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Short Note

Trophic niche comparison of American mink and Eurasian otter under different winter conditions

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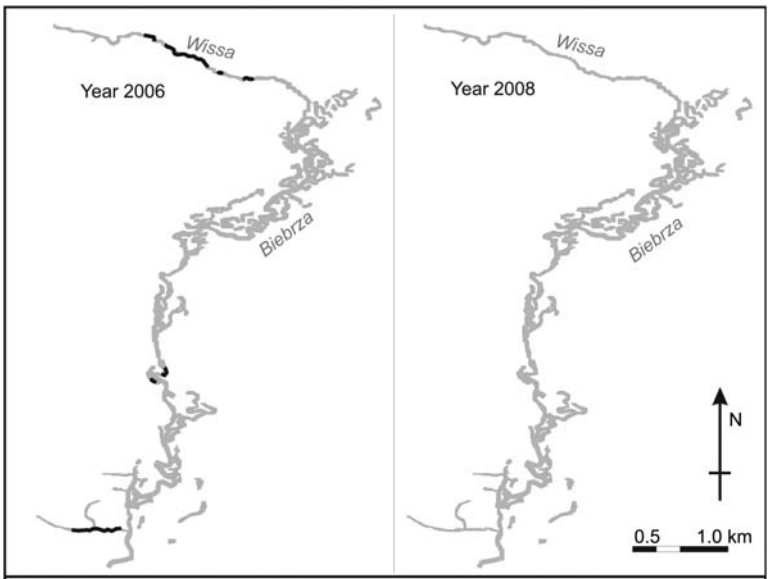
The American mink (*Neovison vison*) is an invasive alien species in Europe, which during the 20th century has colonized habitats occupied by the Eurasian otter and primarily inhabited by European mink (*Mustela lutreola*), now extinct. Today, as a result of escapes and deliberate releases from fur farms, the species is widely distributed across Europe (Bonesi and Palazon 2007). In Poland, the mink has already colonized over half of the territory, achieving the highest densities in northern and eastern parts of the country (Brzeziński and Marzec 2003). The mink is usually described as an opportunistic predator, characterized by variations in the diet composition between spring-summer and autumn-winter seasons, owing to differences in habitat-based prey distribution and abundance (e.g., Lode 1993, Sidorovich 2000, Jędrzejewska et al. 2001, McDonald 2002, Bartoszewicz and Zalewski 2003). By contrast, several studies describe the Eurasian otter (*Lutra lutra*) as a typical, specialized fish-eater (Ruiz-Olmo et al. 2001, McCafferty 2005, Lanszki and Sallai 2006). However, otters occupying different water habitats can change their preferences towards particular fish species and sizes, according to the alternative/main prey ratio (Lanszki and Sallai 2006, Remonti et al. 2007). Moreover, in case of populations inhabiting river banks, the river size and the type of riparian vegetation can also affect otters' diet, resulting in, e.g., increased share of amphibians in the diet (Jędrzejewska et al. 2001). In Poland, mink and otter occupy almost all types of aquatic habitats, but prefer unregulated rivers with rich riparian vegetation providing potential shelter, as well as lake districts (Brzeziński et al. 1996, Romanowski 2006).

The variation in diet composition and territory use compared between American mink and Eurasian otter was widely discussed in many studies across the Europe (e.g., Clode and Macdonald 1995, Sidorovich 2000, Jędrzejewska et al. 2001, Bonesi and Macdonald 2004, Bonesi et al. 2004, Melero et al. 2008, Harrington et al. 2009). Nevertheless, there is still not enough information about changes in the diet of these predators under different winter conditions affecting the availability of prey. As far as we are concerned, only Bonesi et al. (2000) and Sidorovich (2000) have compared trophic niches of both predators. Nevertheless, in both above studies only a single winter season was analysed, so there is no information about trophic interactions between mink and otter under varied winter conditions. However, our previous study shows, for the first time, that American mink is able to change its diet almost entirely between different winter seasons (Skierczyński et al. 2008). Unlike spring and summer, winter is a 'starvation season' for most predators. The availability of prey can be dramatically limited by low temperature, snow and ice cover. Thus during harsh winters small mammals and amphibians are hardly available, and ice cover on rivers allows for hunting for fish only if open water spots are accessible. In this study we focus on describing the diet composition of American mink and Eurasian otter under two varied winter periods.

