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DIURNAL ACTIVITY OF THE AMERICAN MINK (*NEOVISON VISON*) IN CENTRAL SPAIN

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ABSTRACT - The American mink (*Neovison vison*) is an invasive species in Spain and its population ecology is poorly understood. Diurnal activity was studied in a population of central Spain by means of direct observations. This activity peaked in summer and winter, mink being more active just after daybreak (06:00-08:00) and before dawn (16:00-18:00). Foraging (50% of observations; N = 146) and travelling (38.2%), were the main activities recorded during daylight. Mink were recorded as either in water or on land. In the latter, their distance from the water edge never exceeded 5.5 m. This pattern of daylight activity could be a mechanism for reducing potential interactions with nocturnal mammals sharing the same habitats. The success of culling campaigns could be increased by extending trapping sessions to daylight hours.

Key words: *Neovison vison*, behaviour, Mustelidae, population ecology

RIASSUNTO – ***Attività diurna del visone americano* (Neovison vison) *nella Spagna centrale.*** L'ecologia dell'alloctono visone americano in Spagna è tuttora poco nota. Tramite osservazione diretta, è stata indagata l'incidenza della attività diurna in una popolazione della Spagna centrale. Tale attività è risultata più frequente in estate ed inverno, quando i visoni sono attivi nelle prime ore del giorno (06:00-08:00) e prima del tramonto (16:00-18:00). Le attività registrate più frequentemente sono state il foraggiamento (50% delle osservazioni, N = 146) e gli spostamenti (*travelling*, 38,2%). I visoni sono stati osservati indistintamente sia in acqua che a terra; in quest'ultimo caso la distanza dalla riva non è mai stata superiore a 5,5 m. Si ipotizza che l'attività diurna potrebbe essere un meccanismo per ridurre le interazioni con mammiferi prevalentemente notturni legati ai medesimi ambienti. In base ai risultati ottenuti, si suggerisce che il successo delle operazioni di controllo della specie potrebbe essere incrementato estendendo il trappolamento alle ore diurne.

Parole chiave: *Neovison vison*, comportamento, Mustelidae, ecologia di popolazione

INTRODUCTION

The American mink (*Neovison vison*) is an invasive species in Europe, associated with riparian habitats and having a significant negative impact on some native species, such as the water vole (*Arvicola amphibius*) and the European

mink (*Mustela lutreola*) (Dunstone, 1993; Ruiz-Olmo *et al*., 1997; Larivière, 1999; Delibes *et al*., 2004; Bonesi and Palazón, 2007; Holt *et al*., 2008). Feral populations have been established in the Iberian peninsula since the 1980s, escaping from fur farms scattered on the country (Dunstone, 1993; Larivière, 1999; Ruiz-Olmo *et al*., 1997; Bonesi and Palazón, 2007).

Despite relative large number of studies on mink distribution and feeding ecology (e.g. Bravo and Bueno, 1992; Bueno, 1994, 1996; Ruiz-Olmo *et al*., 1997; García-González *et al*., 2002; Delibes *et al*., 2004; Melero *et al*., 2008a), data on population ecology are scarce (but see, Palazón and Ruiz-Olmo, 1995; Melero, 2007; Melero *et al*., 2008b), although this type of information is of value in managing mink populations (Dunstone, 1993; Bonesi and Palazón, 2007). According to other semi-aquatic mustelids (Kruuk, 1995, 2006; Lodé, 1995; Garin *et al*., 2002), the American mink usually shows a nocturnal activity pattern, resting during day hours in den sites (Gerell, 1969; Dunstone and Birks, 1983; Dunstone, 1993; Niemimaa, 1995; Larivière, 1999; Melero, 2007). However, recent work on several introduced populations in Europe have demonstrated that mink can be more active during daylight (Niemimaa, 1995; Palazón and Ruiz-Olmo, 1995; Zuberogoitia *et al*., 2006; Melero, 2007; Harrington and Macdonald, 2008; Harrington *et al*., 2009).

