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Distributional history of the American mink (*Mustela vison*) in Finland with special reference to the trends in otter (*Lutra lutra*) populations

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The distributional history of the American mink (*Mustela vison*) in Finland in 1951–93 was studied by means of game inquiries and compared to the trends in otter (*Lutra lutra*) populations. Minks were brought to fur farms in the late 1920s and the first minks were observed in the wild in 1932. In the early 1950s minks occurred mainly in the western and southwestern coast of Finland, but two decades later minks were found in most parts of the country. Today minks are found almost everywhere in Finland; only few observers report that minks are not found in their area. The relative density of the mink is now highest in eastern Finland, rather high in southern Finland and quite low in Lapland. The data from the archipelago are, however, sparce. Otter density declined in the 1970s, but increased again in some areas in the 1980s, is now highest in the provinces of Kymi, Mikkeli and Central Finland, and almost lacking from SW Finland, especially from the coast. Among the reasons behind the decline in the otter populations may have been environmental pollutants, like dieldrin in inland areas and PCBs in the coast and archipelago. Human disturbance may also have had an effect, especially in the archipelago. The role of the mink is not clear; it seems probable that if there is competition between these species, the otter is the stronger one.

1. Introduction

The American mink (*Mustela vison*) originates in North America, but it has colonized parts of Europe during this century. Today minks are found, besides in Fennoscandia, in the British Isles, Iceland, the Netherlands, France, Spain, the Baltic countries and Russia (e.g. Lever 1985, Ozoliņš & Pilāts 1995). Minks were brought to fur farms, but many of them escaped and the mink started to colonize new areas. Minks have also been deliberately released in European parts of Russia during this century (Danilov *et al.* 1973, Atlas Karel'skoj ASSR 1989).

The first minks were imported to Fennoscandia and the former Soviet Union in the latter half of the 1920's (e.g. Westman 1966, Gerell 1967, Stroganov 1969, Bevanger & Henriksen 1995), and soon afterwards minks were seen in the wild, too. The earliest

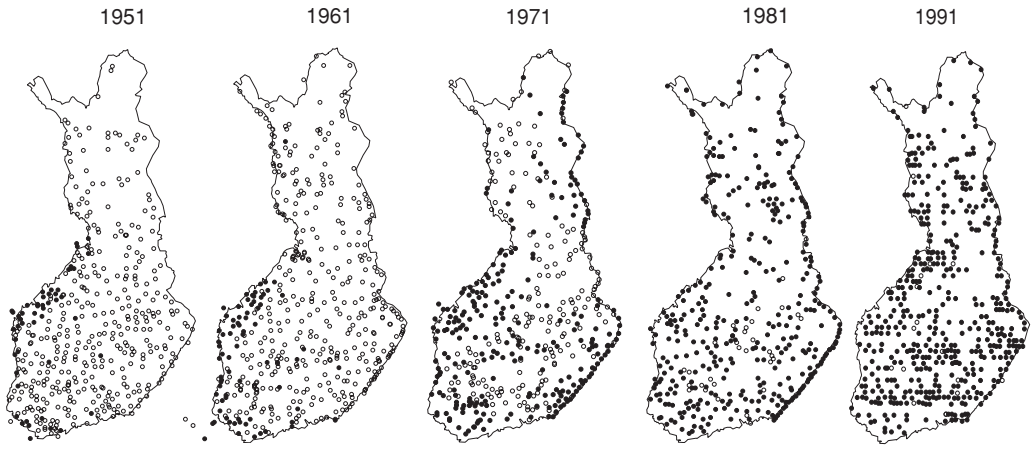

Fig. 1. Distribution of the American mink in Finland in 1951–1991 on the basis of game inquiries. The maps show the observers who reported that minks were found in the area (black dots) and the observers who reported that minks were not found in the area (white dots).

record of a free living mink in Sweden is from 1928 (Gerell 1967), in Norway from 1930 (Bevanger & Henriksen 1995) and in Finland from 1932 (Westman 1966). Most of Norway was colonized during the 1950's and 1960's, and now the Norwegian mainland is fully inhabited; only some islands remain mink-free (Bevanger & Henriksen 1995). Sweden was colonized during the 1930's, 1940's and early 1950's; in the mid-1950's minks were caught in all provinces of Sweden (Gerell 1967).

In Finland, the first free living minks were observed in the 1930's near Kotka in the southeastern corner of Finland (the province of Kymi) and in the western coast (Westman 1966). In the 1940's, minks were observed in the western, southwestern and southern coast and southwestern archipelago, mainly in the vicinity of mink farms. In the 1950's and early 1960's, the mink population started to spread (Westman 1966), but since then very little is known about the distribution history of the mink in Finland.

