

GEA, FLORA ET FAUNA

Situation of feral American mink (*Neovison vison*) in Catalonia: expansion, distribution, ecology and population control

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Abstract

We studied the expansion and ecology of the American mink in Catalonia (NE Spain) using 2567 records of the species collected between 1974 and 2014 as part of the National Control Project and previous literature data. The species expanded from occupying one 10×10-km cell located in northern Montseny in the 1970s to 159 cells of the same size in 2014. The average expansion rate was 0.39 cells/year at the start of the invasion, but it increased to 0.91 cells per year in the last five years. The species currently occupies more than 2770 km of river and 2 km² of wetlands, with an estimated population size of between 5725 and 8390 resident adults. Nevertheless, annual mortality in the population is high (50%) with a high turnover rate (average of 5-6 fetuses per female) and few individuals living to 4-5 years. The distribution of the species is best explained by the availability of prey and resting sites, as well as other environmental factors such as distance to rivers, land-use diversity, summer and annual rainfall and the minimum annual temperature. The diet of the species was composed mainly of small mammals, birds, fish and crayfish, with seasonal differences. American mink poses a serious threat to native biodiversity, such as the European mink and European polecat in Europe and Catalonia, respectively. The control project is still ongoing but more systematic work is needed to increase the effectiveness of the platform traps to reduce the invasive species and safeguard the native ones.

Key words: American mink, Catalonia, expansion, distribution, control.

Resum

Situació del visó americà (*Neovison vison*) a Catalunya: expansió, distribució, ecologia i control poblacional

A partir de 2.567 cites de visó americà recopilades des de 1974 fins a 2014, s'ha estudiat l'expansió i l'ecologia del visó americà a Catalunya. D'una quadrícula UTM (10×10 km) ocupada als anys 1970s, al Montseny, s'ha passat a les 159 quadrícules ocupades al 2014, amb una taxa mitjana d'expansió de 0,39, però augmentada fins a 0,91 l'últim quinquenni. Actualment, l'espècie ocupa a Catalunya més de 2.770 km de riu i 60 km² de zones humides, i el nombre d'exemplars de la població de Catalunya es situa entre 5.725 i 8.390 exemplars adults residents. La mortalitat anual dels visons a la població és molt elevada, al voltant del 50 %, i la taxa de renovació anual elevada, amb pocs exemplars que sobrepassen els 4-5 anys de vida. La reproducció mitjana és de 5-6 fetus. La disponibilitat de preses i de caus, la distància als rius, la diversitat d'usos del sòl, la precipitació estival, la precipitació anual i la temperatura mínima anual són les variables més importants per explicar, ecològicament, la seva distribució. La dieta del visó es basa en petits mamífers, ocells, peixos i crancs de riu, variant la seva proporció segons l'estació primavera/estiu i tardor/hivern. El visó americà és una amenaça sobre la biodiversitat d'espècies natives com el visó europeu i el turó europeu a nivell europeu i català respectivament. De moment, només es pot actuar controlant la població amb paranys «en viu», però s'ha d'augmentar sistemàticament l'esforç i l'efectivitat de captura de visons mitjançant l'ús de plataformes.

Paraules clau: Visó americà, Catalunya, expansió, distribució, control.

Introduction

The American mink (*Neovison vison* (Schreber, 1777)) (Mustelidae) is a semi-aquatic carnivore of the Mustelidae

family. It is a native species of North America (Dunstone, 1993) but currently, it is also an introduced invasive species in Catalonia and most of Europe (Bonesi & Palazón, 2007) due to animals escaping from mink farms, where it has been bred

for its fur since the late 19th century. The first fur farming date to 1866 in the United States (Kellogg *et al.*, 1948) and to the 1920s in Europe. It became widespread in the 1930s and 1940s and after the Second World War (Dunstone, 1993; Bonesi & Palazón, 2007). More farms have continued to be established in other European countries, as well as in South America, the former USSR and China. The first observations of specimens in the wild were made a few years after the establishment of fur farms and these specimens formed the first stable populations in aquatic ecosystems (Mitchell-Jones *et al.*, 1999; Bonesi & Palazón, 2007). Today, the major producers of American mink fur are Denmark, the Netherlands, Poland and China (<http://furcommission.com/us-mink-state-of-the-industry-2011/>).

