Short Communication

Causes and patterns of human-induced mortality in the Critically Endangered European mink *Mustela lutreola* in Spain

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Abstract Human intervention is the main cause of the decline of the Critically Endangered European mink *Mustela lutreola*. In this study we analysed the main causes of direct human-caused mortality of the species in Spain. A total of 47 mortality records were obtained for the period 1950–1989, and 145 for 1990–2008. There was temporal variation in the cause of death, with trapping and shooting being the most common causes of mortality in 1950–1989 and road-kills in 1990–2008. In the case of road-kills there was variation related to road type. Males were more affected by road-kills than females, especially during the mating season when they range more widely. Our results indicate that there has been a change in human social behaviour and in people's awareness of the species, with a reduction in European mink captured and shot but an increase in mortality on roads.

Keywords European mink, human-caused mortality, *Mustela lutreola*, road-kill, Spain

The European mink *Mustela lutreola* is categorized as Critically Endangered on the IUCN Red List and is one of the most threatened mustelids (Maran et al., 2011). Only three isolated wild populations remain, in western, north-eastern and south-eastern Europe (Michaux et al., 2005). Direct human intervention (i.e. commercial exploitation, non-selective control, hunting and road-kills) is considered to be the main cause of the species' decline (Maran & Henttonen, 1995; Fournier-Chambrillon et al., 2006; Zabala et al., 2006; Maran, 2007). In this study we examined the main causes of direct human-caused mortality of the European mink in Spain.

The study covered the entire Spanish area of the European mink range (Fig. 1). We obtained data for 1950–1989 from scientific reports and publications, which were carefully filtered to avoid duplicates. Data for 1990–2008 were obtained from field surveys by local rangers and a network of volunteers. We obtained 71 records for 1950–1989, of which 47 (mean per year = 1.17 ± SE 0.56) were of direct human-induced mortality, and 225 records for 1990–2008, of which 145 (mean per year = 7.25 ± SE 1.20) were of direct human-induced mortality. For each we noted, wherever possible, the UTM coordinates, date, sex and cause of death. We analysed the causes of mortality in the two periods separately. Because of the nature of the data and its variable reliability we only used the data for 1990–2008 to test variations in mortality related to sex, season, stream order of rivers and road type (if mortality was a road-kill). Further information on causes of mortality for 1950–1989 is available in Palazón et al. (2003).

Date of death was categorized into three seasons: mating (March–April), dispersal (late September–November) and resting (based on Mead, 1989, and Palazón, 2003). Causes of death were categorized as trap capture, shooting, road-kill and other (mink killed by dogs or people, drowned, or killed by the American mink *Neovison vison*). To check whether the records were related to stream order we categorized rivers as order 1 (river Ebro), 2 (river Ega), 4 (Zadorra–Ayuda river system) and 5. When the cause was a road-kill the type of road was categorized by traffic volume and speed limit as R1 (dual carriageway and primary national road), R2 (secondary regional road), R3 (tertiary local road) and R4 (unpaved road).

Traps and shooting were the most common causes of mortality in 1950–1989 (traps = 30, shooting = 9, road-kills = 7, others = 1) but this changed to road-kills in 1990–2008 (G-test = 9.75, $P < 0.05$, and G-test = 78.15, $P < 0.001$, respectively; traps = 7, shooting = 1, road-kills = 132, others = 5; Fig. 1). There was a significantly higher frequency of road-kills during the mating season ($G = 23.58$, $P < 0.001$; Fig. 2) but no significant differences in other causes (all $P > 0.05$), although there was a high percentage of road-kills in August (Fig. 2). Of the various causes of

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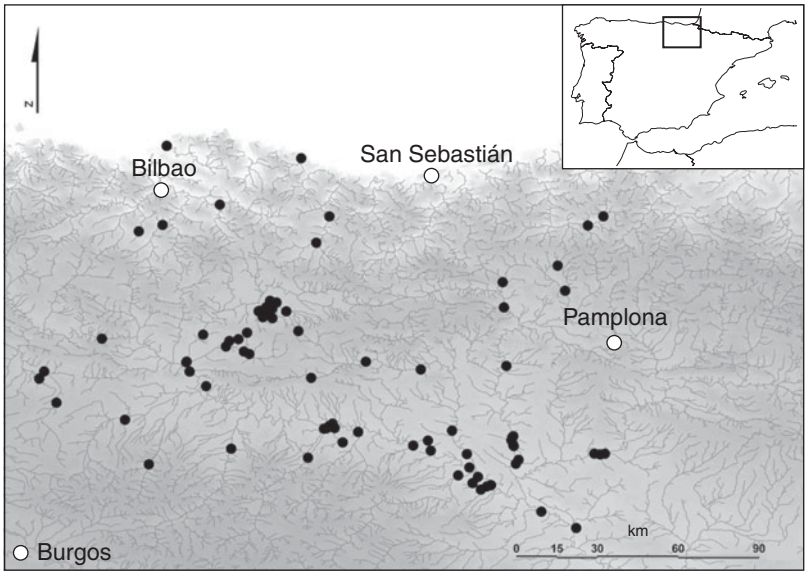

FIG. 1 The locations of European mink *Mustela lutreola* killed on roads in Spain during 1990–2008 (black dots) and the riparian network (grey lines). The rectangle on the inset indicates the location of the main map in northern Spain.