The mink is an introduced carnivore which potentially affects the native fauna, either by competition or predation. One victim of the mink may be the otter (*Lutra lutra*) which may compete with the mink (Lever 1985) and whose populations have declined in many parts of Europe during the latter half of this century (e.g. Dunstone 1993). Also in Finland the otter population decreased after the 1950's, but has increased again, at least in some areas since the mid-1970's (Stjernberg & Hagner-Wahlsten 1994). Another victim may have been the European mink (*Mustela lutreola*) which has disappeared from many places in Europe during this century. In Finland, however, the population of the European mink declined before the spread of the American mink (Maran & Henttonen 1995), thus, other reasons must be involved.

The aim of this study was: (1) to examine the distributional history of the American mink in Finland, (2) to find out its relative abundance at present in different parts of the country, and (3) to compare the trends in mink and otter populations.

2. Material and methods

To study the development of mink and otter populations I used game inquiries carried out annually by the Finnish Game and Fisheries Research Institute (FGFRI). Inquiry forms were sent to observers in 1951–93 each year in March. Mean number of observers were 43/year/province and 473/year (range 417–630). The number of observers did not change much during the study period, except in the early 1980's when the number of observers increased, but declined soon again. The mean number of observers was 39/province in 1951 and 40/province in 1993. The number of observers and FO (see below) did not correlate when compared across provinces.

The observers were asked whether minks/otters are found in their observation area or not. Frequency of occurrence (FO) was then calculated by province; it is the percentage of observers who report that the species is found in their observation area.

To estimate the rate of spreading of the mink, regression lines were calculated for the period of the most rapid increase in FO, i.e. for the period when FO increased from 20% to 80% (dependent variable: FO, independent variable: the year).

An abundance index (AI) for the mink was also calculated from game inquiries (mean for 1991–93). The observers estimated the abundance as: 0 = minks are not found in the area, 1 = rare, 2 = common, 3 = abundant. For calculation of AI, see e.g. Helle and Kauhala (1991).

The abundance index may not be reliable when different areas are compared (e.g. Siivonen 1951, Wirén 1974, Caughley 1977, Lindén 1988). Therefore I compared AI and results of 4 other methods to estimate the relative abundance of the mink at present in different parts of Finland. Besides AI I used: a) the snow track index, b) trap indices, c) tracking tunnels and d) the size of the annual catch.

a) The snow track index is based on snow track counts ('wildlife triangles') carried out annually by FGFRI in cooperation with hunters. The track index gives the number of tracks crossing a line/10 km/night (for details, see Lindén 1994, Lindén *et al*. 1996).
b) Trap indices give the number of minks trapped per 100 trap nights. Two types of traps were used: killing traps and live traps, and indices were calculated separately for both. Minks were caught in September–November 1993 and 1994.
c) An index for relative abundance was also calculated by using tracking tunnels (50/area/year). These were used for 10 nights in September 1994 and 1995 in each area (5 nights in one place and 5 nights in another place). The index is 100 × the number of tracks in the tunnels/500 (10 × 50) tracking nights. Tracking tunnels were placed on mink habitats along shores of lakes and rivers, and the tracks were counted each morning. For details of the method, see King and Edgar (1977). Traps and tracking tunnels were used in 3 inland areas in Finland: in southern Finland (the province of Häme, in eastern Finland (North Karelia) and in Lapland (these counts were also carried out by FGFRI).
d) The size of annual catch per km^2 (calculated from land area) was used as an estimate of relative abundance of minks in each province.

When studing the development of the mink and otter populations I used only the frequency of occurrence, and when comparing the relative densities of the mink and the otter at present I used also the snow track index.

