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17

The continuing decline of the European mink *Mustela lutreola*: evidence for the intraguild aggression hypothesis

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Introduction

European mink, *Mustela lutreola* (Linnaeus 1761) look so similar to American mink, *Mustela vison* (Schreber, 1777) that the two were formerly distinguished only as subspecies (Ognev, 1931; Heptner *et al.*, 1967; for a review, see Novikov, 1939). This similarity offers not only a striking instance of convergence, but also a plausible explanation of the European mink's precipitous decline to the verge of extinction. In fact, phylogenetically the European mink is probably closest to the Siberian polecat, *Mustela sibirica* (Pallas, 1773), whilst the American mink is the most aberrant in the genus *Mustela* (Lushnikova *et al.*, 1989; Graphodatsky *et al.*, 1976; Youngman, 1982).

The European mink was formerly widespread in eastern Europe, but has declined over a long period and by 1990 was clearly endangered (Maran, 1994*b*). Here, after reviewing briefly the species' biology, we will present the results of an up-dated survey of the European mink's status. Against that background we will present a critical review of hypotheses that might explain its decline, dwelling in particular on two that we will subject to a preliminary test by presenting new data. These two implicate the American mink, first through the transmission of disease and second as a direct aggressor. Concerning the possibility that direct aggression between the endemic and alien mink disadvantages the native species, we have in mind that intraguild competition between the two must be evaluated in the context of the entire guild. Therefore, when, elsewhere, we present data on the possibility of competition for food between these congeners, we do so in the context also of the diets of European polecat (*Mustela putorius*) and otter (*Lutra lutra*) (see Chapter 11).

The European mink, of which six subspecies have been distinguished (Novikov, 1939; Heptner *et al.*, 1967), but not universally accepted (Ogney, 1931; Youngman, 1982), is an inconspicuous denizen of small, undisturbed water-courses with rapid currents and lush riparian vegetation, in forested areas (Novikov, 1939; Danilov & Tumanov, 1976*a,b*; Sidorovich *et al.*, 1995). Their prey includes fish, amphibians, small mammals and invertebrates (see
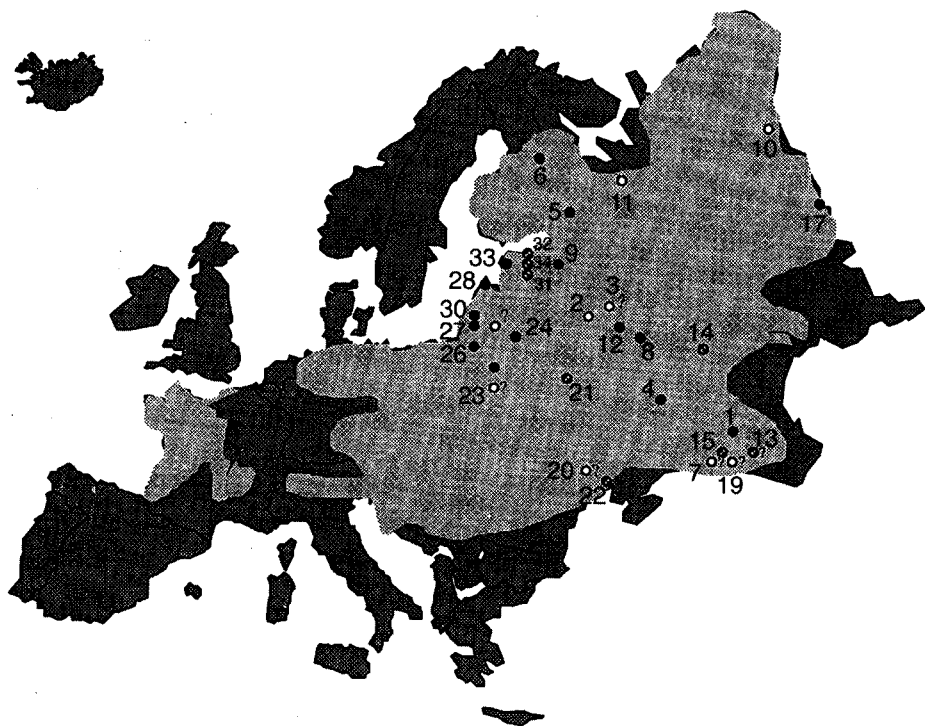
Figure 17.1. Historical and recent range of the European mink. Numbers refer to locations names in Table 17.1. ○, present 1990, present 1995; ◐, present 1990, extinct 1995; ●, extinct in 1990; ○?, present 1990, no data 1995; ◐, no data 1990, extinct 1995.

chapter 11, and see Danilov & Tumanov, 1976a,b; Sidorovich, 1992). European mink mate in the last 2 weeks of April, and a 43 day gestation leads, without delayed implantation, to the birth of 1–7 (mean 3.5) kits. The longest recorded lifespan for the European mink is 7 years (Maran, 1994a).

The only prehistoric records of European mink are from Vlaardingen, in the Netherlands, between 2300 and 2100 BC (van Bree, 1961a,b). From historical records the species' range once extended from the Ural Mountains to eastern Spain and from central Finland to the Black Sea (Novikov, 1939; Heptner et al., 1967) (Fig. 17.1). However since the mid-nineteenth century its range has dwindled (Maran & Henttonen, 1995) and it was recently included as endangered in the IUCN Red Data Book (Groombridge, 1993). In the European Union the European mink is listed in Annex II (species whose conservation requires the designation of special areas) and in Annex IV (species of community interest in need of strict protection) of the Directive on the conservation of

natural habitats and of wild fauna and flora. The IUCN *Action Plan for the Conservation of Mustelids and Viverrids* (Schreiber et al., 1989) nominates the European mink as a priority.

Course of the decline

The European Mink disappeared from Germany in the mid-nineteenth century (Youngman, 1982), then from Switzerland (Gautschi, 1983) and, in the 1890s, from Austria (Novikov, 1939). Subsequently, in western Europe, an isolated enclave of European mink originally persisted between Brittany in France and Galicia in Spain (Blas Aritio, 1970; Chanudet & Saint-Girons, 1981; Braun, 1990; Camby, 1990; Palomares, 1991; Ruiz-Olmo & Palazón, 1991). However, recently they have disappeared from the northern part of this range and appear in widespread decline in what remains of their French range (C. Maizaret, personal communication; Moutou, 1994). In intriguing contrast, and although no data exist prior to 1951, European mink are reported to be spreading southwards in Spain (Ruiz-Olmo & Palazón, 1990).