In this work, the diurnal activity pattern of an introduced population of American mink in central Spain is studied based on direct observations.

STUDY AREA

The study was carried out on a 16 km long stretch of the River Tormes, next to Salamanca, central Spain (40º 57' 21.46'' N, 5º 39' 28.2'' W; 800 m. a.s.l.; Fig. 1). The climate is Mediterranean, winters being cool (mean temperature: 4.4 ºC) and with moderate rainfall (mean rainfall: 40 mm), whereas summers are very hot (mean temperature: 22 ºC) and dry (mean rainfall: 10 mm).

The river has the typical structure of plains rivers, with low slope (< 2%), high width (about 180 m on average), and common presence of islands. Banks are covered by a riparian forest with poplars (*Populus* spp.) and willows (*Salix* spp.). The muddy areas more exposed to sunlight are colonized by helophytic vegetation represented by bulrush (*Thypa latifolia* and *Thypa dominguensis*), reed bed (*Phragmites australis*) and branched bur-reed (*Sparganium erectum*). Due to the proximity of the study area to the city of Salamanca, on some stretches the riparian forest has been removed and the banks are used for recreational purposes.

The first records of the American mink in this area date back to about 30 years ago (García-González *et al*., 2002), and currently the species breeds regularly (own data). The Eurasian otter (*Lutra lutra*) is present, but only in winter (García, 2008; García *et al*., 2009).

METHODS

Data on the diurnal activity of the mink were obtained by direct observations of the animals with binoculars and/or a telescope (magnification: 8 x 32 and 60 x 85, respectively) carried out between January 2006 and February 2009. These encounters took place during specific vigils from bridges or from the banks of the river (Fig. 1). When an animal was observed, the time, its behaviour and location (land or water) were recorded. When mink were on land, the

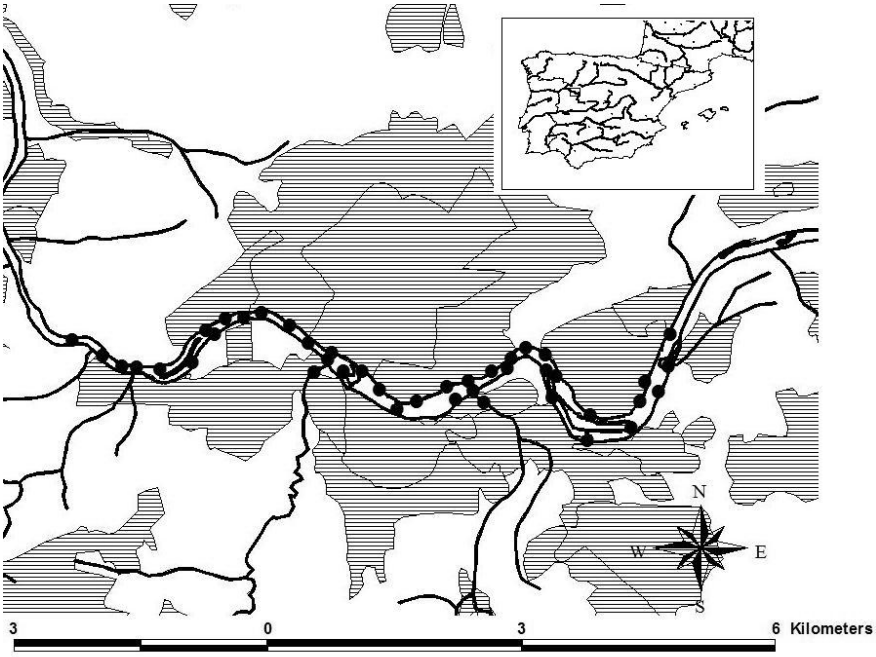

Figure 1. Map of the study area; patches with lines are urban habitats. Black dots mark vigil sites.

distance to the nearest water was also noted. The overall sampling effort for the entire study period was about 3500 hours, albeit slightly different in each year (2006: 984.5 hours/observer; 2007: 1234.9 hours/observer; 2008: 1267.6 hours/observer; January and February 2009: 13.0 hours/observer; see also Fig. 2 for further details on the time distribution of the effort).

