

2008

American Mink (*Mustela vison*) and its impact on native species in the UK

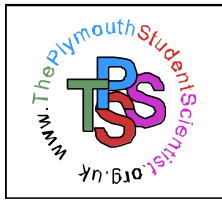
Rey, A.

Rey, A. (2008) 'American Mink (*Mustela vison*) and its impact on native species in the UK', The Plymouth Student Scientist, 1(2), pp. 302-314.

<http://hdl.handle.net/10026.1/13817>

The Plymouth Student Scientist
University of Plymouth

All content in PEARL is protected by copyright law. Author manuscripts are made available in accordance with publisher policies. Please cite only the published version using the details provided on the item record or document. In the absence of an open licence (e.g. Creative Commons), permissions for further reuse of content should be sought from the publisher or author.



American Mink (*Mustela vison*) and its impact on native species in the UK

Alex W. Rey

2008

Project Advisor: [Stephen Burchett](#), School of Biological Sciences, University of Plymouth, Drake Circus, Plymouth, PL4 8AA

Abstract

Introduced alien species are recognised to be a major threat to native biodiversity. The American mink (*Mustela vison*) is a highly adaptable, naturalised predator in the UK, introduced as part of the fur trade in the 1920's. The species became established in the wild in the 1950's through purposeful releases and escapes and since establishing the mink has been held accountable for the decline of many native species, most notably the water vole (*Arvicola terrestris*). There are currently nine species of carnivore in the UK, and American mink presents competition for native predators, particularly those that have similar lifestyles. In recent years interspecific competition within carnivore communities has been recognised as an important factor in the structuring of an ecosystem, and evidence suggests that competition from recovering otter populations are leading to declines in mink. In this review the American mink is discussed in the context of its ecology and invasive success, and its impact on biodiversity both as a predator and a competitor.

Introduction

It has been recognised that introduced species can have a major negative impact on biodiversity; other than loss of habitat the introduction of exotic species is considered to be the second widest global threat to biodiversity (Long 2003; Gittleman *et al.* 2001). The British Isles have experienced a considerable amount of introduced fauna and flora since the arrival of man and through extinction and introduction, the mammalian fauna has been altered significantly (Maroo & Yalden 2000; Manchester & Bullock 2000). Many of the species introduced to the UK have become well established and there have been targeted efforts to eliminate these introduced species, some successful but most un-successful (Manchester & Bullock 2000). One of the most well known of these is the extermination of the Coypu (*Myocastor coypus*), after it became established in the UK (Long 2003; Manchester & Bullock 2000).

Another well known introduced UK species is the Grey Squirrel (*Scirius carolinesis*), which, despite the vast amount of effort, has escaped eradication since its introduction. The Grey squirrel has become a somewhat famous icon of the problems with introduced species in the UK, particularly as it has been influential in the decline of the native Red squirrel (*Scirius vulgaris*), and is considered a major pest of the forestry sector (Long 2003; Manchester & Bullock 2000; Gurnell *et al.* 2004; Bryce *et al.* 2002). The Grey has out-competed the native Red, which is believed to be inferior in terms of foraging ability, thus limiting its competitive efficiency (Bryce *et al.* 2002). In its native range of North America, the Grey competes with multiple species of squirrel. The Red only competed intraspecifically, and when presented with another better-adapted species, it was unable to compete successfully. The probability of invasion success is increased for species that natively occur in a species rich community with high levels of interspecific competition (Sax *et al.* 2005). The Red is now so displaced by the presence of the Grey, despite nationwide culling, that it is widely accepted that the mainland population of the Red will become extinct (Harris *et al.* 1995).

The American mink (*Mustela vison*) was transported to many countries, far outside its native range of North America in the 1920's (Previtali *et al.* 1998; Ferreras & Macdonald 1999; Macdonald *et al.* 2002; Macdonald & Harrington 2003). The species popularity as a furbearer meant that it was transported to many countries to fur farms. It reached UK in the 1920's and through accidental escapes and intentional release became established in the wild by the 1950's (Kauhala 1996; Ferreras & Macdonald 1999; McDonald *et al.* 2007). Since the species 'feral' status in the UK it has been considered a problem to the preservation of native wildlife (Macdonald *et al.* 2002; Macdonald & Harrington 2003; Bonesi & Macdonald 2004). One of the earliest examples of this was the assumption that the mink could have been a factor in the decline of the native otter through competition, as the American mink was establishing in the wild at the same time as the otter was in decline, though this is widely accepted to be unlikely (McDonald *et al.* 2007). Now the mink is implicated in a myriad of conservation issues, in the UK and where it occurs in mainland Europe, (Kauhala 1996; Manchester & Bullock 2000; Aars *et al.* 2001; Macdonald *et al.* 2004) and Bowman *et al.* (2007) have suggested that feral mink which have escaped from fur farms are also a potential factor in the decline of wild mink in Alaska.

The aim of this review is to discuss American mink in the UK, its ecology and its impact on UK biodiversity through predation and competition with other species.