The first farms in the Iberian Peninsula were established in El Espinar, Segovia (1958) and in Pontevedra (1959). Subsequently, in the 1970s and 1980s, farms were established in Barcelona, Girona, Avila and the provinces of Galicia, and, more recently, in Navarre, the Basque Country, Cantabria, Teruel, Castellón and Madrid (Palazón & Ruiz-Olmo, 1997). The first mentions in the wild in Spain were in the Central and Galician mountain ranges at the end of the 1970s (Delibes & Amores, 1978; Delibes 1983; Vidal-Figueroa & Delibes, 1987) and the first in Portugal were in 1985, on the border with Galicia (Vidal-Figueroa & Delibes, 1987). There are currently five populations on the Iberian Peninsula: Galicia and Portugal, Basque Country, central Spain (Castilla and León, Cantabria, Caceres, Madrid, Cuenca and La Rioja), Aragón and Castellón, and Catalonia (Ruiz-Olmo *et al.*, 1997; Palazón & Ruiz-Olmo, 1997; Melero & Palazón, 2011; MAGRAMA, 2013). In 2013, the American mink was classified as an introduced invasive species by Decree 630 of 2 August 2013.

The introduction of the species in Catalonia dates to the 1970s, when two fur farms were established in Viladrau and Taradell, both in the county of Osona. From the former, few animals escaped over time reaching the Major seasonal river and, from there, the River Ter. From the second, hundreds of animals escaped due to a forest fire in 1983. Many died of starvation and others were captured but some were certainly able to survive; these animals adapted and became the founders of the current mink population. Later, when the farm was rebuilt, 10 gestating females escaped and were therefore able to establish a population to the north of the Montseny massif (Ruiz-Olmo, 1985; Ruiz-Olmo & Palazón, 1995; Palazón & Ruiz-Olmo, 1997). There are unconfirmed data of another farm in Oristà, county of Bages. The mink spread in all directions from this part of central Catalonia and had reached 11 major river basins (Fig. 1) and 28 counties by 2014 (Fig. 2).

The causes of the introduction and presence of American mink to the wild are mass escapes, continuous sporadic escapes and deliberate releases. Mass escapes are caused by accidents, acts of vandalism by animal-rights groups (Teruel in 2001; 11 cases in Galicia between 2002 and 2009) (Romero, 2009), by closure and abandonment of farms for economic reasons (Teruel in 1989), and by natural disasters such as forest fires (Taradell in 1983) and hurricanes (Galicia in 1984)



Figure 1. Distribution of American mink (in black) in the river systems of Catalonia in 2014.

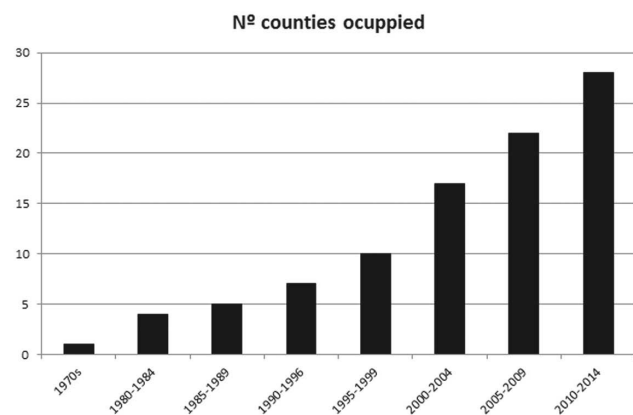


Figure 2. Number of counties occupied by American mink in Catalonia, from 1970 to 2014.

(Palazón & Ruiz-Olmo, 1997). Sporadic escapes are the result of deficient farms and lack of care by farmers. Deliberate releases are carried out with the purpose of subsequently hunting the mink, as happened in several former Soviet republics, where more than 16,000 animals were released at 200 different points over a period of 30 years (1933-1962) (Aliev & Sanderson, 1970).

Males and females mate with multiple partners. This reproductive behaviour enables males to impregnate several females, even those that have lost their young, and allows females to be impregnated by one or more males (Yamaguchi *et al.*, 2004). Because of this strategy, almost the entire mink population contributes genetically to the next generation.

The American mink is a solitary species and is territorial to some extent, with individuals of different sexes and ages living along broad sections of river (juveniles and adults, established and transient). It is a semi-aquatic species that lives along rivers and streams, lakes, marshes, canals and on the coast, from sea level to an altitude of 1500 m, at the headwaters, although they prefer mid-altitude to low-altitude zones (Santulli *et al.*, 2009). In the Nearctic, they are indicators of permanently unfrozen water (Loukmas & Halbrook, 2001). The American mink is a carnivore that swims, dives and lives along water bodies, where it searches for small vertebrates and crustaceans. Their diet is highly varied, depending on season, habitat and altitude (Bonesi *et al.*, 2004).

