for predator control and capture of rabbits) was the main cause of non-natural mortality in central-southern Spain for the period considered.

Keywords: Injured lynx; Survival; Mortality; *Lynx pardinus*; Carnivores; Central-southern Spain

1. Introduction

Since 1975, a number of scientific studies and research projects (CSIC, 1970–1999) have been conducted in Spain to learn about the biology of, ecological interactions, and threats to Iberian lynx (*Lynx pardinus*) in Doñana National Park. Simultaneously, several conservation actions and laws have been developed, e.g. LIFE project, various NGO programmes, regional-level laws, etc. Despite these efforts, the decline of the species has continued, and in the Cat Action Plan elaborated by IUCN (Nowell and Jackson, 1996), the Iberian lynx is placed at the top of the list of naturally vulnerable felids.

In February 1998, a meeting organized by the IUCN Conservation Breeding Specialist Group and the Spanish Ministry of Environment was held in Spain, aimed at assessing the status of the species and to set up guidelines for a common Spanish–Portuguese strategy for its conservation. Among other important issues considered at that meeting, it was realised that our knowledge about populations living in areas other than Doñana National Park is extremely poor, and that research about them should be undertaken.

In Spain, injured lynx and other carnivores are usually sent to recovery centres where they receive veterinary care. When animals show permanent physical handicaps such as lost limbs, they are kept in captivity on the assumption that they may be unable to survive in the wild. However, this is a difficult decision that conservation technicians have to face, since no references about survival of such individuals based on scientific data are available (Biosis, 1970–1996), although sightings and records of handicapped carnivores are relatively frequent among non-scientific literature (e.g. Internet discussion lists).

The questions raised here are: can injured lynx survive in the wild or not?, does survival depend on age?, is breeding ability affected by permanent physical handicaps?, what are the causes of non-natural mortality in the sample? I present some evidence of survival and reproduction of Iberian lynx suffering serious physical handicaps, or showing traces of old injuries. The sample studied comes from "Montes de Toledo" and "Sierra Morena" (central–southern Spain), two poorly known populations, despite the fact that they contain the highest number of individuals of the species.

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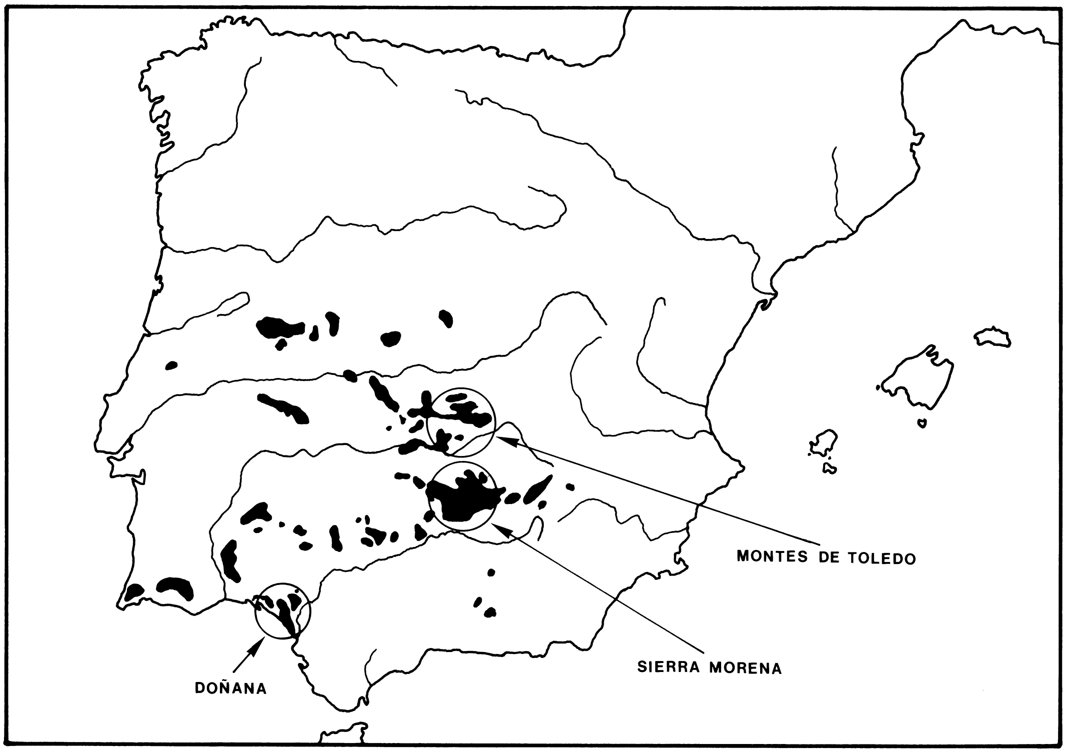