In eastern Europe the European mink's situation is almost unremittingly bad. Between the 1930s and 1950s European mink disappeared from Poland, Hungary, the Czech and Slovak Republics and probably also Bulgaria (Bartá, 1956; Szunyoghy, 1974; Schreiber et al., 1989; Romanowski, 1990). In the closing years of the twentieth century, the species teeters on, or over, the brink of extinction throughout most of the remainder of its range. In Finland, following a rapid decline between 1920 and 1950 only isolated specimens were seen until the early 1970s, when the species was judged extinct until one was trapped in 1992 (Henttonen et al., 1991; Henttonen, 1992). In Latvia the only evidence for the species' survival is single specimens caught in 1984, 1991 and 1993 (Ozolins & Pilats, 1995). In Lithuania, where the last record is 1979 (Bluzma, 1990), an intensive search for European mink in 1989–1990 revealed none (Mickevicius & Baranauskas, 1992) If the European mink survives at all in Georgia, it is as an extreme rarity in the rivers flowing to the Black Sea in the north-west of Georgia, where it was common in the early twentieth century (A. N. Kudatkin, personal communication; Novikov, 1939). Following a decline in Moldova in the 1930s, by the early 1980s the species survived only on the lower reaches of the river Prut, along the Romanian border (Muntjanu cited in Maran, 1994b) where it has not been seen for 15 years and is now considered extinct (A. Mihhailenko, personal communication). In Romania itself, where European mink are legal game, as recently as 1970 2700 pelts were recorded by state hunting organizations. Subsequently, the species has plummeted to rarity in northern Romania, but is apparently more numerous but declining in the Danube delta (H. Almasan, D. Muriaru & O. Ionescu, personal

communications). Although none have been seen in Estonia since 1992, unconfirmed sightings, and the capture of an apparent hybrid with a polecat in both 1994 and 1995, suggest that remnants may persist, as they may in the Ukrainian Carpathians (Turjanin, 1986) following a major decline in the late 1950s (Tumanov, 1992). By 1990 an estimated 100–150 European mink survived in the north-east of Belarus (Sidorovich, 1992). In the early decades of this century the European mink was a common and widespread carnivore almost everywhere in western Russia where it was a valuable furbearer (Novikov, 1939). Its decline there was first noticed in the 1950s and widely lamented by the 1970s (Ternovskij & Tumanov, 1973; Ternovskij 1975; Tumanov & Ternovskij, 1975; Danilov & Tumanov, 1976a). A survey by Tumanov & Zverjev (1986) revealed that by the mid-1980s European mink had declined dramatically throughout Russia, but in the Tver regions there were still reports of 4–6 European mink/10 km of river bank. Several recent reports indicate that the European mink decline is continuing in Russia and recent reports are gloomy (Sidorovich & Kozhulin, 1994; Sidorovich *et al.*, 1995).

To conclude this litany of disaster, Maran (1992a) reported the answers to questionnaires distributed in 33 areas of the former Soviet Union, of which 16 reported extinction, 13 reported very critical status and only 4 considered the populations viable.

Summarizing the population trend, there has been a steady, long-term decline of the European Mink since the nineteenth century, which has led to the general extinction of the species in western Europe, except in Spain. This decline has accelerated very rapidly in the last three decades in eastern Europe.

Below, we present the results of a new survey.

Causes of the decline
The precipitate decline of the European mink caught conservation biologists unawares, and it was not until 1995 that Maran & Henttonen published the first synthesis of possible explanations. Here, before presenting preliminary data on two of them, we review five hypotheses, namely that the decline is caused by:

1   Habitat loss.
2   Pollution.
3   Overhunting.
4   Impact of the European polecat.
5   Impact of the American mink.

Habitat loss
The decline of the European mink has repeatedly been attributed to habitat loss. For example, Claudius (1866) stated that over one decade the European mink was exterminated from several districts of Germany by changes in land-use, and Löwis (1899) foresaw the rapid decline of the species in Lithuania in the wake of agricultural intensification. In the Ukraine and Moldova, Tumanov (1992) links the demise of the European mink with drainage, cultivation and land reclamation. Having evaluated competing hypotheses, Schubnikova, (1982) concluded that in at least several regions of Russia the European mink's decline was due to habitat degradation and loss, particularly in central Russia (Jaroslav, Vladimir, Ivanovo and Kostroma Regions) (see also Shashkov, 1977).

It is indisputable that urbanization and agricultural intensification have radically altered much of the post-war European landscape, generally to the detriment of wildlife (e.g. Macdonald & Smith, 1991). This is true for at least many areas in which European mink have declined and, in particular, natural riverbasins have been canalized. For example, in Estonia during the 1950s and 1960s almost half of all the wetlands were drained (Kask, 1970) and agricultural improvement affected at least 20% of the country (Mäemets, 1972). Furthermore, as European mink thrive in natural river systems (Novikov, 1939, 1970; Danilov & Tumanov, 1976b) and especially in undisturbed streams (Novikov, 1939, 1970; Sidorovich *et al.*, 1995), it seems obvious that these twentieth century landscape changes will have been to their detriment. Nonetheless, beyond this loose historical correlative evidence, there have been no direct quantitative tests of the hypothesis that habitat loss caused their decline. Moreover, while there are sites, perhaps many, where radical degradation of habitat would seem to render rivers inhospitable for the mink, there are other places where the species has declined in apparently suitable habitat. Furthermore, in areas where the European mink is still present, its choice of habitat appears to include types of vegetation and banks that are still in abundance in areas where the species has gone. Therefore, to test this hypothesis rigorously, data are needed to elucidate which aspects of landscape change are detrimental to European mink.

Pollution
Pollution has been mooted as contributing to the European mink's decline by Schröpfer & Paliocha (1989). Riparian pollution is locally severe in Europe, including some areas where European mink do, or did, occur (Blas Aritio, 1970; Novikov, 1970). Furthermore, López-Martin *et al.* (1994) report organochlorine residues in European mink at levels that could perhaps impair

Figure 17.2. Harvest of mink in central regions of Russia (after Shashkov, 1977)

reproduction, although this report is from an area of Spain where the species is doing well. However, while this hypothesis remains largely untested, European mink have declined in some wilderness areas (such as north-eastern Belarus: see Chapter 11) which do not appear to be gravely polluted.