The American mink is considered to be one of the most harmful invasive species (Bonesi & Palazón, 2007) in terms of its effects on biodiversity, ecosystems and the economy. It has an impact on diversity in essentially two ways. First, as a predator of vulnerable species and endangered species, such as the European water vole (*Arvicola amphibius* (Linnaeus, 1758) and *A. sapidus* Miller, 1908) (Cricetidae), the European freshwater crayfish (*Austropotamobius pallipes* (Lereboullet, 1858)) (Arthropoda: Decapoda), the Iberian desman (*Galemys pyrenaicus* (E. Geoffroy St. Hilaire, 1811)) (Talpidae) and seabirds (Palazón & Ruiz-Olmo, 1997; Aars *et al.*, 2001; Schütler, 2009; Fisher *et al.*, 2009). Second, as a competitor, as it occupies the ecological niche of the European mink (*Mustela lutreola* (Linnaeus, 1761)) (Mustelidae) and other carnivores of similar size, such as the European polecat (*Mustela putorius* (Linnaeus, 1758)) (Mustelidae), the Spotted genet (*Genetta genetta* Linnaeus, 1758) (Viverridae) and the otter (*Lutra lutra* (Linnaeus, 1758)) (Mustelidae) (Palazón 2011; Melero *et al.*, 2012a; Palazón & Melero, 2014). Finally, it has been considered to be a vector of Aleutian disease (ADV) (Mañas *et al.*, 2001) in other carnivorous species, although this is the subject of debate (Bowman *et al.*, 2014).

The presence of the American mink in the river systems of Catalonia and Europe has a severely harmful effect on the ecological balance. The species competes ecologically with other semi-aquatic mustelids, especially the European polecat, which is an endangered species in Catalonia (Palazón *et al.*, 2010) and the European mink, which is endangered throughout Europe (Palazón & Ruiz-Olmo, 1997; Maran *et al.*, 1998b; Podra *et al.*, 2013). American mink are specialists in terms of habitat, like the European mink, but are generalists in terms of diet, which gives them an ecological advantage. Moreover, in North America, the American mink occupies the same habitat as the European mink in Europe. It has been shown that, when the American mink arrives in areas occupied by the European mink, it displaces the latter until it disappears (Maran *et al.*, 1998b; Sidorovich & Macdonald, 2001; Macdonald & Harrington, 2003; Podra *et al.*, 2013; Santulli *et al.*, 2014), given that the American species is larger, more aggressive, has an adaptable morphology (Melero *et al.*, 2008c and 2012b), is better at adapting to different diets, has more offspring, with delayed implantation of the fertilized ovum, multiple paternity (Yamaguchi *et al.*, 2004), occupies a broader trophic niche and smaller territories with higher population

densities, adapts better to habitats of poorer quality, and appears to show a more lax territorial behaviour. In summary, it shows more “ecological plasticity” (Sidorovich, 1992; Maran *et al.*, 1998a; Macdonald *et al.*, 1999; Sidorovich & Macdonald, 2001; Macdonald & Harrington, 2003). For this reason, the American mink has led to the extinction of the European mink in many European countries. The European mink is an endangered species worldwide and the only remaining populations are found in Russia, Romania, France and Spain (Maran *et al.*, 2011). Finally, the American mink was introduced into the wild and spread the Aleutian disease virus (ADV) (Mañas *et al.*, 2001) and canine distemper (Philippa *et al.*, 2008) to other semi-aquatic carnivores.

The objectives of this study were to obtain a clear idea of the process of expansion of the species in Catalonia by collecting all the data generated in the past 40 years on the biology and ecology of the species and to discuss its future, taking into account the ecological impact on biodiversity and strategies to be applied in order to control and eradicate it. To date, all attempts at controlling the species have met with failure, as shown by its expansion.

Materials and Methods

The methodology used was a combination of literature review and collection of the data available in Catalonia from 1974 (first sightings in the wild) to 2014. All available information on the species in Catalonia was collected, in the form of scientific articles and technical reports. Data collection provided a total of 2567 mentions of the presence of American mink, including observations, signs, captured specimens and road kill.

The expansion of American mink in Catalonia has been estimated using 10x10-km cells, by county and by river basin. The expansion rate was calculated using the formula $ER = S^{1/2}/t$ (Hengeveld, 1989), where S is the area of new 10x10-km cells occupied by the population in a period of time t, expressed in years (40 years, from 1974 to 2014).