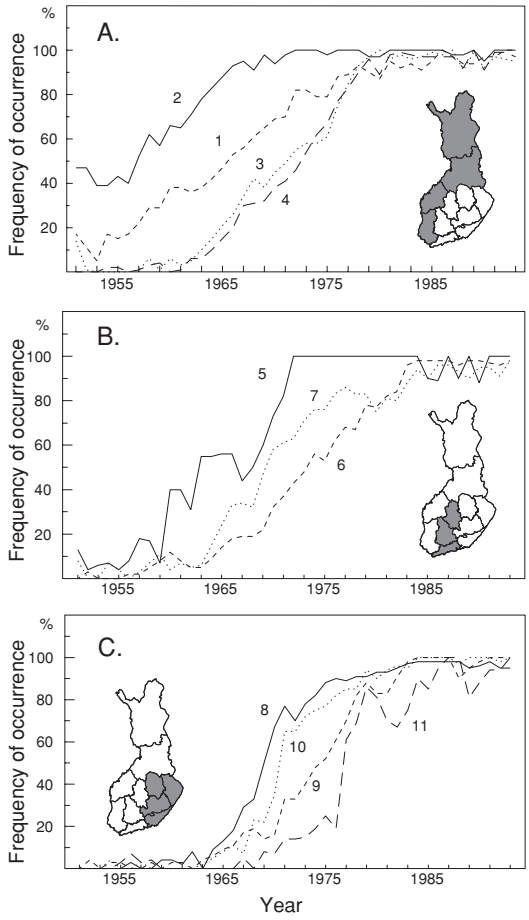

Fig. 2. The frequency of occurrence of the American mink, calculated on the basis of game inquiries, in different parts of Finland since 1951. A = Western Finland and Lapland, B = South-Central Finland and C = Eastern Finland. For the names of the provinces, see legend of Fig. 3.

3. Results

3.1. Development of the mink population in Finland

In the early 1950's, FO was between 40 and 50% in the western coast (the province of Vaasa) and between 6 and 15% in the SW coast (the provinces of Turku–Pori and Uusimaa) (Figs. 1 and 2). Very few minks were observed in other provinces at that time. The first minks were observed in the Island of Åland in 1955.

During the first half of the 1960's, FO increased from 65 to 88% in the western coast and from 39 to 52% in the SW coast. In the other provinces, especially in eastern Finland, FO was still very low. In the early 1970's, minks were found in most parts of the country, but in most provinces FO was still increasing. In the provinces of Vaasa and Uusimaa FO reached 100% in 1972.

The mink population did not increase in the provinces of Kuopio and Mikkeli until the first half of the 1970's (Figs. 2 and 3), but since then FO increased rapidly reaching the level of 80% in a few years. Thus, in areas which the mink reached latest, the rate of increase was very fast.

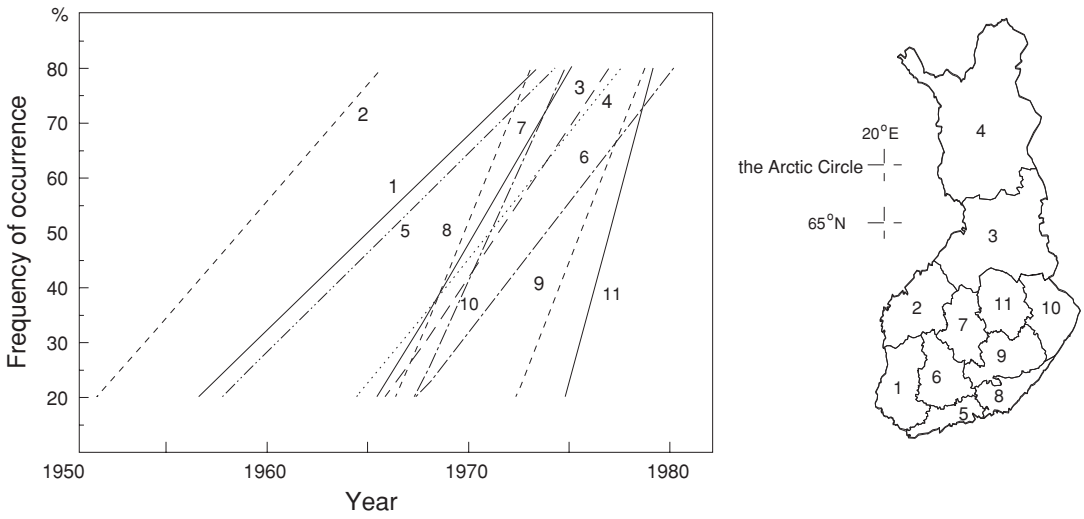

Fig. 3. The rate of increase of the American mink population in different provinces of Finland, based on the frequency of occurrence (*FO*) from game inquiries. The regression lines were calculated for the period of the most rapid increase, i.e. the period when *FO* increased from 20% to 80%. The provinces and slopes (P): 1 = Turku–Pori: b = 3.57 (P = 0.0000), 2 = Vaasa: b = 3.20 (P = 0.0000), 3 = Oulu: b = 4.59 (P = 0.0000), 4 = Lapland: b = 5.49 (P = 0.0000), 5 = Uusimaa: b = 3.16 (P = 0.0001), 6 = Häme: b = 4.76 (P = 0.0000), 7 = Central Finland: b = 5.51 (P = 0.0000), 8 = Kymi: b = 7.93 (P = 0.0007), 9 = Mikkeli: b = 7.08 (P = 0.0000), 10 = North Karelia: b = 8.13 (P = 0.0003), 11 = Kuopio: b = 17.2 (P = 0.0170).