Mink activity for each time interval was measured as the number of observations divided by the per cent sampling effort [(n° of hours of observation in each time interval / total n° of hours of observation) × 100], thus correcting for potential biases due to different sampling intensities (Lizana *et al*., 1990):

$$\text{Activity index I} = \frac{\text{number of observations in a period}}{\text{\% of sampling effort in this period}}$$

Each activity index was then expressed as a percentage according to the following formula:

$$\text{Activity index corrected} = \frac{\text{Activity index I}}{\Sigma\text{Activity indexes I}} \times 100$$

In this paper, the corrected percentage index is used. The seasonal and daily variation of the activity index was tested by the chi-square (χ^2) test, applying Yates' correction for test with only one degree of freedom.

RESULTS

Overall 79 observations of individual American mink and 146 behavioural observations were registered, because on 72 occasions minks were observed while carrying out different activities.

The index of diurnal activity showed two significant peaks in winter and sum-

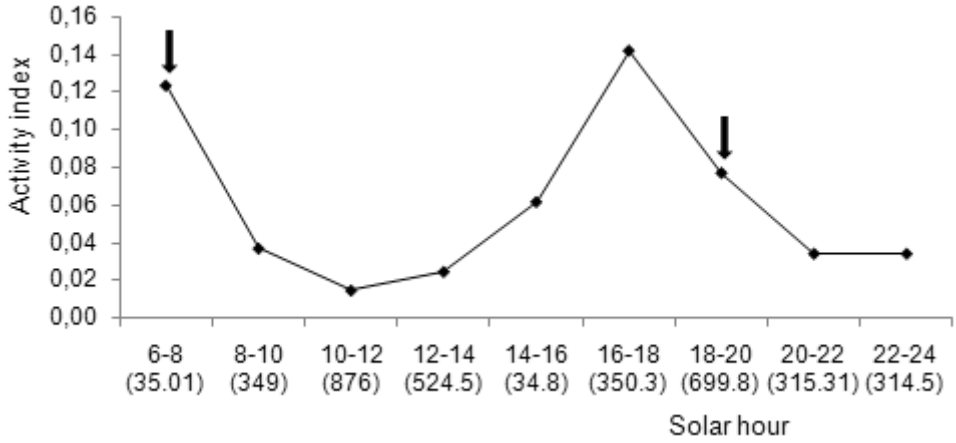

Figure 2 - Hourly variations in the index of diurnal activity. Arrows indicate the approximate time of sunset and daybreak. The sampling effort in each period (hours per observer) is shown into brackets.

mer (χ^2 = 14.78, 3 d.f., P<0.01), reaching, respectively, 29.52% and 27.92% of the total activity. Spring was the season with least diurnal activity (0.09%), whereas in autumn intermediate values were recorded (15.96%).The activity index showed two main peaks, dawn, from 06:00 to 08:00, and before dusk, between 16:00 and 18:00 solar hours (χ^2 = 34.85, 8 d.f., P<0.01); mink were rarely active at midday (Fig. 2).

The main behaviour of mink during diurnal activity were foraging (50% of observations) and travelling (30.82%). Interactions with other mink were reported on 16.43% of occasions, including two copulations (1.37%). Other activities were occasional and included grooming (1.37%) and defecation (0.68%). No interactions with other mammals were observed.

No significant difference was detected between the number of mink observations on land (51.90%) and in water (48.1%) (χ^2 = 0.16, 1 d.f., N.S.). All mink were closely related to the water, mink on land being, on average, only 1.12 ± 0.21 m (mean ± SE; min-max = 0.1-5.5 m) from the water edge.