American mink is a river-bank carnivore and its territories are distributed along river systems and in wetlands. The size of the territories depends on the availability of food and the quality of the habitat (Birks & Linn, 1982). Thus, estimated mink population size in Catalonia was calculated by the number of kilometres of river occupied by the mink in each river basin multiplied by the mean linear density. In the case of wetlands (marshes and lakes), the number of square kilometres occupied was also calculated, multiplied by the mean surface density (obtained from European literature). For major rivers, a density of 3 stable individuals per km of river (1 male and 2 females) was determined based on data from studies carried out in central Catalonia, in the Llobregat and Gavarresa rivers, where the males hold a mean territory of 1 km and the females 0.5 km (Melero *et al.*, 2008a). For smaller rivers and small seasonal rivers, the density was arbitrarily taken to be half: 1.5 individuals per km of river (0.5 males and 1 female). A density of 4 specimens per km² was estimated for wetlands (Gerell, 1971). Each adult female

has an average of 4-6 kits per litter (Chanin, 1983; Skirnisson, 1989; Dunstone, 1993; Amtislavsky & Ternovskaya, 1994; Sidorovich, 1997; Melero *et al.*, 2015) at the end of spring, although mortality between the dispersal phase and the next reproductive season is 46.3 % (Mañas *et al.*, 2016). In summary, the population of American mink varies widely throughout the year, reaching a maximum in spring and early summer (May-June) and a minimum at the start of the following year's mating season (January-February). We are aware that this measurement may produce data that do not tally with the real situation, but the objective was to provide an approximate figure for the adult population of American mink currently inhabiting Catalonia.

For reproduction, we analysed 632 autopsies of American mink captured in Catalonia between 2002 and 2013. In the case of males, we determined two sexual states: active (in heat, with the testicles outside the abdomen) and inactive. In the case of females, we determined four states: it was determined whether the vagina had undergone copulation (based on the morphology of the vulva), whether the animals were gestating (number of embryos), whether they were raising young or suckling (number of active nipples), or whether they were inactive. The fertility rate (number of embryos per pregnant female) and the birth rate (number of kits per female) were estimated, together with the exact season corresponding to each period of the reproductive cycle, thereby establishing a pattern of sexual activity for each of the sexes. We agreed that the birth of the kits took place on 1 May (Mañas *et al.*, 2016a).

The review of the literature also allowed us to gather information on the social behaviour and organization of the species in Catalonia, its diet and its relationship with the habitat. We also performed a summary of the ecological impact and management activities carried out in order to control the species in Catalonia, together with suggestions and comments on the efficacy of the control programmes.

Results and Discussion

Distribution in Catalonia

Of the 2567 mentions of American mink collected in Catalonia between 1974 and 2014, 73 % were captured specimens, 12.6 % were observations and 8.65 were signs. In the 1970s, the only data on feral mink were from the counties of Osona and La Selva, in the Major seasonal river basin, in the Ter river basin, occupying a single 10×10-km cell. In the 1990s, the mink expanded in three directions: north, east and south-east (crossing the Montseny massif), and west (Moianès and Bages). They occupied 8 10×10-km cells (Figs 3a-b) (Ruiz-Olmo, 1985, 1987). By the late 1980s, they had reached the basins of the Tordera, Besòs and Llobregat rivers, occupying 17 cells and four counties: Osona, La Selva, El Vallès Oriental and El Bages (Fig. 3c). Expansion between then and 2014 is shown in Figures 3d-h. In this period, the species came to occupy 159 10×10-km cells (Fig. 4). The mean expansion rate calculated for these 40 years was 0.39, with a rising trend over this time: 0.26 (1974-1984), 0.46 (1984-1994), 0.69

(1994-2004), 0.91 (2004-2014). The predictive expansion models carried out five years ago (Santulli *et al.*, 2009) were accurate for the last 5-year period (2010-2014).

Reproduction

Of the 399 males studied, 56.89 % were in heat and 43.11 % were sexually inactive. Most of the males were active in the first six months of the year and, specifically between February and April, more than 90 % of the studied males were active (Fig. 6).

During this period, females went through three reproductive stages: heat from February to May (70 % of the females in February), gestation from March to June (50 %-70 % of the females in April) and raising litters from May to September (> 60 % of the females in May) (Fig. 7). Of the 233 females studied, 62.23 % were in one of the reproductive stages and only 37.77 % were inactive. Of the reproductive females, 53 were in heat, 34 had recently copulated and 58 were suckling and raising offspring. The animals were in heat from 1 February to 31 March (2 months), with 60 %-80 % of all the females captured (Fig. 7) in heat during this period. Heat, which is affected by hours of light, can occur twice if the female does not become pregnant. Ovulation is induced by copulation. This species delays implantation of the ovum for 13 to 50 days and gestation lasts from 28 to 33 days (Enders, 1952). This strategy means that the litter can be born when prey is most available, between late April and late June in Catalonia (Fig. 8). Of the females studied, 60 % were gestating in April (Fig. 7).