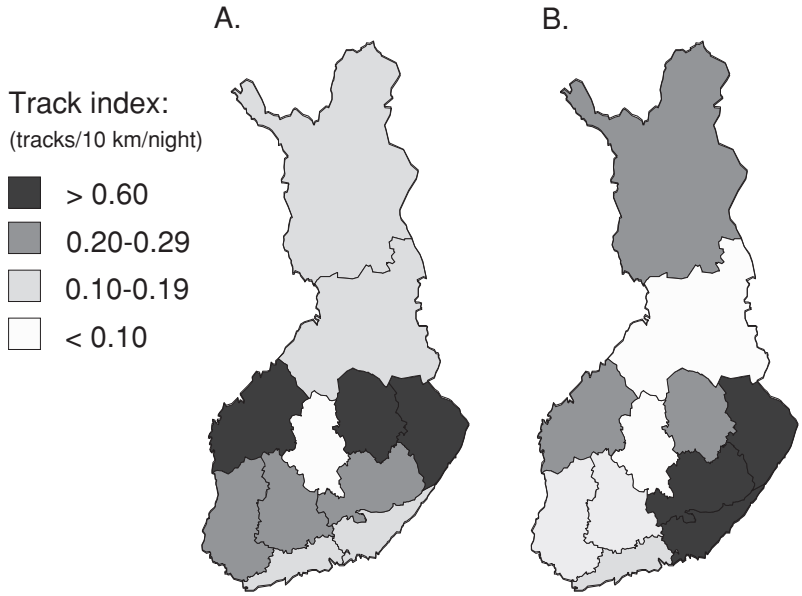

Fig. 4. The relative abundance of the American mink in different provinces of Finland, estimated on the basis of the snow track index (tracks/10 km/night) from wildlife triangles in 1992–95 (A) and on the basis of the abundance index from game inquiries in 1991–93 (B).

In the early 1980's, five decades after the first observations in the wild, almost the whole country was inhabited. In SW Finland, the province of Oulu and Lapland FO was about 100%, and also in other provinces it had reached the level of 80%. In the early 1990's, only few observers reported that minks were not found in their observation area (Fig. 1).

3.2. Relative density of the mink in different areas of Finland

The wildlife triangles and game inquiries (AI) gave rather different pictures on the relative abundance of the mink at present in different provinces of Finland (Fig. 4, Table 1). The trap indi-

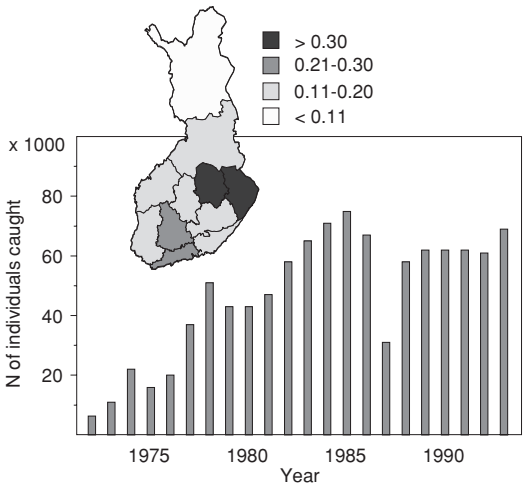

Fig. 5. The annual catch of the American mink in Finland since 1971. The map gives the number of minks trapped per km^2 in different provinces in the hunting season of 1992/93. (Data: FGFRI/Ermala).

ces and the tracking tunnels gave highest density to the province of North Karelia, and lowest to Lapland (Table 1), a result similar to that obtained from wildlife triangles.

The annual catch increased from 6 321 in the hunting season 1972/73 to 69 000 in 1993/94 (FGFRI/Ermala; Fig. 5). The number of minks caught/km^2 were highest in eastern Finland (the provinces of Kuopio and North Karelia) and lowest in Lapland. This also points to the conclusion that the density of mink population is highest in eastern Finland and lowest in Lapland.

Table 1. Relative abundance of the American mink in 3 provinces of Finland estimated using 6 different methods. A = game inquiries (mean abundance index from 1991–93), B = wildlife triangles (mean snow track index from 1992–95), C = trap index from 1993–94 (killing traps), D = trap index from 1993–94 (live traps), E = tracking tunnels from 1994–95, F = catch in 1992/93 (ind./km^2).