Overhunting
At least in the eastern part of its range the European mink has traditionally been trapped for its pelt. For instance, Schubnikova (1982) reports that as early as the seventeenth century 11 500 mink pelts were exported annually from the Arkhangelsk Region of Russia alone, while in the early decades of the twentieth century the annual Russian bag was 40 000–60 000 with a maximum of 75 000 in the winter of 1927–28. Overhunting was perceived as such a threat to the fur harvest that a moratorium on killing European mink was imposed around the

former Leningrad and in the north Caucasus at the beginning of the present century (Novikov, 1939). Following World War II, intensive harvest of European mink continued apace in Russia and, after 15 years of increasing tallies, plummeted – a decline that Shashkov (1977) attributed to local extinctions due to overhunting (Fig. 17.2).

Scarcity appears to have affected the demand, and thus value, of European mink pelts. In the late nineteenth century in Russia the pelts of European mink and polecat were valued equally (Martenson, 1905) whereas by 1983 in the Soviet Union the value of an unspecified mixture of the two mink species had increased tenfold in real terms and fetched twice the price of polecats (Maran, 1991). Although it is difficult to separate the inflationary effects of fashion and scarcity, the end result is an increased incentive to trap European mink. The official harvest target in the 1960s and 1970s in the Jaroslav Region was 28–35% of the estimated total European mink population prior to the hunting season, and approximated the annual productivity of the species (Shashkov, 1977). However, Shashkov (1977) shows that, at least for the Kostroma Region, the actual harvest was double the official figure.

Clearly, prolonged, widespread hunting significantly in excess of a population's recruitment will inevitably lead to its decline. Hunting statistics provide compelling, if somewhat fragmentary, evidence that European mink have been seriously over-harvested in some regions. This is the first of several instances in which the spread of American mink in Europe both complicates the interpretation of data and may disadvantage the European mink. First, the hunting statistics for European mink may be confounded by confusion between the two species. Second, the expanding population of American mink may have sustained the incentive for trapping beyond the time at which numbers of European mink were so low that they alone were not economically harvestable. However, although over-hunting has clearly been rife, and continues to be so (Sidorovich *et al.*, 1995), and although it seems certain to have reduced their numbers in many places, there is no clear evidence that it has been the sole, or principal, cause of European mink disappearance anywhere. Indeed, on the grounds that other semi-aquatic mustelids, such as American mink, polecat and otter, have not been exterminated by comparably intense hunting, support for this hypothesis requires evidence that European mink are strongly selected by hunters or very much more susceptible to hunting pressure than are their congeners.

Impact of the European polecat, Mustela putorius
In a variant of the habitat-change hypothesis, Schröpfer & Paliocha (1989) argue that landscape changes associated with agricultural encroachment have

not, or not only, disadvantaged European mink directly, but also indirectly by favouring a competitor, the European polecat. While it may be true that polecats are better adapted to the new European landscape than European mink are, there are no data with which to evaluate the hypothesis that this has led to a competitive disadvantage for the mink. However, it is noteworthy that in relatively undisturbed habitat in Belarus, polecats and European mink co-existed both before and after the arrival of American mink and there is little overlap in diet (see Chapter 11).

A second potential hazard to European mink posed by polecats became apparent with the discovery of hybrids between them. Granqvist (1981) postulated that climatic warming in the early twentieth century may have facilitated a northward extension of the polecat's range, as it has that of the red fox, *Vulpes vulpes* (Hersteinsson & Macdonald, 1992), and led to greater contact between the two species and hence greater risk of genetic introgression. While the climatic change aspect of this hypothesis is weakened by the historical co-existence of these two species in southern Europe, it remains the case that genetic introgression of rare carnivores is a real threat (e.g. *Canis lupus, Canis rufus, Canis simensis, Felis silvestris*).

Hybridization between European and American mink appears out of the question; the chromosome number of the European mink is 38 and that of the American mink is 30 (Graphodatsky *et al.*, 1976). Hybrids of polecat and European mink are relatively well-known (Ognev, 1931; Novikov, 1939; Heptner *et al.*, 1967; Tumanov & Zverjev, 1986), but appear to have remained a rarity in the days prior to the mink's dramatic decline. For instance, of 500–600 pelts examined by Tumanov & Zverjev (1986) only 3–5 were suspected to be hybrids. Therefore, while there are no grounds to implicate this hybridization in triggering the mink's decline, the critical question is whether its incidence has increased where the mink are rare. Maran & Raudsepp (1994) report that during the last years of the European mink's existence in Estonia, a surprisingly high proportion of suspected mink–polecat hybrids were found: six between 1992 and 1994. The hypothesis that in fragmented populations such hybridization may pose an additional threat to European mink therefore merits further testing.

Impact of the American mink, Mustela vison

The success of the American mink throughout Europe provokes several potentially linked hypotheses for the demise of the European mink. These include (i) sustained trapping pressure of which the European mink has been a partly incidental victim (see above), (ii) scramble competition for shared (and possibly declining) food resources (see Chapter 11), (iii) transmission of disease against which the European mink has inadequate resistance, and (iv) intraspecific aggression. The first line of evidence for each of these is the spread in the American mink's range and contemporaneous shrinkage of the European mink's. American mink were brought to Europe in 1926 both for farming and for release, and are now widespread (Stubbe, 1993). Initially they came to France, in 1928 to Sweden, Norway and the UK in 1929, Denmark and Iceland in 1930. Between 1933 and 1963 they were deliberately released in many localities in the former Soviet Union (Heptner *et al.*, 1967). Indeed, 20 400 mink had been released by 1971 in nearly 250 sites (Pavlov & Korsakova, 1973).

The arrival of the American mink could have changed the epidemiological circumstances of European mink, most plausibly by introducing a pathogen to which the European mink had inadequate immunity. In view of the inconspicuousness of the species, the absence of evidence of ill mink is hardly a weakness of this hypothesis, which has been suggested by Henttonen & Tolonen (1983) and Henttonen (1992). We also present some further preliminary evidence, but there is no solid conclusion.