Ecology of the American Mink

The American mink is a member of the family Mustelidae (Genus Mustelinae), the largest family of the order Carnivora with 67 species (King & Powell 2007; Woodroffe 2007). It is characterised by a long sinuous body, short legs, a tail and a pointed muzzle, traits common to the Mustelidae (Johnson *et al.* 2000). Like all Mustelids, females are smaller than males (Birks & Dunstone 1985; Nowak 2005). Colour forms are variable, but typically vary from a dark blackish to brown, often with a white chin (Nowak 2005; Woodroffe 2007).

All members of the Mustelidae are carnivorous (Johnson *et al.* 2000; Woodroffe 2007; King & Powell 2007). As a generalist predator the diet of the mink is variable but predominantly comprises of fish and small to medium size mammals (e.g. *Microtus agrestis* or *Oryctolagus cuniculus*). Carrion, amphibians, birds, crustaceans and other invertebrates also form part of the diet (See Table 1). (Birks & Dunstone 1985; Maran *et al.* 1998; Ferreras & Macdonald 1999; Macdonald & Harrington 2003; Nowak 2005). Birks and Dunstone (1985) recognised sexual dimorphism in the diet of American mink. Through identification of prey items in scats, it was found that females were more inclined to predate aquatic prey, e.g. crustaceans and fish, whereas males preferred larger terrestrial prey, such as rabbits (*Oryctolagus cuniculus*). Sexual dimorphism can reduce intraspecific competition in that males and females of the species are less likely to compete with each other for exploitation of prey when living sympatrically within a territory (McDonald 2002). This, and the fact that the mink has a generalist diet, has probably aided its establishment in the UK (Birks & Dunstone 1985).

The American mink is a small semi-aquatic mustelid, with a preferential habitat of densely vegetated rivers or streams (Previtali *et al.* 1998; Bonesi *et al.* 2000; Macdonald & Harrington 2003; Nowak 2005). The generalist diet of the mink also allows it to exploit a number of habitats, although its use of habitat appears to be dependent on competition and abundance and availability of resources, particularly food and it appears always tied to water (Bonesi *et al.* 2000; Bonesi *et al.* 2004).

	Occurrence (%) (n = 184)	Dry weight (%) (W = 140 g)	Ingested biomass (%)	Energetic value (KJ g ⁻¹)	Ingested energy (%)
Rabbit	28.4	33.0	45.4	6.21	42.8
Fish	17.7	18.2	25.1	7.00	26.7
Small mammals	23.9	22.2	13.8	6.34	13.2
Rallidae (coot/moorhen)	13.0	12.9	10.1	7.35	11.2
Passerines	4.0	4.5	2.1	7.29	2.3
Crustacean	4.0	0.5	0.2	3.00	<0.1
Anatidae	3.9	3.7	2.4	7.35	2.7
Undetermined bird	2.8	1.9	0.9	7.29	1.0
Insects	2.3	0.1	<0.1	3.00	<0.1

Table 1: Diet composition of American mink estimated from scats (n = 115) collected in upper Thames in 1996 (After Ferreras & Macdonald 1999)

The American mink is a solitary species, except at times of breeding, although the female is the sole carer when raising young (Nowak 2005). The American mink has a unique reproductive process (Nowak 2005; Macdonald & Harrington 2003). Females exhibit superfecundation (multiple ova from a single ovum) and super foetation (multiple ovations within a single mating season) (Macdonald & Harrington 2003). Among Mustelids mink are unusual in that, despite delayed implantation, the gestation period is only up to 35 days long (Macdonald & Harrington 2003). This mechanism has undoubtedly helped the American mink colonise areas where it can reproduce quickly, compensating population losses with a high reproductive rate leading to increased establishment success (Owens & Bennet 2000; Fisher & Owens 2004).

The American mink is widespread in the UK and can be found in most regions of England and Wales (See Figure 1) (Harris *et al.* 1995; Crawford 2003; Long 2003). In the south of Scotland the mink is more common than the north (Aars *et al.* 2001), but is considered abundant where it does occur (Kruuk *pers. comm.*).

American mink as a predator

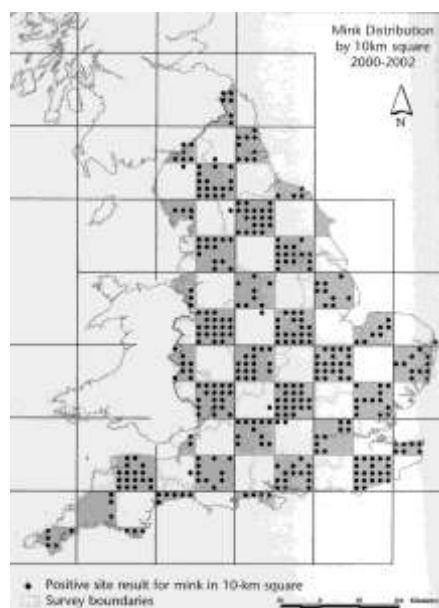
Where American mink occurs as an introduced species it has been implicated in the decline of native fauna (Barreto *et al.* 1998; Previtali *et al.* 1998; Maran *et al.*, 1998; Ferreras & Macdonald 1999; Manchester & Bullock 2000; Aars *et al.* 2001;

Macdonald *et al.* 2002). Merely as a top predator the mink will have an impact on fauna, however, there have been significant correlations found which suggest that some species are particularly vulnerable to mink predation (Barreto *et al.* 1998; Ferreras & Macdonald 1999; Rushton *et al.* 2000; Aars *et al.* 2001).