In Catalonia, we found a fertility rate of an average of 5-6 fetuses (SD, 1.19; range, 3-7), based on 8 females with a mean weight of 756.37 g (SD, 121.36). Between 1 and 12 kits may be born (mean, 4-6) (Chanin, 1983; Skirnisson, 1989; Dunstone, 1993; Amtislavsky & Ternovskaya, 1994; Sidorovich, 1997; Melero *et al.*, 2015). The kits are born with their eyes closed, without teeth or fur and with a mean body weight of 8.5 g. After the first month of life, they open their eyes, teeth appear and they begin to eat solid food and are covered with fur (Dunstone, 1993). The number of active nipples on the mother indicates the number of kits being suckled. In Catalonia, the litter-rearing state runs from 1 May to 15 August, with 60 % of the studied females raising offspring in this period; the peak period was in June, with approximately 90 % of captured females raising offspring. Based on 21 mentions of observations of females with kits in Spain, we estimated a birth rate of 3.38 kits per female.

At four months, the young animals have almost reached adult size, but males continue to grow throughout the second year (Eagle & Whitman, 1987; Melero *et al.*, 2008, 2012). They leave the maternal territory between August and September (Chanin, 1983; Dunstone & Ireland, 1996). At this time, they are juveniles and begin to search for new territories in which to settle; they are dispersing mink (Clark, 1970). According to the literature, postnatal mortality and mortality during dispersal is very high, and only between 25 % and 30 % reach adulthood and sexual maturity, which is reached at

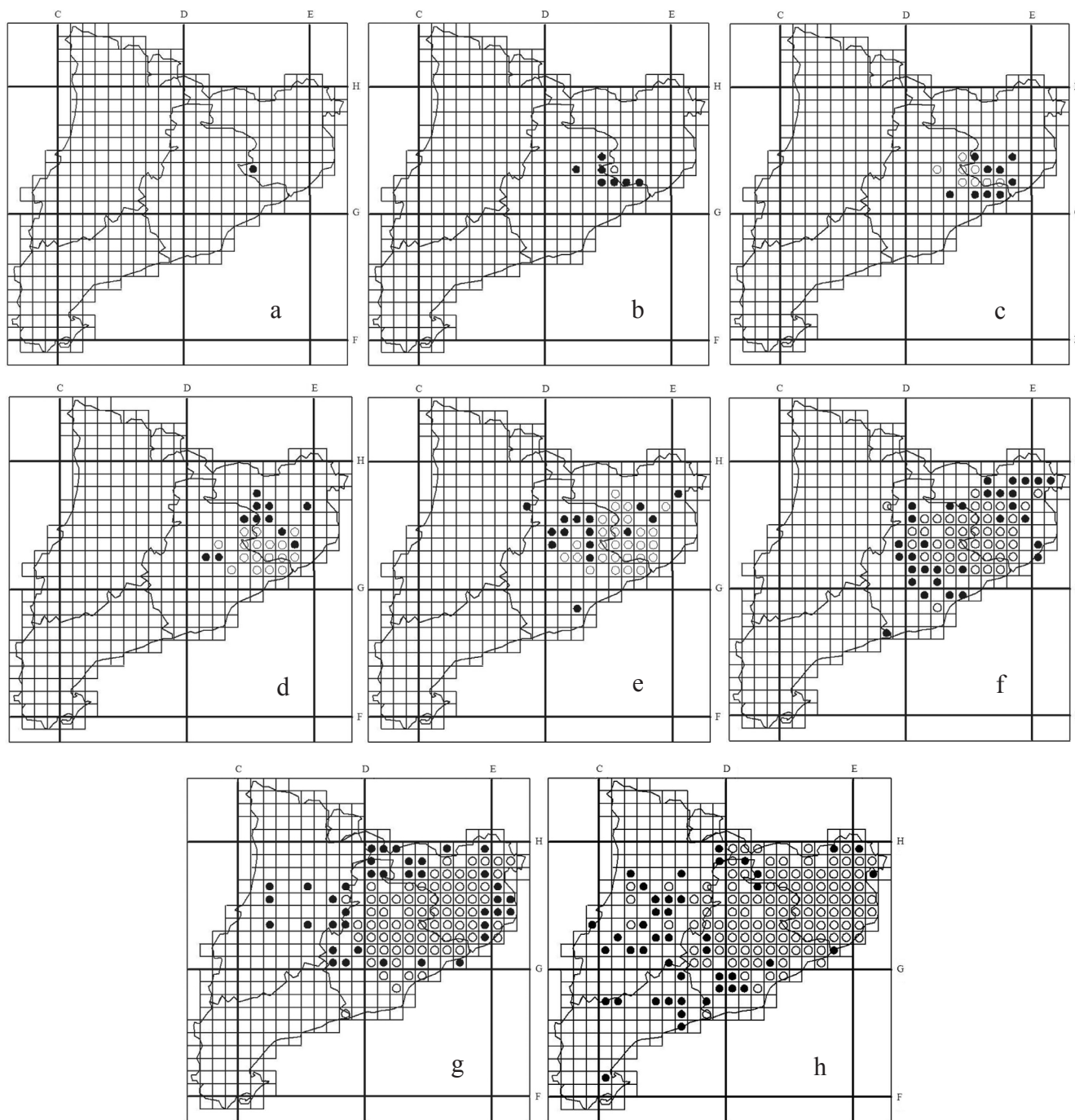


Figure 3. 10×10-km cells occupied by American mink in 8 periods: a) 1974-1979; b) 1980-1984; c) 1985-1989; d) 1990-1994; e) 1995-1999; f) 2000-2004; g) 2005-2009; h) 2010-2014.