Male American mink weigh 0.9–2.0 kg, with a head–body length (HBL) of 37–47 cm. The corresponding figures for male European mink are 0.7–1.1 kg and 30–43 cm. Female American mink weigh ca. 0.7–1.0 kg with a HBL of 33–42 cm. The corresponding figures for female European mink are ca. 0.5–0.8 kg and 25–34 cm (Sidorovich, 1995). The male American mink is thus substantially heavier than its European counterpart, and even the female American mink is on a par with the male European mink (Danilov & Tumanov, 1976b; Sidorovich, 1992) and may be more robust in the face of harsh climates: the range of the European mink is confined below 66 °N in central Finland (Heptner *et al.*, 1967), whereas the American mink is abundant in Iceland (Stubbe, 1993) and Norway (Bevanger & Henriksen, 1995). Furthermore, Maran (1989) reports that in captivity American mink were more versatile than European mink in using artificial environments, and this may reflect greater opportunism in adapting to diverse environments in the wild. While European mink are generally recorded from small, fast-flowing streams (Novikov, 1939, 1970) or, in snow-free periods, inland lakes and marshes (Danilov & Tumanov, 1976b; Sidorovich *et al.*, 1995), American mink appear adapted to almost any body of water, including coastlines, offshore islands and large lakes (Gerell, 1967; Dunstone, 1993; Bevanger & Henriksen, 1995; Niemimaa, 1995).

The reproductive biology of the two species also differs in that the gestation of the American mink may vary, due to delayed implantation, from 30–92 days (Ternovskij, 1977), whereas that of the European mink always lasts 40–43 days

(Maran, 1994a). Furthermore, American mink litters are larger ($x = 5.4$ (± 0.35), $n = 38$, versus 4.3 (± 0.10), $n = 280$: Ternovskij & Ternovskaja, 1994).

There are also differences in behaviour, with captive European mink appearing more nervous of their keepers, and less socially interactive with conspecifics (Maran, 1989).

It is therefore possible that the European mink might be disadvantaged in contest competition against the American mink in three, non-exclusive, ways, various combinations of which have been espoused by Popov (1949), Danilov & Tumanov (1976b), Maran (1991, 1994b), Ryabov et al. (1991) and Sidorovich (1992). First, in contests for mates, and assuming interspecific sexual attraction, larger, more vigorous male American mink might exclude European males from females. Furthermore, if, as suspected, the American mink becomes reproductively active earlier in the year than European mink males do, and as Ternosvkij (1977) records that hybrid embryos are resorbed, early interspecific pregnancies would pre-empt the European males' reproduction and render the female European mink reproductively abortive for that year. The proposal that becoming reproductively active earlier enables American males to monopolize matings with European females begs the question of whether European mink females come into breeding condition earlier than their males. Second, the robust build and confident character of American mink may allow them to overwhelm European mink in direct contests over other resources, such as food or dens. Third, there is mounting evidence of interspecific aggression between carnivore species, which may constitute pre-emptive competition for resources or territory, and generally results in the larger of two species within a guild harassing the smaller (e.g. Hersteinsson & Macdonald, 1992). The more numerous the American mink became – and Sidorovich (1993) has emphasized their great reproductive capacity (up to 7.3 embryos/female) in expanding populations – the worse would be the impact of each of these variants upon European mink.

There are no published data with which to evaluate these variants of the interspecific competition hypothesis, so there we present the results of an experiment designed to elucidate the tenor of encounters between American and European mink in captivity.

Methods

1995 Questionnaire survey
In 1995 we conducted a questionnaire survey of 19 reserves in Russia that had reported European mink populations in 1990 (Maran, 1992a). With the aim of

detecting changes in status, we asked the correspondents for evidence of the status of European mink in their reserve.

Disease transmission
A partial test of the hypothesis that American mink have transmitted a fatal disease to European mink would be to capture wild specimens of both species and expose them to each other in captivity. This test has been performed incidentally since 1983 at Tallinn Zoo, where both species of mink have been housed in adjoining pens, and sometimes successively in the same pen, in the course of developing captive breeding populations. We have explored the zoo records to enumerate the instances when European mink were exposed to American mink, and any subsequent illness.

Interspecific aggression
The mink were housed in an outdoor **L**-shaped enclosure comprised of three 5×5 m compartments, each separated by a metal wall. Each compartment contained four nest-boxes, four stumps and a pool. During the 'sympatric' phase two adult male and two adult female European mink were housed in one compartment, and a similar group of American mink was housed in another, with the intervening compartment empty. All the animals had been wild-caught in Estonia. During the 'allopatric' phase the interconnecting doors were open so that all eight mink had access to the entire 72 m² enclosure.

The animals were fed at midday on gruel and meat supplemented with rats and mice. Nocturnal observations were aided by electric light.

Observations were made from a small cabin in the middle of the enclosures. Interactions and activity were recorded every minute for 24 h during three, generally consecutive, days each month between September 1989 and July 1990.

Results

1995 survey
Of 19 reserves sent questionnaires, 13 replied (Table 17.1). Of these, five reported the mink population to be extinct since 1990. Of two which reported abundant European mink in 1990, one now judges it to be in decline, the other judges it extinct. Pinegeja Reserve, reporting a decline in 1990, judges that the population has now stabilized at a new low. In summary, our 1995 survey indicates that the European mink continues in a fast decline. Indeed, we have

Table 17.1. *The European mink,* Mustela lutreola, *in protected areas in the territory of the former Soviet Union*

Protected area	Area (ha)	Status 1990	Status 1995	Last evidence
1. Astrakhansky	62 500	Extinct	Extinct	?
2. Central forest	21 380	Good	Declining	1995
3. Darvinsky	112 630	Declining	No reply	1989
4. Hopersky	29 800	Extinct	Extinct	1940
5. Kivach	10 460	Extinct	Extinct	1975
6. Kostomuksky	47 567	Extinct	Extinct	?
7. Kavkavsky	263 300	Declining	No reply	1990
8. Mordovsky	32 140	Extinct	Extinct	1965
9. Nizhne svirsky	40 972	Extinct	Extinct	?
10. Pechoro Ilychsky	721 322	Declining	Declining	1990–92
11. Pinegeysky	41 224	Declining	Rare	1994
12. Prioksko Terrasny	4945	Extinct	Extinct	?
13. Severo Osetinsky	2990	?	Extinct	1950–60
14. Zhigulevsky	23 100	?	Extinct	1940
15. Teberda	85 840	Declining	Extinct	1981
16. Voronezhsky	31 053	Extinct	extinct	1950
17. Visimsky	3767	Extinct	Extinct	1958
18. Kunashir	?	?	No reply	?
19. Skrutsinsky	85	Good	No reply	?
20. Dunaiskiye Plavni	14 815	Declining	No reply	?
21. Kanevsky	1035	Declining	Extinct	1977
22. Tshernomorsky	87 348	Declining	Extinct	1989
23. Karpatsky	12 706	Declining	No reply	?
24. Berezinsky	35 000	Extinct	Extinct	1963
25. Pripjatsky	63 120	Extinct	Extinct	?
26. Bielovezhskayapushcha	87 600	Extinct	Extinct	?
27. Zhuvintas	5443	Extinct	Extinct	?
28. Slitere	15 440	Extinct	Extinct	?
29. Kruskalny	2902	Extinct	Extinct	?
30. Grini	1076	Extinct	Extinct	?
31. Endla	81 162	Declining	Extinct	1991
32. Lahemaa	64 911	Declining	Extinct	1992
33. Matsalu	48 640	Extinct	Extinct	1950
34. North Kôrvemaa	11 283	Good	Extinct	1992

failed to find a single reserve within the former USSR that reported a healthy population of the species.