Most notable of these is the Water vole (*Arvicola terrestris*) for which the mink is considered the second most important reason for the decline in the species (Rushton *et al.* 2000; Aars *et al.* 2001; Macdonald *et al.* 2007). The change in use of agricultural land is considered to be the most important (Rushton *et al.* 2000). In the early half of the 20th century one third of agricultural land was covered by rough semi-natural vegetation to allow for extensive cattle grazing, with a change in practice to arable farming, important water vole habitat was lost (Rushton *et al.* 2000; Macdonald & Harrington 2003). Based on these factors and the assumed intense predation by American mink, the water vole has now become the most endangered British mammal (Aars *et al.* 2001).

There is evidence to suggest that the mink is a key component in the decline of the water vole. Aars *et al.* (2001) considered the impact of disturbance on water vole

Figure 1: Distribution of American mink in England (After Crawford 2003)



populations after the American mink introduction. The study was conducted in the Scottish uplands, on water vole populations north of the mink's invasive front and these were compared to populations in areas of similar habitat on the edge of the mink's range. They found that the colonies of water vole studied consisted of smaller metapopulations, this structure being independent of the presence of mink, with local extinctions and re-colonisation of areas being commonplace. Where the mink occurred at all times, on the edge of its invasion front, water vole were more prone to local extinction because of predation by mink. This shows that despite the water vole being a species that lives naturally in small isolated metapopulations, mink presence can have a negative affect on the re-colonisation of areas through intense predation.

Water voles are known to actively avoid areas where mink are present. Barreto *et al.* (1998) found that the mink was a significant factor in the decline of water vole in the Thames river catchments in Southern England. They found that water vole were pressured to live in areas which were negatively favourable to them but were free of mink. There does indeed appear to be a correlation in the decline of water vole and the presence of mink, and furthermore correlations of this type have also been found in other areas of Europe where the mink has been introduced. Macdonald *et al.* (2002) found that there was a significant correlation between mink occurrence in Belarus and the decline in water vole suggesting that mink were a key reason for the decline of the species in that area. It has been suggested that the sexual dimorphism in size of American mink mean that females are more likely to predate on water vole as they are small enough to hunt the species in areas of cover (Birks & Dunstone, 1985).

Ferreras and Macdonald (1999) investigated the impact of American mink on water birds in the upper Thames. Water bird (Rallidae) abundance and breeding success was surveyed and mink scats analysed for predation on water birds. They found that coot (*Fulica atra*) numbers were affected by mink presence, hypothesising that this occurred because of two reasons; either the coot were avoiding mink inhabited areas or there was a direct reduction in coot numbers via mink predation. They also found that in areas occupied by mink, fewer chicks per breeding pair were born and the proportion of hatchings was lower. They also found a negative, though not significant, impact of mink on moorhen (*Gallinula chloropus*) numbers (See Table 2).

	With mink		No mink		
	<i>n</i>	Mean \pm SE (min – max)	<i>n</i>	Mean \pm SE (min – max)	<i>t</i> -test
Coot					
Number of pairs	28	0.6 \pm 0.1 (0–2)	38	1.0 \pm 0.2 (0–4)	*
Number of nests per pair	12	2.2 \pm 0.4 (1–6)	21	2.1 \pm 0.2 (1–5)	NS
Number of clutches per pair	12	1.1 \pm 0.2 (0–2)	21	1.2 \pm 0.1 (0–2)	NS
Number of chicks per pair	12	1.9 \pm 0.7 (0–6)	21	2.4 \pm 0.5 (0–8)	NS
% hatched clutches	10	59.2 \pm 13.3 (0–100)	19	55.0 \pm 9.3 (0–100)	NS
% hatched eggs	9	40.5 \pm 13.1 (0–100)	19	41.3 \pm 8.0 (0–100)	NS
Moorhen					
Number of pairs	28	1.6 \pm 0.2 (0–4)	38	1.6 \pm 0.2 (0–4)	*
Number of nests per pair	26	1.7 \pm 0.2 (1–4)	34	2.5 \pm 0.2 (1–7)	
Number of clutches per pair	26	1.2 \pm 0.1 (0–3)	34	1.5 \pm 0.1 (0–3)	
Number of chicks per pair	26	2.2 \pm 0.4 (0–7)	34	2.1 \pm 0.3 (0–5)	NS
% hatched clutches	25	82.2 \pm 6.5 (0–100)		64.0 \pm 6.2 (0–100)	*
% hatched eggs	25	28.0 \pm 3.7 (0–83)	32	26.5 \pm 4.5 (0–83)	NS