between 10 and 11 months of age, in the year after their birth, when they stabilize their territories (Melero & Palazón, 2011).

Population and Density

The density estimated in the studies carried out in Catalonia is three mink per kilometre of river (Melero *et al.*, 2008c), so that one kilometre of river theoretically contains at least one resident male and two resident females; however, there are also a number of transitory dispersing animals look-

ing for a territory in which to establish themselves. Based on these data and the estimation that the American mink occupies more than 2770 km of river and 60 km² of wetlands in Catalonia, the figure for the Catalan population (underestimated because the transitory mink and the endless number of seasonal rivers and streams were not counted) may be between 5725 and 8390 resident adults.

According to Dunstone & Ireland (1996), 50 % of juveniles die in the first year of life - a similar percentage to that in the data obtained in Catalonia (Mañas *et al.*, 2016). Foxes,

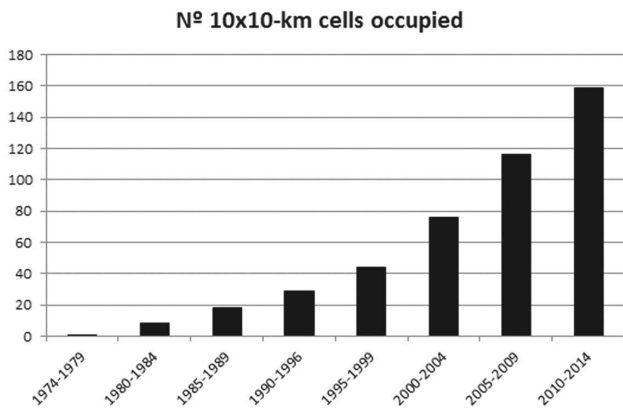


Figure 4. Increase in the number of 10×10-km cells occupied by American mink between 1974 and 2014, in 5-year periods, in Catalonia

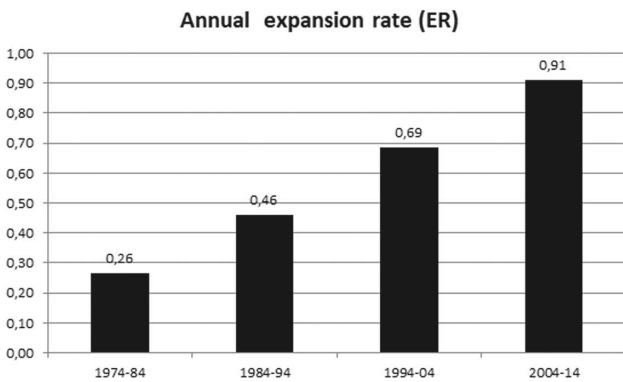


Figure 5. Annual expansion rate (ER) of American mink in Catalonia, estimated based on the number of 10×10-km cells occupied in the different 10-year periods between 1974 and 2014.

dogs, otters and birds of prey may kill mink. Inexperience and limited resources during the dispersal phase are the main factors affecting mortality. In Spain, Mañas *et al* (2016) found mortality for all populations of mink, with no inter-population differences, to be very high: mortality in the first year of life (0+) is 0.463 and is higher than 0.50 in subsequent years, until the eighth year of life (7+), which is the highest longevity found in the wild on the Iberian Peninsula. This high mortality over the years means that very few animals reach more than 4 or 5 years of age. It appears that males have a slightly higher mortality than females at all ages (Mañas *et al.*, 2016). In Scotland, it has been found that males are more resistant to trapping and capture and that dispersed specimens may compensate for the reduction in density after trapping (Oliver *et al.*, 2016). In summary, the short reproductive cycle, the large number of offspring and high infantile and juvenile mortality, as well as high mortality at other ages, all lead to a high turnover of the population (Mañas *et al.*, 2016); this has been corroborated by European and American authors, who give a figure of three years for complete turnover of the population (Mitchell, 1961; Gerell, 1971; Dunstone & Ireland, 1996).