Disease

Since 1983, 51 European mink and 40 American mink have been housed in close proximity at Tallinn Zoo. For eight European mink we could verify the number of different American mink that had occupied adjoining cages. Despite up to four such exposures, there was not one case of patent illness; all individuals survived and most subsequently bred. During 1987 eight European mink and nine American mink were involved in tests for interspecific aggression during which two individuals of either species were observed in the same cage for 15 min sessions. In each of 24 dyads, European mink were exposed to 15–75 min/day of direct contact with American mink over 34–62 days. During these observations (T. Maran, unpublished results) there was much physical contact and some fighting. However, no illness was observed subsequently in any of the experimental animals, and several became amongst the most successful breeders in the colony. In 1990, four European mink were housed in cages that had immediately beforehand housed American mink, and none developed illness.

The role of interactions within species

During 6 days of observation of the four American mink there were 45.3 ($\text{SE} = 13.35$) recorded behavioural events per day per animal, of which 10% were aggressive and 33% were approach. In contrast, during 5 days there were only 23.4 ($\text{SE} = 4.66$) recorded behavioural events per day per animal between the four European mink. However, the quality of interactions was similar, involving 11.7% aggressive and 46% approach. The American mink were markedly more active and more socially interactive than the European mink.

The flow of interactions amongst the quartet of each species is most easily compared visually (Fig. 17.3). There was no obvious difference between the species in the proportion of intraspecific interactions involving the initiation of aggression. In the quartet of American mink, 5.2% of 655 interactions initiated by females were aggressive, whereas amongst the European mink the comparable figure was 3.7% of 241 interactions. In the quartet of American mink, 17.1% of 432 interactions initiated by males were aggressive, whereas amongst the 230 interactions initiated by male European mink, 20.2% were aggressive.