Table 2: Average number, standard error (SE), minimum and maximum birds per 500m sector (n = number of sectors, excluding those sectors with either no pairs or missing values). Statistics are also shown for nesting success parameters (averaged per 500m sector). Results of univariate tests or comparing mink and no mink areas are shown for the bird variables (NS = not significant; * $P < 0.05$) (After Ferreras & Macdonald 1999)

There is evidence to suggest that mink is responsible for the decline of native UK species and the species ability to significantly impact on biodiversity is also supported by evidence from other regions (e.g. Macdonald *et al.* 2002). However as a generalist predator it cannot be distinguished as the single factor in the decline of species as it is not dependent on those prey sources exclusively. Mink diet also differs between individuals, between sexes and may be dependent on seasonal availability of habitat and resources (Macdonald & Harrington 2003; Bonesi *et al.* 2004).

Rather than being a key factor in the decline of water vole it is more likely that intense predation by mink was the final push of a species already on the edge because of habitat degradation (Macdonald *et al.* 2007). Forman (2005) identified that there was a bias against mink in scientific and popular press. He found that both Heron (*Ardea cinerea*) and Red Fox (*Vulpes vulpes*) were key predators of water vole, and suggested that the impact of native predators on the water vole need further research.

Predator	Frequency of occurrence (%)	County/area	Source
Otter	0.5	Somerset	Webb (1977)
	14	Deeside	Jenkins, Walker & McCowan (1979)
	2.8	Gwynedd	D. W. Forman (pers. obs.)
	5.9	Gwynedd	D. W. Forman (pers. obs.)
Mink	3.3	Devon	Chanin & Linn (1980)
	13	Central and southern England	Strachan <i>et al.</i> (1998)
	20	Yorkshire	Howes (1979)
Fox	30	Carmarthenshire	This study
	91	England	Lowe (1954)
Heron	17	Carmarthenshire	This study
	12	Yorkshire	Glue (1974)
Barn owl	15	Norfolk	Glue (1974)
	16	Somerset	Glue (1974)
	35	Kent	Glue (1974)
	14	Southern England	Love <i>et al.</i> (2000)

Table 3: Local occurrence of water vole in the diet of native predators (After Forman 2000).

American Mink as a competitor

There are currently eight species of native mammalian carnivore in the UK, six Mustelids (*Mustela nivalis*, *M. erminea*, *M. putorius*, *Martes martes*, *Meles meles*, *Lutra lutra*) one Canid (*Vulpes vulpes*) and one Felid (*Felis sylvestris*). The American mink is the ninth resident carnivore, and as such potentially presents competition for the other carnivore species, particularly as it is a generalist predator and does not exploit a vacant niche. Understanding carnivore communities and how the species within these guilds interact is of considerable importance in wildlife conservation as top predators can have a considerable impact on an ecosystem and other organisms (Palomares & Caro 1999; Linnell & Strand 2000; Johnson *et al.* 2000; Neale & Sacks 2001; McDonald 2002; Vieira & Port 2006). Relationships such as these are becoming increasingly interesting to conservation science (Palomares & Caro 1999; St-Pierre *et al.* 2006).

A guild is characterised by sympatric taxa which use similar resources, and this use of resources can lead to direct and indirect competition, including the direct (intraguild) predation of members of that guild (Lodé 1993; McDonald 2002; St-Pierre *et al.* 2006; Davies *et al.* 2007). This common usage of resources, primarily prey, can lead to interspecific competition between carnivores (Neale & Sacks 2001; Arim & Marquet 2004). There are numerous examples of interspecific competition and intraguild predation in the natural world, particularly in mammalian carnivore communities, and in general size dictates dominance (e.g. larger species dominant over smaller) (Palomares & Caro 1999; Wu 1999; Delibes *et al.* 2003; Macdonald *et al.* 2004). To avoid potential competition it is predicted that species exhibit niche differentiation or resource partitioning to avoid competition (Wu 1999).

As a semi aquatic predator there are two main UK mammalian carnivores which could present competition for the American mink if they live sympatrically; the Otter (*Lutra lutra*) and the Polecat (*Mustela putorius*). Both species are aquatic (otter) and semi-aquatic (polecat) and could present competition for the mink as they exhibit overlap in diet and habitat preference (Lodé 1993; Bonesi & Macdonald 2004a; Bonesi *et al.*

2004b; Bonesi *et al.* 2004). Neither are common in the UK, having been subject to persecution, practically to national extinction (Griffiths 2000; Crawford 2003). The absence of these species probably aided to the American mink's colonisation of the UK, as there was little competition and vacant niches to exploit (McDonald 2007). Both of these species are now increasing in the UK and this could draw them into conflict with mink (Griffiths 2000; Crawford 2003; Macdonald & Harrington 2003).