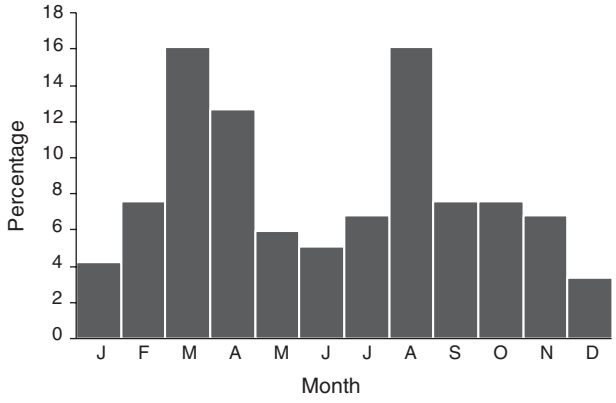

FIG. 2 Monthly distribution of road-kills of the European mink in Spain during 1990–2008 expressed as a percentage of the total number of road-kills.

mortality only road-kills were significantly different between sexes, with more males killed than females overall ($\chi^2 = 12.48$, $P < 0.001$) and during the mating season ($\chi^2 = 4.22$, $P < 0.05$) but not during other seasons (all $P > 0.05$). There were no variations with stream order for any of the causes of mortality.

For roads the frequency of road-kills overall was in the order R1 > R2 > R3 > R4 ($G = 59.97$, $P < 0.001$). There were also differences in frequencies related to road type over time. Mortality was higher on R2 followed by R1 roads during the 1990s ($G = 23.98$, $P < 0.001$) but from 2000 onwards mortality was more frequent on R1 roads, followed by R2 ($G = 38.83$, $P < 0.001$).

The temporal variation in causes of death concords with studies in France, where the main cause of mortality has changed from traps to road-kills within the last 20 years (de Bellefroid & Rosoux, 2005). In France, however, the frequency of road-kills is lower than in Spain (Lodé et al., 2001; Fournier-Chambrillon et al., 2006). Several factors may be interacting with temporal variations. Causes of mortality have changed substantially between 1950 and 2008, suggesting a change in human social behaviour and people's awareness of the species. This change has led to a reduction in the number of European mink killed by trap captures and shooting to just a few illegal incidents. There has, however, been an increase in mortality of the European mink on roads.

Overall, road traffic is now the main cause of direct human-caused mortality of the European mink. The species' semi-aquatic habits and the linear nature of its home range increase the likelihood of mortality wherever there is an intersection between a river (and hence the mink's home range) and roads. In such situations mink, like other semi-aquatic species (Madsen, 1996), are forced to cross roads during foraging, patrolling their range or dispersal. In many of the riparian systems inhabited by European mink in Spain there are mortality black spots, such as bridges and roads, that run closely parallel to or cross a river. For example, 12 European mink were found dead at the intersection between the National-104 road and the Ayuda–Salburua river system, and eight European mink and several otters *Lutra lutra* were found killed at the intersection between the National-124 road and the Ayuda river. European mink in Spain appear to be spreading eastwards and south-eastwards (Gómez et al., 2011) and this could be influencing the frequency of road-kills.

Differences in causes of mortality between genders can be explained by mink behaviour. Males travel more frequently and over greater distances than females while foraging and patrolling (Palazón, 1998; Palazón & Ruiz-Olmo, 1998; Garin et al., 2002) and hence they are more likely to be killed on roads. In addition, once they have established their home ranges, females never leave them,

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and while pregnant or with cubs their activity is reduced to short foraging trips (Palazón, 1998). In contrast, males abandon their home ranges during the mating season in search of females. This explains the peak in road-kills during this season and the higher proportion of males killed during this period. This finding may also be affected by seasonal changes in traffic volume, with a high percentage of road-kills in August, which, being the holiday season, is generally the month with the highest volume of traffic.

Our findings are of concern because the population of the European mink in Spain seems to be disappearing from its northern range and dispersing to the south-east. Further research is required on the effects of different types of intersection between rivers and roads (e.g. roads crossing rivers and roads running parallel to rivers) and traffic volume. It would be of value to study black spots of road-kill mortalities and to explore the possibility of providing passageways for the European mink and other species at such sites. Low-cost actions such as reductions in speed limit and/or warning signs on roads could also be considered.

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Santiago Palazón has conducted field research on the European and American mink and brown bear in Spain since 1990. He now works on mammal management and conservation in the Catalonian Government. Yolanda Melero's research focuses on behavioural ecology and species interactions. She is now studying the spatial population dynamics of the American and European mink. Asun Gómez is working on conservation of the European mink and control of the American mink. Javier López de Luzuriaga specializes in semi-aquatic mammals and non-invasive genetic techniques in wildlife surveys. He has been working on European mink conservation in Spain since 2000. Madis Podra is the coordinator of the European mink Captive Breeding Programme in Spain, and technical consultant for several regional governments in Spain. Joaquim Gosàlbez has been working on the biology and systematics of mammals for more than 30 years and has recently become interested in research on the invasive American mink.