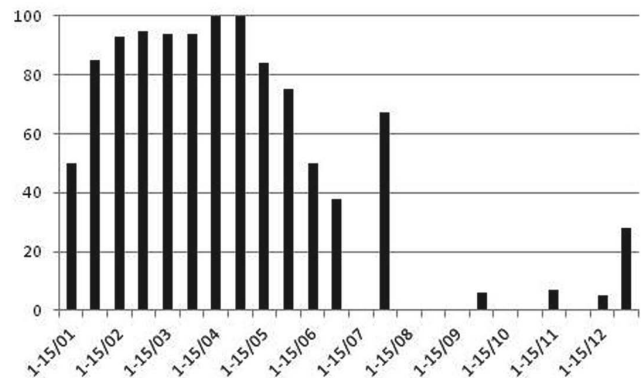


Figure 6. Percentage of sexually active males throughout the year in Catalonia, distributed in two-week periods, from 2002 to 2013.

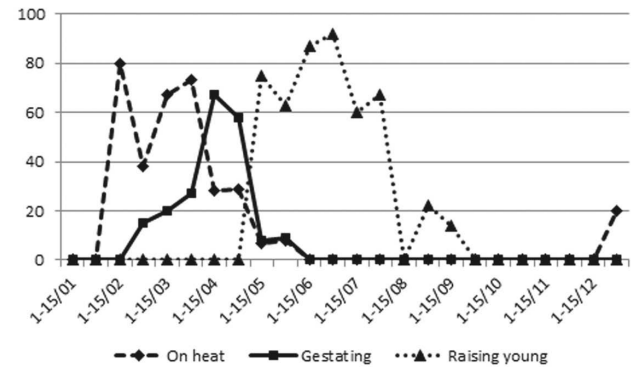


Figure 7. Percentage of females in the three reproductive states (in heat, gestating and raising young) throughout the year in Catalonia, distributed in two-week periods, from 2002 to 2013.

Social Organization and Behaviour

In Catalonia, home ranges have been estimated at 1.19 km of river for males (± 0.73) and 0.54 km for females (± 0.14) (Melero *et al.*, 2008a). The animals are mainly active at night and twilight but their lack of fear of humans makes it easy to observe them during the day. Some animals are highly nocturnal and others are highly diurnal (Melero *et al.*, 2011), as if they shared the ecological niche. American mink is a species with a large dispersal capacity and a strong ability to swim and cross rivers and sections of sea in order to reach islands near the coast. For example, all of the islands within a distance of two kilometres of the west coast of Scotland have been invaded by mink (Craik, 1997; Fraser *et al.*, 2015), as have the Salvora and Cies islands in Galicia (Romero, 2009), where they have endangered the European shag (*Phalacrocorax aristotelis* (Linnaeus, 1761)) (Phalacrocoracidae) (Velando & Munilla 2008). In Scotland, dispersal distances of more than 30 km have been observed in mink (Oliver *et al.*, 2016). This represents a potential risk for the protected species living in places like the Medes Islands, such as the European shag (*Phalacrocorax aristotelis desmarestii*

Payraudeau, 1826), the European storm petrel (*Hydrobates pelagicus melitensis* Schembri, 1843) (Hydrobatidae) and some species of heron (*Ardeola ralloides* (Scopoli, 1769), *Egretta garcetta* (Linnaeus, 1766), *Bubulcus ibis* Linnaeus 1758 and *Ncticorax ncticorax* Linnaeus, 1758) (all belonging to Ardeidae) (Ricard Gutiérrez, per. com.).

Habitat

In Catalonia, American mink have only been found along river courses and in wetlands. The species is highly adaptable and lives mostly in North American plant ecotones (Larivière & Jennings, 2009). Their preferred habitats in Mediterranean areas such as Catalonia have broad areas of dense vegetation along the banks of bodies of water (brambles, reeds, willow, alder, elm, etc.) and a large quantity of water. Two factors affect the choice of habitat: availability of prey and resting sites (Melero *et al.*, 2008c); the animals are very tolerant of human presence and activity. Although they live close to water, mink spend a lot of time at some distance from it (Dunstone & Birks, 1983; Lodé, 1991; Melero *et al.*, 2011), but always within the area of influence of riverbank habitats. The distribution of the species in Catalonia is most strongly determined by distance to rivers, summer rainfall, land-use diversity, annual precipitation and the minimum annual temperature (Santulli *et al.*, 2009).

Diet

In central Catalonia, the diet of the species was composed mainly of small mammals, birds, fish and crayfish, with seasonal differences in the proportion of each item (Melero *et al.*, 2008b). Birds form a very large part of the diet in autumn/winter, accounting for 46.1 % of the biomass consumed, and crayfish (37.0 %) and fish (34.4 %) form a larger part in spring/summer (Melero *et al.*, 2008b). High densities of the American crayfish have been observed to facilitate the density of the American mink, thereby increasing its potential negative effects on biodiversity (Melero *et al.*, 2014).