Figure 17.3 also reveals no striking difference between the species in the flow of other categories of interaction. For example, in both species, most aggression initiated by females was directed towards females, whereas aggression
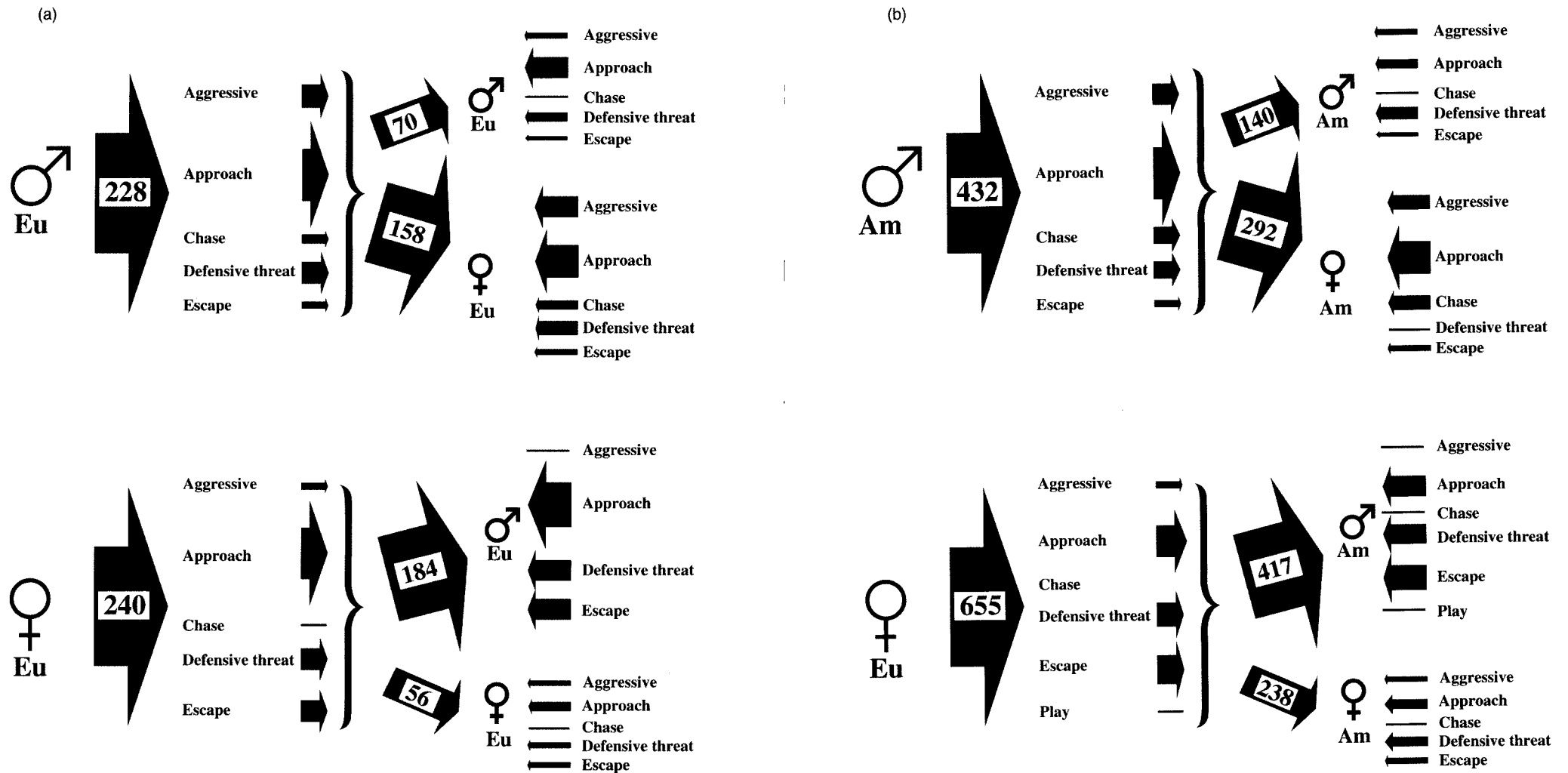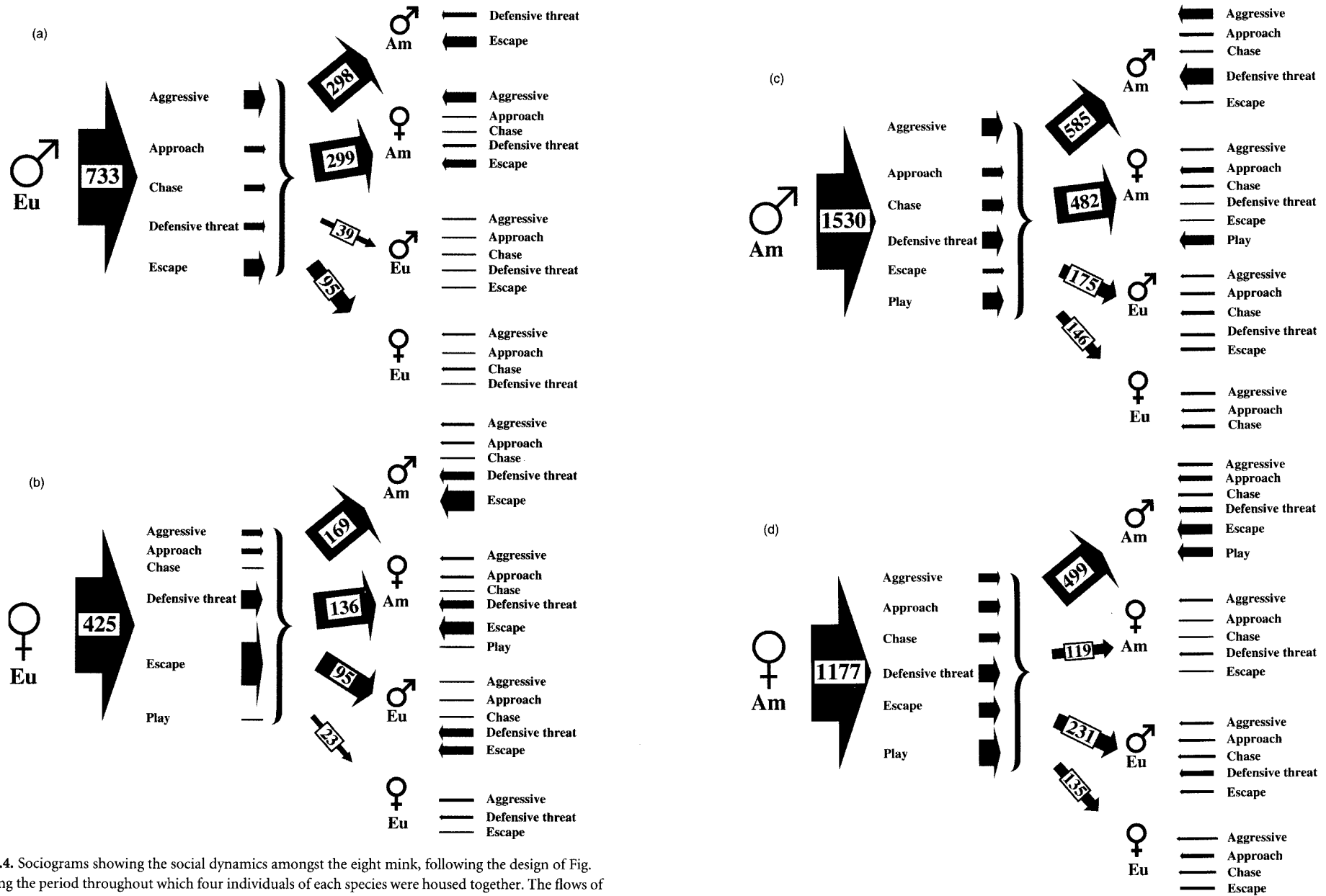
Figure 17.3. Sociograms showing the social dynamics amongst quartets of (a) European mink (Eu) and (b) American mink (Am) when housed separately. The thickness of the arrows is approximately proportional to the relative flow of interactions of a given class between each category of conspecific. Thus, in Fig. 17.3(a), of 228 events (of which the proportions comprising five behavioural classes are schematized) initiated by the two male European mink, 158 flowed from one male to the two females, whereas 70 flowed to the other male and of the latter the most common class of interaction was an approach.

initiated by males was directed at both males and females. Furthermore, in both species, a greater proportion of chases involved males chasing females than chasing males.

The role of interactions between species

During the 10 months when both species were housed together, 5060 behavioural events were recorded during 22 days of observation, 4947 of which involved interactions between individuals. The remainder were mainly solitary play, which was more commonly observed in the males of both species

Figure 17.4. Sociograms showing the social dynamics amongst the eight mink, following the design of Fig. 17.3, during the period throughout which four individuals of each species were housed together. The flows of interactions are schematized separately for (a) male European mink (Eu), (b) female European mink, (c) male American mink (Am) and (d) female American mink. The thickness of the arrows indicates, for example, that of the 733 behavioural events initiated by male European mink, 298 involved male American mink; the proportional representation of these 298 amongst five behavioural classes is depicted by the five arrows indicating that these interactions rarely involved the European male chasing the American male, but frequently involved the European male escaping from the American male.

(41 instances in the American males compared with 11 in females, and 36 and 18 for European males and females, respectively. Overall, the behaviour of both species did not alter radically from that observed during the exclusive intraspecific interactions. In particular, American mink continued to be significantly more active and the majority of their interactions were intraspecific (of 2751 behaviours initiated by adult American mink, 67.5% were directed at conspecifics). In contrast, of 1158 behavioural events initiated by European mink only 21.8% were directed at conspecifics. The overall flow of behaviour patterns from adults of each sex of each species is schematized in Fig. 17.4(a)–(d).

First, we ask whether interspecific relationships were generally non-aggressive, neutral or aggressive. Male American mink were aggressive in 20.2% of their 1530 behavioural events. This aggression was largely directed at males, both conspecifics and European mink. Of their interactions with the male conspecifics 31.1% were aggressive, as were 20.0% of their interactions with male European mink. For male European mink, 19.1% of 733 behavioural events involved aggression. They were more interactive with both male and female American mink than with either sex of their own species, and a greater proportion of the interactions with both sexes of American mink were aggressive than were those involving either sex of conspecific. American mink males frequently (24.1%) played with conspecific females, but never played with European mink of either sex. European mink males interacted rather rarely. European mink males were more aggressive to conspecific females than were American mink males, whereas European mink females were more playful amongst themselves than were American mink females.