Fig. 1. Black areas represent the main breeding ranges of Iberian lynx, after Rodriguez and Delibes (1992). Circles in "Montes de Toledo" and "Sierra Morena" delimit two areas which include the localities where specimens studied were collected.

2. Material and methods

The sample consisted of 44 animals coming from montane areas of central-southern Spain (Fig. 1), kept in the UZA collection (Museo Nacional de Ciencias Naturales, Madrid, Spain). Iberian lynx, like other carnivores, were considered pest and game species for decades, before they were protected by Spanish laws in 1973. Specimens dating from before 1973 were mainly carcasses donated by taxidermists, while specimens collected after that date were either confiscated by wildlife officers or found dead. The time period covered by specimens studied ranges from 1960 to 1983.

All skins, skulls and skeletons were examined for signs of recovery from important physical injuries, such as bone scars, stumps or lost toes. Footsnares and coil-spring traps do not usually cause direct amputation, but the animal may eat its own limb trying to get free from the artifact (e.g. one of the specimens from my sample had remains of its own leg in the stomach). Toes can be lost by necrosis after being seized in a trap, due to long period of obstruction of blood circulation. In central Spain, another factor is involved: overnight exposure to low temperatures (frosts are common in central Spain in winter and early spring), resulting in freezing of toes (also reported for *Lynx canadensis* by G. Mowat, pers. comm.)

In order to assess whether survival depends or not on age, specimens were aged after the following criteria. Age of skulls was estimated from canine sections by counting annual cementum lines (Zapata et al., 1997), or other cranial criteria (García-Perea, 1996). Skeletons without skulls were considered as juveniles (<1 year) when all epiphyses were separated from diaphyses, subadults (<2 years) when epiphyses and diaphyses were partially fused, and adults (>2 years) when epiphyses and diaphyses were completely fused (García-Perea, 1991). As used here, "adult" is a term related to postnatal growth, not to reproductive ability. Differences in the proportions of young and adult specimens found when comparing the whole sample versus the sample of lynx with old injuries were analyzed by applying the chi-square test (Sokal and Rohlf, 1981). Data on mammae condition or pregnancy of females and stomach contents of specimens were gathered when possible, looking for signs of reproduction or ability to hunt wild prey.

Age analysis by canine sections allowed estimation of absolute age of 41 specimens. This sample showed that young lynx (juveniles + subadults) constituted the most important part of the sample (68%, $n=27$). Animals ranged from <1 to 12 years old, with the following structure: <1 ($n=14$), <2 ($n=13$), 3 ($n=4$), 4 ($n=4$), 5 ($n=1$), 6 ($n=0$), 7 ($n=1$), 8 ($n=0$), 9 ($n=1$), 10 ($n=1$), 11 ($n=1$), 12 ($n=1$).

When the cause of death was unknown, a combination of abnormally worn teeth, broken legs and skull traumatism was considered an unequivocal sign of death in a trap, because animals bit the traps, traps broke the legs, and trappers often killed the animals by hitting their heads (García-Perea and Gisbert, 1986).

3. Results

3.1. Lynx with old injuries

Nine specimens (22.5% of the total sample) showed evidence of old injuries that had healed. Except for two individuals showing skull traumatism, the remainder showed different degrees of limb injuries, ranging from abnormal bone ossification to stumps (Fig. 2).

Table 1 summarises data on age, sex, and estimated causes of death of these specimens.