DISCUSSION

The recording of diurnal activity agrees with previous works (Dunstone and Birks, 1983; Dunstone, 1993; Niemimaa, 1995; Palazón and Ruiz-Olmo, 1995; Zuberogoitia *et al*., 2006; Melero, 2007; Harrington and Macdonald, 2008; Harrington *et al*., 2009), even if the main hours of activity of mink can differ markedly, probably partially as a consequence of methodological differences in the sampling procedures in each study. In southern England, mink have been reported to be more active from 08:00 to 16:00, whilst before dusk and at night the activity was less than 10% (Harrington and Macdonald, 2008). In coastal areas of the UK diurnal activity was reported for both male and female mink in winter and summer,

although the species was predominately nocturnal (Dunstone and Birks, 1983; Dunstone, 1993). In Finland different patterns have been recorded, some individuals being nocturnal, others diurnal, while some showed no specific activity pattern (Niemimaa, 1995).

In northern Spain, American mink are active mainly after dusk and during the night, with an important peak of activity at daybreak (Palazón and Ruiz-Olmo, 1995; Zuberogoitia *et al*., 2006; Melero, 2007) and, interestingly, 30 % of locations at midday (from 14:00 to 16:00; Palazón and Ruiz-Olmo, 1995).

Nevertheless, most works have shown a common pattern, with mink being most active during the night, the period of activity being determined by night temperature and length (Gerell, 1969; Dunstone, 1993; Niemimaa, 1995; Larivière, 1999). Animals active during daylight hours are rare, activity occurring mostly at dusk and/or at dawn and only in a few months (Gerell, 1969; Dunstone and Birks, 1983; Dunstone, 1993; Niemimaa, 1995).

In our study area, the seasonal variation in diurnal activity was marked, mink being more active during winter and summer days.

The decrease in diurnal activity in spring could be explained, at least partially, by the inactivity of pregnant females, confined at den sites (Gerell, 1969). The winter peak could depend on the low nocturnal temperatures (Gerell, 1969; Dunstone, 1993; Hays *et al*., 2006) (about -4ºC by night in comparison to those during daylight hours, about 8-10 ºC), or be a reaction to the presence of a top predator such as the Eurasian otter (*Lutra lutra*) (see below).The summer peak could be explained by the appearance of mink born in spring (Dunstone, 1993; Bonesi *et al*., 2006a).

Minks active during daylight hours were mainly hunting and travelling. Surprisingly, given the apparent importance of scats for social communication (Dunstone, 1993), only one observation was made of scent marking with faeces, suggesting that scats are mainly deposited at night. Otters use spraints to mark their fishing sites (Kruuk, 1992, 1995, 2006), whilst mink were usually observed while hunting but not defecating (50% and 0.68% of behavioural observations, respectively).

Two matings were reported during the day. Although occurring in spring (according to the observation of cubs and cubs' tracks; own data), when a decline in mink diurnal activity has been observed, they are more likely to happen during the night. This shift towards a more diurnal activity in some feral populations of the American mink could be interpreted as an attempt to reduce potential interference with native semi-aquatic mammals, as the Eurasian otter, the European polecat (*Mustela putorius*) or the common genet (*Genetta genetta*). These species have a nearly exclusive nocturnal period of activity and can displace minks from their habitat (Lodé, 1995; Maran *et al*., 1998; Garin *et al.,* 2002; Bonesi and Macdonald, 2004a, b; Bonesi *et al*., 2004, 2006b; McDonald *et al.,* 2007; Camps, 2008; Harrington and Macdonald, 2008; Melero *et* al., 2008a; García *et al*., 2009; Harrington *et al*., 2009).

These observations appear to support this hypothesis. Firstly, no encounters between mink and other species sharing the study area were recorded. Secondly, in winter, when the otter is present in

the study area, the field signs of the mink decrease significantly (García *et al*., 2009), at the same time daylight activity increases. In contrast, when otters are absent, mink diurnal activity tends to be lower than in winter. Moreover, Harrington *et al*. (2009) found a similar shift towards diurnal activity after the arrival of the otter on the River Thames (UK).

Mink culling campaigns are carried out essentially at night (Yamaguchi *et al*., 2002; Bonesi *et al*., 2006a; Melero, 2007). Our results suggest that trapping success could be increased if these management actions would be carried out also during the day, checking the traps at dusk and dawn.

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