The otter, which uses riparian and coastal habitats as does the mink (Woodroffe 2007; Kruuk *pers. comm.*) has been the most thoroughly investigated species in terms of its recovery impacting on American mink, although the evidence is not conclusive (Bonesi & Macdonald 2004a; Bonesi *et al.* 2004b; Bonesi *et al.* 2004; McDonald *et al.* 2007; Kruuk *pers. comm.*). In a review of competition and co-existence in Mustelid communities Powell and Zielinski (1983) reported that due to differences in habitat use and minimal dietary overlap the American mink and otter do not compete extensively and can co-exist. Kruuk (*pers. comm.*) commented that he had observed mink and otter sharing the same holt / den where they occur sympatrically. In its native range the American mink lives sympatrically with the River otter (*Lutra canadensis*) through niche separation allowing minimal competition and co-existence (Ben-David *et al.* 1995). Indeed, there has also been co-existence demonstrated in communities where species with similar niche use as American mink and otter live sympatrically (Somers & Purves 1996). However, research conducted in Europe including the UK suggests that American mink and otter cannot co-exist, with otter displacing mink (Bonesi & Macdonald 2004a; Bonesi *et al.* 2004b; Bonesi *et al.* 2004; McDonald *et al.* 2007).

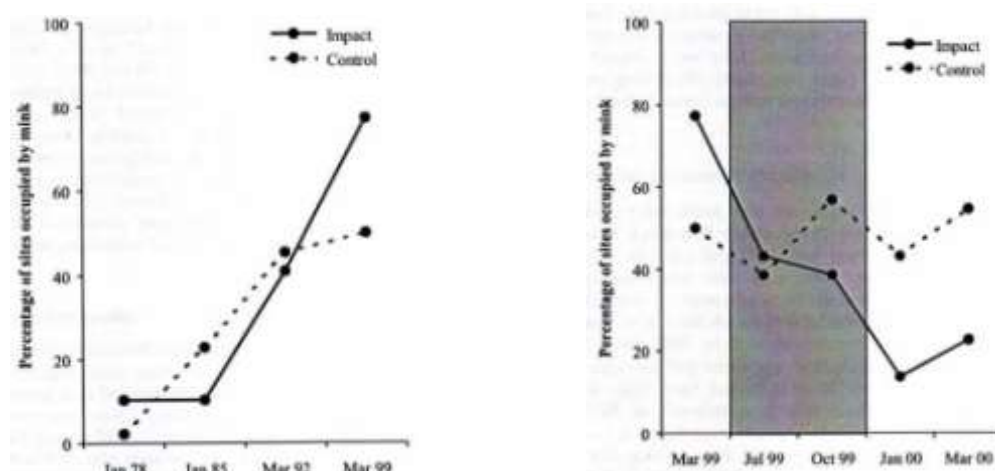


Figure 2: The percentage of site occupancy in the 'Impact' (where otter were released) and 'Control areas' (no otter). The grey block represents when otter were released. (After Bonesi & Macdonald 2004)

Bonesi and Macdonald (2004a) demonstrated this with an experimental approach. In an area where otters were being reintroduced, they investigated the impact of the otter on the established mink population. They found that mink declined dramatically with the release of otter with the percentage of mink occupied sites decreasing from 77% to 23% (See Figure 2). The spatial patterns of mink were also measured. Prior to otter release, mink were widely distributed throughout the survey site. Upon release of otter, mink had disappeared from almost all otter occupied areas. Mink later re-colonised the area, but the population became fragmented occupying areas of minimal otter activity. The findings of this study provide strong evidence that increasing otter numbers reduce mink numbers, through competition. McDonald *et al.* (2007) found similar

results, however, Bonesi and Macdonald point out that although the results of their study indicate a decline in mink numbers, it may be that mink were instead exploiting other habitats where the otter will not occur, rather than actual population decreases, supporting the theory that sympatric potential competitors will exhibit niche separation to minimise competition (Wu 1999; Bonesi & Macdonald, 2004a; Bonesi & Macdonald 2004b).

To date there have been no studies on the impact of polecat recovery on mink in the UK. It is believed that where otter displace mink, and drive them inland they are brought into competition with more terrestrial species, including polecat if it is present (Crawley *pers. comm.*). In western France, where the species occur sympatrically Lodé (1993) found that in habitats which supported a greater diversity of prey resources mink and polecat can co-exist, despite a great overlap in habitat use (See Table 4 and Table 5). In Europe, Sidorovich *et al.* (1999) noted that before the arrival of American mink the native European mink (*M. lutreola*) and polecat co-existed sympatrically. They suggest that differences in size (*M. lutreola* are smaller than *M. putorius*) between males and females of both species allowed greater co-existence and minimised competition. Interestingly Sidorovich *et al.* (1999) also found that presence of American mink led to a decrease in European mink.