Specimen no. 3, a female with a lost forepaw, had well developed mammae, with naked surrounding areas, evidence that she was rearing kittens. Stomach contents of specimen no. 4 had remains of the usual wild prey, namely rabbit (*Oryctolagus cuniculus*) and partridge (*Alectoris rufa*) (Delibes, 1980), suggesting that, despite

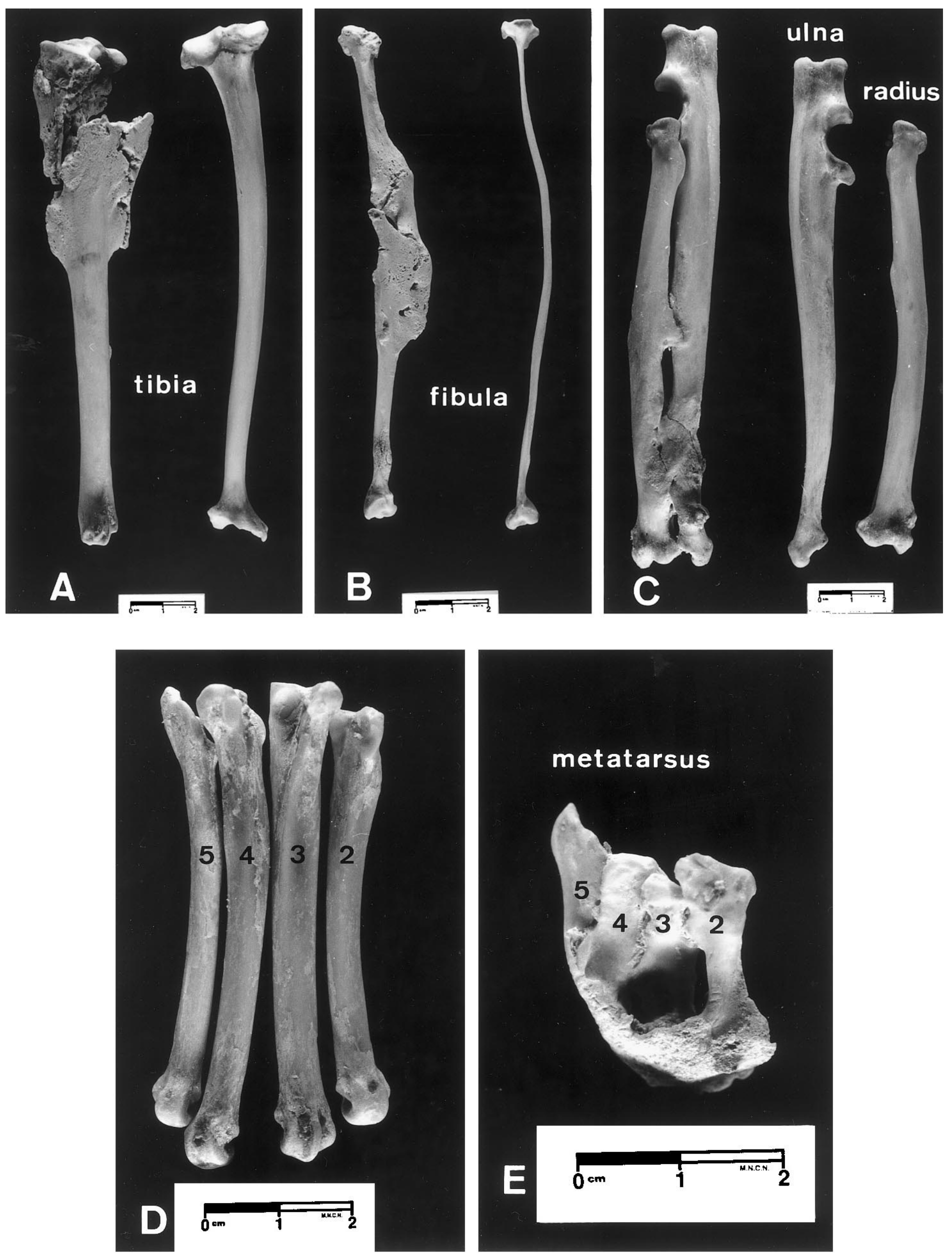

Fig. 2. Examples of bones showing old injuries healed caused by coil-spring traps. A. Left and right tibiae of a lynx from "Montes de Toledo" (specimen no. 9, Table 1). B. Left and right fibulae of the same specimen; left tibia and fibula show exostosis developed after healing of the broken bones. C= Ulna and radius of a lynx from "Sierra Morena" (specimen no. 7, Table 1) showing abnormal bone ossification (left), compared to normal ulna and radius (right). D. Normal metatarsus of a lynx from "Sierra Morena". E. Sectioned, abnormally ossified metatarsus found in the stump of specimen no. 9 (Table 1). 2, 3, 4, 5. 2nd, 3rd, 4th and 5th metatarsal bones.