The study area was located in the north-eastern Poland (52°34′N, 14°43′E), in the Biebrza Wetlands. Data were collected in 2006 (harsh winter) and 2008 (mild winter), under different conditions, such as: average temperature, water level, snow and ice cover (Figure 1). Research was conducted on the Biebrza River and its tribute Wissa, on a 21-km transect along river banks. Data on numbers of American mink and Eurasian otter were obtained from snow and mud tracking and observations of free-ranging individuals. Numbers of recorded animals were similar in both winter seasons (mink: 2006, n=7 and 2008, n=8; otter: 2006, n=3 and 2008, n=4). The diet analysis was based on 125 mink scats and 171 otter spraints collected in 2006 (n=60, n=78; both from 14 different locations) and 2008 (n=65 from 23 locations, n=93 from 34 locations). Mink scats were collected from their dens, identified as occupied on the basis of tracking and visual observations. The odour was also helpful in species identification (see Lode 1993). Otter spraints were collected from their latrines and near tracks. Prey remains separated from samples were weighted (0.01 g accuracy) and divided into five groups: invertebrates (Inv.), fish (Fis.), amphibians (Amp.), birds (Bir.) and mammals (Mam.). The relative biomass (BIO) of each prey group in the diet was calculated on the basis of dry mass of prey remains and digestion coefficients for both predators (Jędrzejewska et al. 2001, Brzeziński and Marzec 2003). We used the RFO (relative frequency of occurrence), the most frequently used method for diet comparison between otters living in various habitat conditions (e.g., Jędrzejewska et al. 2001, Clavero et al. 2003). To estimate differences in the diet we used direct uni-



Conditions (values given in average)	2006	2008
Snow depth (meadows)	10 cm	0 cm
Vegetation height (meadows)	0 cm	6 cm
Ice cover (river)	85%	0%
Open water (river)	15%	100%
Water level (river)	High	Very high
Temperature (air)	-5°C	+7°C

Figure 1 Winter conditions during two winter periods. Distribution of water spots free from ice cover was observed only during the harsh winter in year 2006 (black line).

modal canonical analysis (CCA) with the Monte Carlo permutation test (1000 permutations). We calculated differences in diet components between both predators and between winter seasons. Statistical analysis was performed using Canoco 4.5 for Windows software. To estimate the trophic niche overlap (α coefficient) we used Pianka's adaptation of Levins' formula which is varied from 0=no overlap, to 1=complete overlap (Pianka 1973).

We found several differences in diet composition of the American mink and Eurasian otter between winter seasons. During the harsh winter the mink diet consisted mainly of fish, birds and mammals (Table 1), whereas during the mild winter amphibians and mammals appeared to be the main source of food (Table 1). The analysis of otter diet between winter seasons did not show significant difference in the main prey, which was always fish (Table 1). The secondary prey were amphibians; however, they appeared in the otter diet only during the mild winter and their share did not exceed 20% of total prey biomass (Table 1). However, during the harsh winter we found a high number of invertebrates (mainly crayfish and mollusc species) in the diet of the otters (Table 1).

We found that the mink trophic niche differed between winter seasons. The main prey types responsible for such

Table 1 The diet of American mink and European otter during two different winter periods.

	Prey type (values given as % of RFO)					Prey type (values given as % of BIO)				
	Inv.	Fis.	Amp.	Bir.	Mam.	Inv.	Fis.	Amp.	Bir.	Mam.
Mink										
Harsh winter	0.1	32.9	1.9	21.5	43.7	1.6	39.8	1.2	24.4	33.0
Mild winter	0.1	2.7	27.2	1.2	68.8	0.3	2.7	43.1	3.1	50.7
Otter										
Harsh winter	17.2	82.2	0.0	0.0	0.0	3.1	96.9	0.0	0.0	0.0
Mild winter	3.0	84.0	13.0	0.0	0.0	0.7	91.7	7.6	0.0	0.0

Prey groups: Inv., invertebrates; Fis., fishes; Amp., amphibians; Bir., birds; Mam., mammals.
RFO, relative frequency of occurrence; BIO, biomass.

Table 2 Direct unimodal canonical analysis (CCA) of the American mink and Eurasian otter diet between different winter conditions.