	European polecat				American mink			
	Autumn	Winter	Spring	Total	Autumn	Winter	Spring	Total
n prey items	45	53	30	128	35	35	22	92
Mammals	84.4	96.2	56.7	82.8	45.7	48.6	22.7	41.3
Norway rat	22.2	30.2	10.0	22.6	11.4	14.3	4.5	10.9
Vole	48.9	54.7	46.7	50.8	22.9	14.3	18.2	18.5
Muskrat	4.4	3.8	—	3.1	8.6	11.4	—	7.6
Rabbit	2.2	—	—	0.8	2.9	2.9	—	2.2
Shrew	6.7	7.5	—	5.5	—	5.7	—	2.2
Birds	—	—	3.3	0.8	22.9	17.1	27.3	21.7
Amphibians	13.3	—	40.0	14.1	—	—	18.2	4.3
Fish	—	—	—	—	31.4	31.4	31.8	31.5
Cyprinids	—	—	—	—	25.7	17.1	22.7	21.7
Eel	—	—	—	—	2.9	2.9	—	2.2
Perch	—	—	—	—	2.9	2.9	4.5	3.3
Other	—	—	—	—	—	8.6	4.5	4.3
Invertebrates	2.2	3.8	—	2.3	—	2.9	—	1.1
Index H' =	0.707	0.243	1.143	0.789	1.527	1.615	1.969	1.831

Table 4: Frequency (%) occurrence of prey in the scats of Polecat and American mink (After Lodé 1993)

	European polecat				American mink			
	Autumn	Winter	Spring	Total	Autumn	Winter	Spring	Total
Woodland	60.1	47.2	2.3	40.8	10.3	9.7	1.1	5.8
Meadow	18.9	9.7	—	11.4	27.6	5.5	2.2	7.4
Marsh and ditches	20.9	43.1	97.7	47.8	62.1	84.7	96.6	86.6
n	148	72	86	306	29	72	89	190

Table 5: Percentage of habitat use by polecat and American mink (After Lodé 1993)

The American mink is similar in size and resource use to the polecat, so it may be expected to compete to a greater extent than the European mink. As mentioned, in an ecosystem with more than one predator, size can dictate dominance hierarchy intra- and interspecifically. When species come into competition which are of a similar size it may be expected that morphological changes will occur which will minimise competition (Dayan & Simberloff 2005; Meiri *et al.* 2007), so it may be expected that polecat recovery will lead to character displacement of mink or that mink presence will suppress either polecat recovery or result in character displacement of polecat (Sidorovich *et al.* 1999)

Conclusion

The American mink has undoubtedly had an impact on UK biodiversity, and when considering the species in the context of the damage it has caused to the native fauna, many people find it easy to blame the species (Forman 2005). It has been shown that other factors have affected species decline in the UK, and mink are merely a definitive factor (Forman 2005; Macdonald *et al.* 2007). It is widely believed that extermination of American mink will benefit species in decline due to reduction in mink predation (Aars *et al.* 2000). When considering the potential of increased native UK fauna through extermination of the American mink, Macdonald and Harrington (2003) characterised the reality of the process; "But that triumph, if it comes, will be bought at the cost of another tragedy – the deaths at human hands of many American mink. The cause of both these tragedies lies not with the American mink, or the marvel of their adaptability, but with the thoughtlessness with which people dispersed them."

There is considerable amount of literature on the impact of American mink on native fauna in areas where it has been introduced (Barreto *et al.* 1998; Previtali *et al.* 1998; Ferreras & Macdonald 1999; Sidorovich *et al.* 1999; Aars *et al.* 2001; Macdonald *et al.* 2002) and it is becoming increasingly interesting to understand the potential impact of recovering native predators on the American mink (Bonesi & Macdonald 2004a; Bonesi *et al.* 2004b; Bonesi *et al.* 2004; McDonald *et al.* 2007).

There is unquestionably a need for management of the mink in the UK. A nationwide cull would have to be managed at a high level and would require the same effort used for the extermination of the coypu (Macdonald & Harrington 2003). It should not be practiced carelessly, would be extremely expensive and more than just a question of conservation priorities, it would raise ethical questions (Aars *et al.* 2000; Long 2003; Macdonald *et al.* 2007). Instead of this, it is proposed that through competition with species for habitat and resources, recovering native predators, particularly otter, will be a significant implication in the management of American mink in the UK possibly leading to its decline (Bonesi & Macdonald 2004a; Bonesi & Macdonald 2004b; McDonald *et al.* 2007; Crawley *pers. comm.*).

There have been studies conducted on this in recent years suggesting that competition with other species lead to mink decline, although the evidence is not conclusive and needs more research (Powell & Zielinski 1983; Bonesi & Macdonald 2004a; Bonesi *et al.* 2004b; McDonald *et al.* 2007; Kruuk *pers. comm.*), particularly into the impact the presence of both polecat and mink will have on each other. Understanding the relationships between the otter and mink, and polecat and mink,

could prove beneficial in the conservation of native fauna, such as the water vole, and in the management of the naturalised American mink.

As a way of understanding this, my wider research project will be investigating the impact of recovering otter populations on American mink in the UK by assessing published data on this subject. The hypothesis for this project will be that an increase in otter will lead to a decrease in American mink through competition for resources, primarily habitat.