In summary, the general tenor of interspecific relationships was hostile, and did not differ obviously from intraspecific interactions. To elucidate the intraguild hostility hypothesis we sought evidence that male and female American mink dominated either sex of European mink.

Males

1   Do male American mink dominate male European mink? American mink males were much more aggressive to European mink males than *vice versa*, and often chased them (20.2% of their interactions). Of the 40.7% of male European mink behavioural events that were interactions with male American mink, 25.2% involved fleeing, whereas male American mink only fled from male European mink on 3.4% of occasions. We conclude that these male American mink did dominate the male European mink.

2   Do male American mink dominate female European mink? Of the
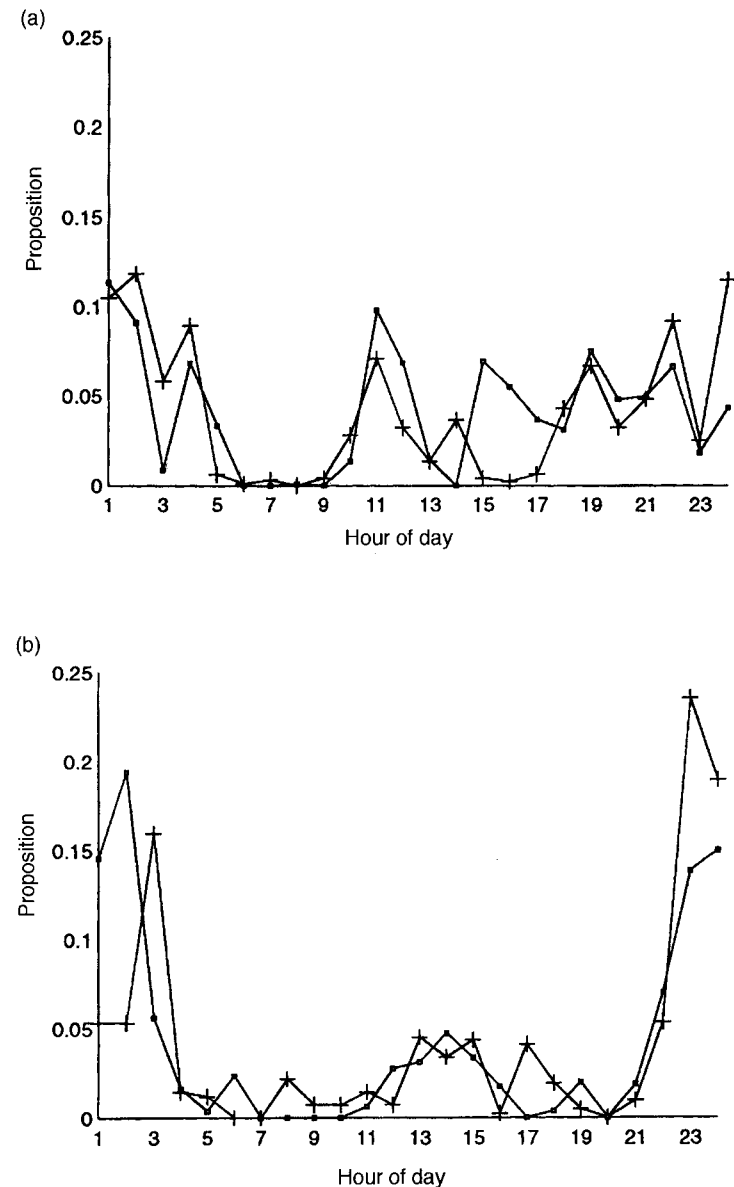
Figure 17.5. Specimen activity rhythms for (a) American mink and (b) European mink when the two species were housed together in June, showing the proportion of records, taken at 1 min intervals, during which males (+) and females (□) were, on average, active during each hour of the day.

interactions of male American mink with female European mink, 11.6% were aggressive and 39.7% involved chasing them. Indeed, 49.7% of female European mink's interactions with American mink involved fleeing from them. Only 5.8% of the male American mink's interactions with conspecific females were aggressive, as were 11.6% of those with female European mink. We conclude that these male American mink did dominate the female European mink.

Females

1   Do female American mink dominate male European mink? European mink males fled from American mink females on 22.4% of interactions. Of the interactions of male European mink with female American mink, 25.4% were aggressive, but only 3.3% involved chasing them. Only 13.0% of female American mink's interactions with male European mink involved fleeing from them. We conclude that while aggression flowed approximately symmetrically between these female American mink and male European mink, the male European mink were more inclined to flee from the female American mink than *vice versa.*

2   Do female American mink dominate female European mink? Of the interactions of female American mink and female European mink, 11.8%, 22.2% and 17.0% involved aggression, approaching and chasing, respectively. The equivalent figures for interactions of the female European mink with the female American mink were 9.5%, 7.4% and 2.2%. Indeed, 44.1% of female European mink's interactions with female American mink involved fleeing from them. We conclude that these female American mink dominated the female European mink.

The foregoing observations, together with other patterns displayed in Fig. 17.4, are compatible with the overall conclusion that within each sex, the American mink were aggressive towards, and dominant to, the European mink. Furthermore, male American mink appeared to harass female European mink, whereas male European mink were less assertive towards female American mink and, overall, fled from them. Female American mink appeared undaunted by male European mink, whereas female European mink fled from male American mink.

These overall conclusions combine data from different seasons, and we scrutinized the dynamics of interactions in each month of the study. These monthly observations on one unreplicated octet of mink are not the basis for generalizations, but serve to prompt questions for further study. The salient

points include (i) soon after giving birth, one female American mink savagely attacked the other, (ii) there were indications that the males of each species showed sexual interest in the females of the other, (iii) there was hostility between breeding females of the two species, and one female European mink killed the kits of an American mink female.

The mink differed in their activity rhythms. Overall, European mink were largely nocturnal, whereas American mink, while tending to nocturnality, were more inclined to be active throughout the day (Fig. 17.5). In particular, American mink of both sexes had a supplementary peak of activity around 12:00 when they were fed. The result is that the American mink had generally eaten fully before the European mink emerged in the evening. The female European mink were even less inclined that the males to emerge by day. We compared, for each sex, the activity rhythms during the sympatric and allopatric phases, and there was no marked difference. The asynchrony in activity between the species meant that we made few observations of clashes over food, because the American mink had finished feeding before the European mink emerged.

Discussion

Our 1995 survey indicates that even since 1990 the distribution of the European mink has shrunk drastically. This trend suggests that the species faces imminent extinction.