Comparison type		Prey type	CCA statistics		
			λ	p	F
Harsh vs. mild winter	Mink	Fis.	0.22	0.002	10.08
		Bir.	0.10	0.019	5.02
		Amp.	0.09	0.028	4.75
		Inv.	0.02	0.272	1.28
		Mam.	0.01	0.451	0.58
	Otter	Inv.	0.15	0.009	8.35
		Amp.	0.08	0.031	4.75
		Fis.	0.05	0.091	2.85
		Bir.	–	–	–
		Mam.	–	–	–
Mink vs. otter	Harsh winter	Mam.	0.28	0.001	10.23
		Bir.	0.10	0.017	3.77
		Inv.	0.04	0.185	2.06
		Fis.	0.04	0.218	1.64
		Amp.	0.01	0.880	0.09
	Mild winter	Mam.	0.63	0.001	91.90
		Fis.	0.06	0.002	11.38
		Inv.	0.01	0.087	2.52
		Bir.	0.01	0.293	1.19
		Amp.	0.00	0.731	0.14

Prey groups: Inv., invertebrates; Fis., fishes; Amp., amphibians; Bir., birds; Mam., mammals.

differentiation were fish, birds and amphibians (Table 2, Figure 2). By contrast, the Eurasian otter trophic niche was very similar during both winter seasons, except for slight differences caused by the varying share of amphibians and invertebrates (Table 2, Figure 2). We found that: (1) under harsh winter conditions differences in trophic niches between both species were caused mainly by the mammal and bird component in the mink diet (Table 2, Figure 3); (2) under mild conditions, trophic niches of both predators diverged owing to the high contribution of fish in the otter diet and strong mammalian component in the mink diet (Table 2, Figure 3). The trophic niche overlap coefficient of the mink diet was

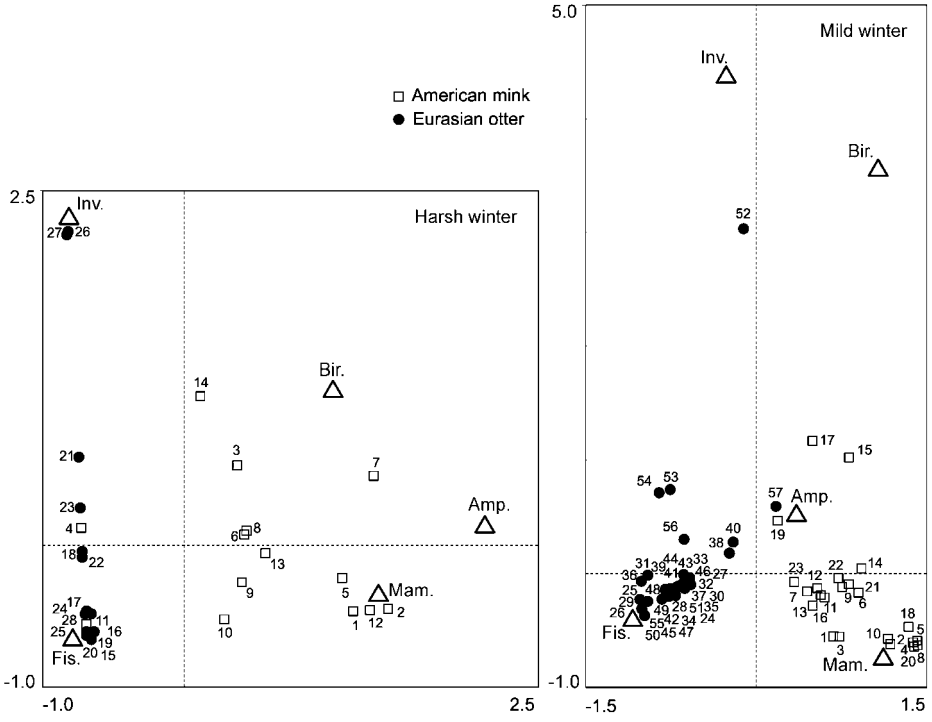


Figure 2 Inter-species trophic niche comparison under two different winter periods.