References

- AARS, J., LAMBIN, X., DENNY, R. & GRIFFIN, A. C. (2001) Water vole in the Scottish uplands: distributions patterns of disturbed and pristine populations ahead and behind the American mink invasion front. *Animal Conservation*, 4, 187-194.
- ARIM, M. & MARQUET, A. (2004) Intraguild predation: a widespread interaction related to species biology. *Ecology Letters*, 7, 557-564.
- BARRETO, G., RUSHTON, S. & MACDONALD, D. (1998) The role of habitat and mink predation in determining the status and distribution of water voles in England. *Animal Conservation*, 1, 129-137.
- BEN-DAVID, M., BOWYER, R. T. & FARO, J. B. (1995) Niche separation by mink and river otters: coexistence in a marine environment. *Oikos*, 75, 41-48.
- BIRKS, J. D. S. & DUNSTONE, N. (1985) Sex-related differences in the diet of the mink *Mustela vison*. *Holarctic Ecology*, 8, 245-252.
- BONESI, L., DUNSTONE, N. & O'CONNELL, M. (2000) Winter selection of habitats within intertidal foraging areas by mink (*Mustela vison*). *Journal of Zoology*, 250, 419-424.
- BONESI, L. & MACDONALD, D. (2004a) Impact of released Eurasian otters on a population of American mink: a test using an experimental approach. *Oikos*, 106, 9-18.
- BONESI, L. & MACDONALD, D. (2004b) Differential habitat use promotes sustainable coexistence between the specialist otter and the generalist mink. *Oikos*, 106, 509-519.
- BONESI, L., CHANIN, P. & MACDONALD, D. W. (2004) Competition between Eurasian otter *Lutra lutra* and American mink *Mustela vison* probed by niche shift. *Oikos*, 106, 19-26.
- BOWMAN, J., KIDD, A. G., GORMAN, R. M. & SCHULTE-HOSTEDDE, A. (2007) Assessing the potential for impacts by feral mink on wild mink in Canada. *Biological conservation*, 139, 12-18.
- BRYCE, J., JOHNSON, P. & MACDONALD, D. (2002) Can niche use in red and grey squirrels offer clues for their apparent coexistence. *Journal of Applied Ecology*, 39, 875-887.
- CRAWFORD, A. (2003) Fourth Otter Survey of England 2000-2002. Bristol, Environment Agency.
- DAVIES, T. J., MEIRI, S., BARRACLOUGH, T. G. & GITTLEMAN, J. L. (2007) Species co-existence and character divergence across carnivores. *Ecology Letters*, 10, 146 - 152.
- DAYAN, T. & SIMBERLOFF, D. (2005) Ecological and community-wide character displacement: the next generation. *Ecology Letters*, 8, 875-894.

- DELIBES, M., TRAVAINI, A., ZAPATA, S. C. & PALOMARES, F. (2003) Alien mammals and the trophic position of the lesser grison (*Glaictis cuja*) in Argentinean Patagonia. *Canadian Journal of Biology*, 81, 157-162.
- FERRERAS, P. & MACDONALD, D. (1999) The impact of American mink *Mustela vison* on water birds in the upper Thames. *Journal of Applied Ecology*, 36, 701-708.
- FISHER, D. O. & OWENS, I. P. F. (2004) The comparative methods in conservation biology. *Trends in Ecology and Evolution*, 19, 391-398.
- FORMAN, D. W. (2005) An assessment of the local impact of native predators on an established population of British water voles (*Arvicola terrestris*). *Journal of Zoology*, 266, 221-226.
- GITTLEMAN, J. L., FUNK, S., MACDONALD, D. & WAYNE, R. (Eds.) (2001) *Carnivore Conservation*, Cambridge, Cambridge University Press.
- GRIFFITHS, H. I. (2000) *Mustelids in a Modern World*, Leiden, Backhuys Publishers.
- GURNELL, J., WAUTERS, L., LURZ, P. & TOSI, G. (2004) Alien species and interspecific competition: effects of introduced eastern grey squirrels on red squirrel dynamics. *Journal of Animal Ecology*, 73, 26 - 35.
- HARRIS, S., MORRIS, P., WRAY, S. & YALDEN, D. (1995) A review of British mammals: population estimates and conservation status of British mammals other than cetaceans. JNCC.
- JOHNSON, D., MACDONALD, D. & DICKMAN, A. (2000) An analysis and review of models of the sociobiology of the Mustelidae. *Mammal Review*, 30, 171-196.
- KAUHALA, K. (1996) Distributional history of the American mink (*Mustela vison*) in Finland with special reference to the trends in otter (*Lutra lutra*) populations. *Annales Zoologici Fennici*, 33, 283 - 291.
- KING, C. M. & POWELL, R. A. (2007) *The Natural History of Weasels and Stoats: Ecology, Behaviour, and Management*, Oxford, Oxford University Press.
- LINNELL, J. D. & STRAND, O. (2000) Interference interactions, co-existence and conservation of mammalian carnivores. *Diversity and Distributions*, 6, 169-176.
- LODE, T. (1993) Diet composition and habitat use of sympatric polecat and American mink in western France. *Acta Theriologica*, 38, 161-166.
- LONG, J. (2003) *Introduced Mammals of the Worlds: Their History, Distribution and Influence*, Collingwood, CSIRO Publishing.
- MACDONALD, D., SIDOROVICH, V. E., ANISMOVA, E., SIDOROVICH, N. V. & JOHNSON, P. (2002) The impact of American mink *Mustela vison* and European mink *Mustela lutreola* on water voles *Arvicola terrestris* in Belarus. *Ecography*, 25, 295-302.
- MACDONALD, D. & HARRINGTON, L. (2003) The American mink: the triumph and tragedy of adaptation out of context. *New Zealand Journal of Zoology*, 30, 421-441.
- MACDONALD, D., BUESCHING, C. D., STOPKA, P., HENDERSON, J., ELLWOOD, S. & BAKER, S. (2004) Encounters between two sympatric carnivores: red foxes (*Vulpes vulpes*) and European badgers (*Meles meles*). *Journal of Zoology*, 263, 385-392.
- MACDONALD, D., KING, C. M. & STRACHAN, R. (2007) Introduced species in the line between biodiversity conservation and naturalistic eugenics. IN MACDONALD, D. & SERVICE, K. (Eds.) *Key Topics in Conservation Biology*. Oxford, Blackwell Publishing.