Table 1
Specimens with evidence of old injuries healed[a]

Specimen	Old injury healed	Age	Sex	Cause of death
1	Skull traumatism	2	?	Roadkill
2	Skull traumatism	9	?	Shot
3[b]	Forelimb stump	10	F	Trap
4[c]	Forelimb stump	< 2	F	Trap
5	Hindlimb stump	> 2	M	Unknown
6[c]	Limb bones with scars	> 2	F	Illness
7	Limb bones with scars	5	?	Trap
8	Limb bones with scars	3	F	Rabbit snare
9	Hindlimb stump	< 2	?	Unknown

[a] Age has been estimated in years when possible. Sex is expressed as M (male), F (female) and ? (unknown).
[b] Evidence of rearing kittens.
[c] Remains of wild prey in the stomach.

lacking a forepaw, it was able to hunt. The stomach contents of specimen no. 6 also had the remains of wild prey (lagomorph; hoopoe, *Upupa epops*; blue tit, *Parus caeruleus*), suggesting that it was fit enough to hunt. This suggests that its emaciated condition was not due to starvation but probably to some illness, although I could not determine if this was a result of the injury.

3.2. Causes of mortality

Forty-one specimens showed identifiable causes of death, which were classified in four categories: trap or snare, shot, roadkill, and illness. The three remaining individuals died of unknown causes (Table 2). Overall, traps and snares were the most important cause of non-natural mortality in my sample (64%), followed by shooting (23%).

4. Discussion

Until 1973, carnivores were legally trapped or shot in Spain, since they were considered pest and game species, with the largest individual wolves (*Canis lupus*), bears (*Ursus arctos*) and lynx registered as game trophies. This is probably why the age structure of the sample studied is similar to those observed for other species of lynx (e.g. bobcat *Lynx rufus*) captured by trap and hunting. Samples of bobcats legally harvested in the USA in the 1970s usually contained a high proportion of young specimens (e.g. 75% after Frederickson and Rice, 1979; 62% after Johnson, 1979). My sample size was not large enough to test whether the age structure before and after 1973 was similar or not, but results suggest that lynx from central-southern Spain were "harvested" even after legal protection. The age structure of my sample reflects a mortality that fits the trends described for some harvested bobcat populations (Bailey, 1979), predicting high mortality among dispersing individuals (usually 1–2 years old), and low mortality among adults 5–7 years old that have established territories and good hunting skills. These data are also consistent with those presented by Ferreras et al. (1992) for lynx in Doñana National Park.

Main causes of non-natural mortality in my sample, traps/snares and shooting, are consistent with those identified by Rodriguez and Delibes (1990) for this population of lynx between 1978 and 1988. Carnivores trapped were caught either in snares set to catch rabbits, or coil-spring traps used for carnivores. Table 2 shows that death from traps and snares in my sample increased after 1973, whilst the number of animals shot decreased remarkably after 1973. These data are consistent with deaths observed in Doñana National Park over the

Table 2
Causes of non-natural mortality in Iberian lynx from central-southern Spain for the periods 1960–1973 and 1974–1983[a]

Causes of death	No. specimens 1960–1973	1974–1983	Total	Age range (years)
Trap or snare	9	19	28	< 1–11
Shot	9	1	10	< 1–12
Roadkill	0	2	2	< 2
Illness	0	1	1	> 2
Unknown causes	1	2	3	< 2–10
Total	19	25	44	

[a] For "Unknown causes", only complete specimens have been considered.

period 1983–1989, where illegal trapping was the main cause of mortality, and shooting was not identified among causes of death (Ferreras et al., 1992). My data likewise suggest that poachers shifted from shooting to trapping after 1973, and that legal protection alone was not effective in preventing the killing of Iberian lynx in central-southern Spain.

Results shown in Table 1 indicate that animals suffering important physical injuries may be able to survive, hunt wild prey, and even produce offspring. They may, indeed, represent a substantial part of a population (22% of my sample) under certain circumstances.

Of the nine specimens with old injuries, seven were adults. Since adults only formed 32% of the whole sample, this bias was statistically significant ($p < 0.05$, $\chi^2 = 3.013$, d.f. = 1). It is possible that some adults could have been injured and healed while subadults, but adults have better hunting skills, are stronger, have no special feeding requirements for growth, and do not face so many risks as dispersing animals do, so my results suggest that adults have a better chance of recovery than juveniles.