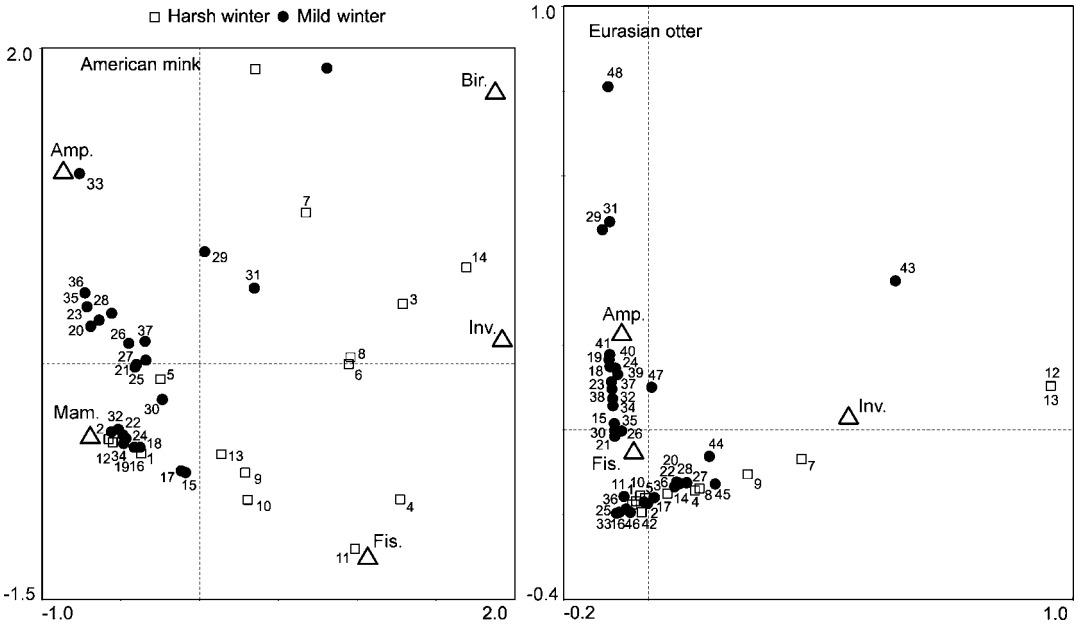


Figure 3 Intra-species trophic niche comparison under different winter periods.

different when winter seasons were compared (α=0.50). By contrast, the otter showed a stable and almost perfect trophic niche shift independently of winter seasons (α=0.97). We found that niche overlap between studied carnivores was greater under harsh conditions (α=0.49) compared with the mild winter (α=0.13).

Low temperature and the presence of ice cover are important factors reducing the availability of aquatic prey. In the studied area open water spots were present during the harsh winter allowing predators to catch fish more effectively (however, their abundance was sketchy). Under such conditions, American mink and Eurasian otter tracks and visual observations were usually located nearby open water spots. Similar behaviour of both species was also reported by Brzeziński et al. (2008). The higher amount of fish in the mink diet during the harsh winter can be explained by the presence of deep snow cover which resulted in the low availability of mammals, considered as an alternative prey group for this predator (Jędrzejewska et al. 2001). Thus, our results differ from those reported by Sidorovich (2000), who found that mink tended to feed mostly on mammals (80.6%) during the harsh winter. By contrast, during the mild winter fish became the marginal food source for mink and the dominant prey were amphibians and mammals. The Eurasian otters in the studied area relied on fish during the whole study period, however, their diet was supplemented with amphibians (mild winter) and invertebrates (harsh winter). Nevertheless, otters are particularly good swimmers and can dive for a longer time than minks (McDonald 2002), therefore during both winters they kept to fish as the main prey. Such a specialized feeding strategy is typical for otters, as also observed in the north-eastern part of Poland (Jędrzejewska et al. 2001), and other parts of Europe (Lanszki and Sallai 2006, Melero et al. 2008). During this study we discovered, however, an interesting feeding behaviour of the American mink. The food niche shift between different winter seasons demonstrates that this predator can change diet almost entirely to adapt to varying weather and habitat conditions. By contrast, the Eurasian otter seems to have a stable and narrow niche regardless of environmental conditions, as also reported in other studies (Jędrzejewska et al. 2001, Bonesi et al. 2004, Melero et al. 2008).

We found that the trophic niche overlap between considered carnivores was different than that reported by Sidorovich (2000). We observed that the niche overlap during harsh winter conditions was greater in the Biebrza Wetlands (0.49) than in the Lovat River (0.10). This might be explained by the different availability of particular prey types in both areas, although there are no data on prey abundance available for direct comparison. However, snow cover depth might be the crucial factor explaining the observed differences, causing poor accessibility of small mammals for the American mink and resulting in the niche overlap with the Eurasian otter. Moreover, during mild winter conditions the niche overlap index was lower in the Biebrza Wetlands (0.13) compared with results obtained in similar winter conditions by Sidorovich (2000) in the Lovat River mouth (0.79). Observed differences are mostly related to the share of amphibians in the diet of both carnivores (in the Lovat River amphibians were more frequently consumed by both mustelids than in the Biebrza Wetlands, possibly owing to their high availability).

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