- MANCHESTER, S. & BULLOCK, J. (2000) The impacts of non-native species on UK biodiversity and the effectiveness of control. *Journal of Applied Ecology*, 37, 845-864.
- MARAN, T., KRUUK, H., MACDONALD, D. & POLMA, M. (1998) Diet of two species of mink in Estonia: displacement of *Mustela lutreola* by *Mustela vison*. *Journal of Zoology*, 256, 218-222.
- MAROO, S. & YALDEN, D. W. (2000) The Mesolithic mammal fauna of Great Britain. *Mammal Review*, 30, 243-248.
- MCDONALD, R. A. (2002) Resource partitioning among British and Irish mustelids. *Journal of Animal Ecology*, 71, 185-200.
- MCDONALD, R. A., O'HARA, K. & MORRISH, D. J. (2007) Decline of invasive alien mink (*Mustela vison*) is concurrent with recovery of native otters (*Lutra lutra*). *Diversity and Distributions*, 13, 92-98.
- MEIRI, S., DAYAN, T. & SIMBERLOFF, D. (2007) Guild composition and mustelid morphology - character displacement but no character release. *Journal of Biogeography*, -, 1-11.
- NEALE, J. & SACKS, B. (2001) Resource utilization and interspecific relations of sympatric bobcats and coyotes. *Oikos*, 94, 236-249.
- NOWAK, R. M. (2005) *Carnivores of the World*, Baltimore, John Hopkins University Press.
- OWENS, I. P. F. & BENNETT, P. M. (2000) Ecological basics of extinction risk in birds: habitat loss versus human persecution and introduced predators. *Proceedings of the National Academy of Science* 97, 12144-12148.
- PALOMARES, F. & CARON, T. M. (1999) Interspecific Killing Among Mammalian Carnivores. *The American Naturalist*, 153, 492-508.
- POWELL, R. A. & ZIELINSKI, W. J. (1983) Competition and coexistence in mustelid communities. *Acta Zoologica Fennici*, 174, 223-227.
- PREVITALI, A., CASSINI, M. H. & MACDONALD, D. (1998) Habitat use and diet of the American mink (*Mustela vison*) in Argentinian Patagonia. *Journal of Zoology*, 246, 482-486.
- RUSHTON, S., BARRETO, G., CORMACK, R. M., MACDONALD, D. & FULLER, R. (2000) Modelling the effects of mink and habitat fragmentation on the water vole. *Journal of Applied Ecology*, 37, 475-400.
- SAX, D. F., STACHOWICZ, J. J. & GAINES, S. D. (2005) *Species Invasions: Insights into Ecology, Evolution and Biogeography*, USA, Sinauer Associates.
- SIDOROVICH, V., KRUUK, H. & MACDONALD, D. (1999) Body size, and interactions between European and American mink (*Mustela lutreola* and *M. vison*) in Eastern Europe. *Journal of Zoology*, 248, 521-527.
- SOMERS, M. J. & PURVES, M. G. (1996) Trophic overlap between three syntopic semi-aquatic carnivores: Cape clawless otter, spotted-necked otter and water mongoose. *African Journal of Ecology*, 34, 158-166.
- ST. PIERRE, C., OUELLET, J. & CRETE, M. (2006) Do competitive intraguild interactions affect space and habitat use by small carnivores in a forested landscape? *Ecography*, 29, 487-496.
- VIEIRA, E. M. & PORT, D. (2006) Niche overlap and resource partitioning between two sympatric fox species in southern Brazil. *Journal of Zoology*, 272, 57-63.
- WU, H.-Y. (1999) Is there current competition between sympatric Siberian Weasels (*Mustela sibirica*) and Ferret Badgers (*Melogale moschata*) in a subtropical forest ecosystem of Taiwan? *Zoological Studies*, 38, 443-451.