Rodriguez et al. (1995) describe the careful process of recovery and training of a juvenile Iberian lynx injured by a car, including several months of resting, recovery of muscle mobility, and training on hunting skills before release. However, in the wild, successful recovery of non-adult individuals would require specially favourable conditions (perhaps maternal support).

Reproduction of female no. 3 (Table 1) deserves reflection, because she was not only handicapped (lack of a forepaw), but she was also an old female (10 years). In contrast, all attempts to breed handicapped Iberian lynx kept in captivity in a recovery centre in southern Spain have been unsuccessful (Heredia et al., 1998). This raises the question of whether it is better to keep such animals in captivity or release them after an adequate recovery.

In general, the conditions described in this article also apply to other carnivores in central-southern Spain, e.g. red fox (*Vulpes vulpes*), and European wildcat (*Felis silvestris*), since they are affected by the same factors. The recovery and analysis of carcasses of endangered carnivores found dead should be established as a common practice by wildlife managers, in order to learn about factors affecting their survival.

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References

Bailey, T.N., 1979. Den ecology, population parameters and diet of Eastern Idaho bobcats. National Wildlife Federation, Scientific and Technical Series 6, 62–69.

BIOSIS, 1970–1996. Zoological Record (Mammalia), Vols. 107–132. The Zoological Society of London.

CSIC, 1970–1999. Memorias del Consejo Superior de Investigaciones Científicas. Madrid.

Delibes, M., 1980. Feeding ecology of the Spanish Lynx in the Coto Doñana (Huelva, Spain). Acta Theriologica 25 (24), 309–324.

Ferreras, P., Aldama, J.J., Beltrán, J.F., Delibes, M., 1992. Rates and causes of mortality in a fragmented population of Iberian lynx *Felis pardina* Temminck, 1824. Biological Conservation 61, 197–202.

Frederickson, L.F., Rice, L.A., 1979. Bobcat management survey study in South Dakota, 1977–79. National Wildlife Federation, Scientific and Technical Series 6, 23–26.

García-Perea, R., 1996. Patterns of postnatal development in skulls of lynxes, genus *Lynx* (Mammalia, Carnivora). Journal of Morphology 229(3), 241–254.

García-Perea, R., 1991. Variabilidad morfológica del género *Lynx* Kerr, 1792 (Carnivora: Felidae). Ph.D. thesis, University Complutense, Madrid.

García-Perea, R., Gisbert, J., 1986. Causas de mortalidad del lince ibérico en los Montes de Toledo y Sierra Morena. Actas de las Jornadas sobre la Conservación de la Naturaleza en España, pp. 183–185.

Heredia, B., Gaona, P., Vargas, A., Ellis, S., Seal, U. (Eds.), 1998. Taller Análisis de la Viabilidad de Población y del Hábitat para el Lince Ibérico (*Lynx pardinus*). Unpublished report draft.

Johnson, N.F., 1979. Efforts to understand Kansas' bobcat populations. National Wildlife Federation, Scientific and Technical Series 6, 37–39.

Nowell, K., Jackson, P.(Eds.), 1996. Wild Cats. Status Survey and conservation action plan. IUCN, Gland.

Rodriguez, A., Delibes, M., 1990. El lince ibérico (*Lynx pardina*) en España. Distribución y problemas de conservación. Colección Técnica, ICONA.

Rodriguez, A., Delibes, M., 1992. Current range and status of the Iberian lynx *Felis pardina*, Temminck, 1824 in Spain. Biological Conservation 61, 189–196.

Rodriguez, A., Barrios, L., Delibes, M., 1995. Experimental release of an Iberian lynx (*Lynx pardinus*). Biodiversity and Conservation 4, 382–394.

Sokal, R.R., Rohlf, F.J., 1981. Biometry. The Principles and Practice of Statistics in Biological Research, 2nd Edition. Freeman and Co, New York.

Zapata, S., García-Perea, R., Beltrán, J.F., Ferreras, P., Delibes, M., 1997. Age determination of Iberian lynx (*Lynx pardinus*) by canine radiographs and count of teeth cementum annuli. Zeitschrift für Säugetierkunde 62 (2), 119–123.