Impact, Management and Control of American Mink

The presence of the American mink in the river systems of Catalonia has a severely harmful effect on the ecological balance. In terms of predation, the American mink affects endangered, protected, fishing, hunting, farming and fish-farming species, as well as introduced and invasive species (Melero *et al.*, 2012a, 2014). The species competes ecologically with other semi-aquatic mustelids, especially the European polecat (*Mustela putorius*), which is an endangered species in Catalonia (Palazón *et al.*, 2010).

To date, a systematic approach has not been taken in the fight against this invasive species in Catalonia and the results have been highly questionable (Melero, 2007; Melero *et al.*, 2010). New Spanish legislation (Decree 630 of 2 August 2013 on the Spanish catalogue of introduced invasive species) does not allow the establishment of new farms (Decision 637/2016 of the Spanish Supreme Court) and, as there are currently no

American mink farms in Catalonia, regional legislation must be passed to prevent new farms from setting up.

Controls of American mink have been carried out irregularly in time and space in Catalonia since 2000. Studies carried out in Catalonia indicate that, in order to prevent expansion, continuous, methodical controls on a larger scale are required (Melero, 2007), such as controls in areas of interest (protected spaces) and areas within a 30-km radius of the distribution limits (Melero, 2007; Oliver *et al.*, 2016). The only method that can currently be used is live capture using cages – a selective method that only affects the American mink and does not affect other species. This system is very effective if used with floating platforms, as shown in England (Reynolds *et al.*, 2004; Bryce *et al.*, 2011) and Northern Spain, in the fight to preserve the European mink (Life Lutreola Spain, 2014). However, this system of platforms must be applied on a large scale, continuously and methodically in order to be effective enough to begin to reduce the population density. Traps should be placed in areas of no less than 30 km of river to prevent expansion by dispersing animals (Melero, 2007; Oliver *et al.*, 2016).

The partial use of traps in time and space cannot continue. This generates voids that are rapidly occupied by compensation and dispersal when trapping finishes. However, preliminary studies indicate that an annual increase of at least 50 % in captures compared to current figures is required to begin to reduce the population to low densities (Calderón, 2015).

Furthermore, mink must be trapped when the effort/capture ratio is most efficient and must be repeated at least three times in order to leave the population close to zero (Plaza & Palazón, 2013). Traps should be placed based on studies of population dynamics and the processes that regulate the population. Controls began some 15 years ago and the Catalan population of American mink is therefore relatively young (Mañas *et al.*, 2016) and females have a larger number of offspring (Melero *et al.*, 2015). It is very important to place traps before reproduction and birth, and to continue throughout the dispersal period. Capture by trapping should exceed the population growth rate and the compensation capacity of the species (Melero *et al.*, 2010).

The capture campaigns carried out must be tested each year (locations, sites, bait, attractant, etc.), as captures are high during the juvenile dispersal period yet many of these will die during the dispersal phase.

Unfortunately, the only way to fight the species is by killing mink, quickly and without causing suffering, in accordance with current Catalan, Spanish and European legislation on animal welfare.

A plan for the control of the American mink must be established and applied. This plan should include all public authorities, as well as foundations, environmental, nature, hunting, fishing and voluntary organizations. In other European countries, volunteers provide a steady workforce free from funding dependency (Bryce *et al.*, 2011). It should be understood that fighting the American mink (and other introduced invasive species) means fighting to increase biodiversity and preserve endangered species; but it also means fighting to maintain hunting and fishing populations.

Finally, some questions may be put forward, such as: is it possible to eradicate the population? Can it be controlled? Are the results to date in line with the work done? Can we increase the effectiveness of controls? Is it worth continuing with these control and eradication practices? Should work be focused only on special areas, such as protected spaces, rivers with populations of endangered species, etc.? Should we control expansion to the west to prevent the European mink from being affected?

The data obtained on expansion and the quantity of animals captured lead us to be pessimistic, as it appears that being able to control the expansion of this species in Catalonia is a chimera; however, as mentioned above, this trend can be changed with large-scale, sustained, continuous controls, and by maintaining a capture rate in excess of the recovery rate of the American mink (Melero *et al.*, 2015; Oliver *et al.* 2016).

Current control of invasive species focuses on reducing their effects on ecosystems and biodiversity. In Catalonia, it is necessary to focus on controlling the American mink where it does most harm: in protected spaces and in areas where there are species vulnerable to its predation and ecological competition (Melero, 2007). As well as controls, studies must be carried out using mathematical models to define and improve the effectiveness of the controls and their effect on the ecosystems and species involved.

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