The explanation for this precipitate decline remains unknown. Variations on at least five non-exclusive hypotheses have been proposed. All are plausible and the evidence allows few to be rejected categorically. Sidorovich *et al.* (see Chapter 11) reject the hypothesis, at least for our field study area in northeastern Belarus, that a declining prey base is responsible. Similarly, in our Belarussian study area European mink are declining in wilderness areas around natural floodplains with little evidence of pollution. Here, we report that there was no evidence of European mink in Tallinn Zoo succumbing to disease transmitted by American mink, but this evidence is scarcely grounds for rejecting the possibility. However, we also report here preliminary evidence for spontaneous hostility between American mink and European mink. If the evidence of our unreplicated experiment can be generalized, it suggests that American mink of both sexes go out of their way to harass European mink. There is even a possibility that shared social odours exacerbate this hostility when females are in oestrus. Furthermore, although domination was predominantly by the larger American mink over the smaller European species, we

nonetheless recorded one instance of a female European mink killing the 3 week old kits of American mink.

There is increasing evidence of significant intraguild aggression amongst carnivores. Red foxes may deliberately kill pine martens, *Martes martes*, in Scandinavia (Storch *et al.*, 1995), coyotes, *Canis latrans*, kill kit foxes, *Vulpes velox*, in California, and lions kill cheetah cubs in Tanzania (Caro, 1994). In this context Hersteinsson & Macdonald (1922) argued that harassment by red foxes determines the southern limit to the range of Arctic foxes, and they suggested that the larger, more robust, red fox behaved towards Arctic foxes, *Alopex lagopus*, rather as if they were inferior conspecifics. There is evidence of red foxes killing Arctic fox cubs. It is plausible that a similar relationship exists between the American and European mink (and indeed, the interactions of both with polecats merit investigation). Our evidence suggests that American mink do not treat European mink exactly as if they were diminutive conspecifics – one female savagely attacked her female conspecific and merely harassed the female European mink. Nonetheless, the preliminary evidence presented here is compatible with the idea that the two species act to disadvantage each other when the opportunity arises, and the differential in body size, timorousness and activity patterns is such that the balance of disadvantage may generally be borne by the European mink. Further assessment of this hypothesis must consider the two species of mink in the context of the guild of semi-aquatic predators that also includes the European polecat and otter.

The question arises as to whether intra-guild hostility from the American mink is a sufficient explanation for the widespread extinction and invariable rarity of the European mink. Evaluating this possibility is difficult because much of the European mink's eastern range is remote and little populated with people (albeit many of them very skilled and active fur trappers). However, while the American mink population was largely seeded between the early 1930s and early 1960s (when at least 16 000 of them were deliberately released in the USSR), it seems European mink were already in decline (Tumanov & Zverjev, 1986). The simplest, if somewhat woolly, explanation would be that habitat loss, riparian engineering, pollution and ever more intensive hunting (backed by greater human mobility and encouraged by economic need) all set in train the European mink's decline. These same factors may in various combinations, continue to threaten the species, reducing their populations to a state of frailty in which intraguild hostility from the American mink becomes the last straw. This argument closely parallels the tightrope hypothesis proposed by Barreto *et al.* (1998) to explain the catastrophic impact of American mink on water voles, *Arvicola terrestris*, in Britain (see Chapter 19). They argue that the reason that American mink so effectively eradicate water voles,

sometimes with a year of colonizing a section of river, is that agricultural intensification has reduced the vole's habitat to a 'tightrope' from which any detrimental factor will displace them. In the same way, there may be places where habitat loss and over-hunting weakened the European mink's population and American mink delivered the *coup de grâce*. On the other hand, there are places, and our study area is one of them, where the habitat remains wild and where despite intensive trapping, American mink flourish but European mink are declining fast. We therefore conclude that there is, as yet, no satisfactory explanation for the European mink's plight.

Whatever the cause of its decline, our data confirm that the European mink faces extinction. What has been done about it? There have been several attempts to release European mink into sites free of American mink. First, between 1981 and 1989 European mink bred at the Institute of Biology at the Siberian Branch of the Academy of Sciences of the then USSR were released well north of their geographical range on two islands (Kunashir and Iturup) in the Kuril Archipelago, amidst much debate (Shvartz & Vaisfeld, 1993). After 10 years significantly fewer mink survive than were released. Second, in 1988, 108 European mink were released along the River Shingindira in Tadjikistan, with unknown results (Saudskj, 1989). Third, in 1982, 11 European mink were released on Walam Isalnds in Lake Ladoga (Leningrad Region; Tumanov & Rozhnov, 1993), but by 1992 none remained. Modern conservation thinking would have foreseen these failures: the Kuril Islands flood, the Walam Islands are too small for a sustainable population and lack suitable habitat, and no or little thought was given to the genetic or demographic features of the founding populations.

Clearly, the immediate conservation goals must be to identify the causes of the European mink's decline and to remedy them. We are undertaking field-work on the guild of semi-aquatic mustelids in north-eastern Belarus and central Russia, but even when good data become available, reversing the species decline will pose enormous practical problems. The problem of excessive hunting is more difficult to solve. Because the two species cannot be trapped selectively, and indeed many hunters cannot distinguish them at all, any ban on hunting European mink would necessitate a similar veto on hunting American mink (a politically controversial proposal that currently keeps European mink out of the Russian and Belarussian Red Data Books). The American mink is incompatible with the persistence of European mink populations so one might seek selective means of reducing their numbers, but innovations such as virus-vectored immunocontraception are not only far off, but problematic in themselves (Bradley, 1994; Tyndale-Biscoe, 1994). An option is to introduce European mink to island reserves but, to our knowledge,

all the suitable islands are already occupied by American mink which would have to be removed first.

Nonetheless, the apparently imminent threat of extinction, and the anticipated goal of providing founding populations for island sanctuaries, both make urgent the need for a captive breeding programme. This was first initiated in Tallinn Zoo in 1984, and re-launched there in 1992 under the auspices of the European mink Conservation & Breeding Committee, thus putting the conservation efforts under international supervision and control (Maran, 1992*b*, 1994*a*). Insufficient founders exist in captivity, the prospect of catching them is low, and the likelihood of housing the target population in European zoos is minimal. However, in practice the black-footed ferret (*Mustela nigripes*) recovery project has been relatively successful with only five founders (Thorne & Russel, 1991), so that are grounds for cautious optimism.

ACKNOWLEDGEMENTS

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