	Method					
Province	A	B	C	D	E	F
Häme	1.5	0.3	–	1.1	2.1	0.28
North Karelia	1.9	0.6	0.8	1.2	2.7	0.37
Lapland	1.6	0.1	0.6	–	1.9	0.07

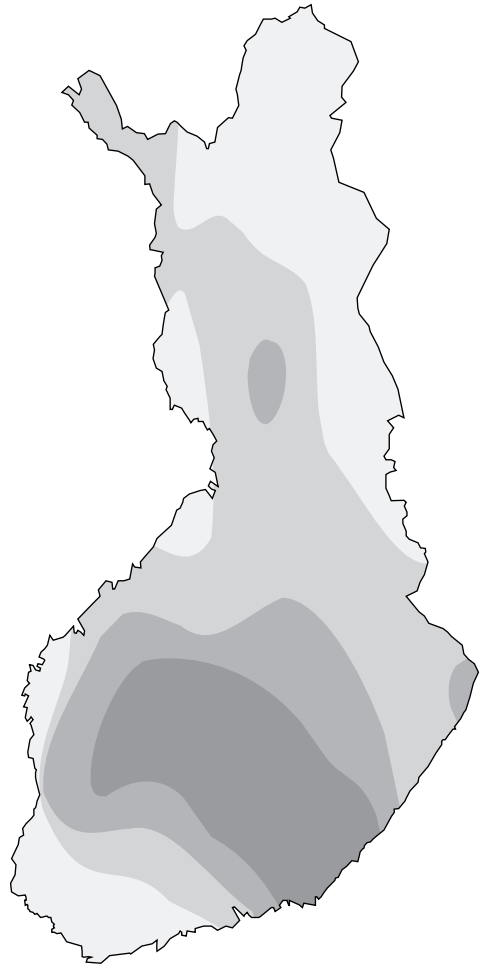

Fig. 6. Relative abundance of the otter based on the snow track index (tracks/10 km/night) from wildlife triangles in different parts of Finland in 1990–95. (The map: FGFRI/Wikman).

3.3. Comparison of the mink and the otter

The highest snow track index of the otter is in area II (the provinces of Kymi, Mikkeli and Central Finland, Fig. 6); especially in Kymi and Central Finland the track index of the mink is rather low (Fig. 4). The otter is nearly absent from SW Finland, especially in the coast where it has withdrawn since the early 1950's (Fig. 7). FO of otter declined in the 1970's, but increased again in the 1980's in most areas despite of the fact that minks were found almost everywhere (Fig. 8). (Area I is SW Finland where mink density is rather high, area II is the area where otter density seems to be highest at present,

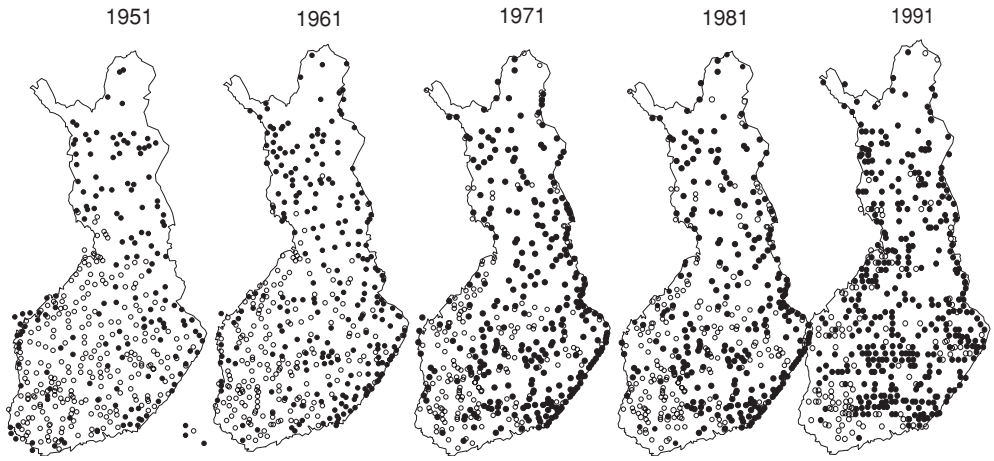

Fig. 7. Distribution of the otter in Finland in 1951–1991 on the basis of game inquiries. The maps show the observers who reported that otters were found in the area (black dots) and the observers who reported that otters were not found in the area (white dots).

• Observer who reported that otters were found in the area
° Observer who reported that otters were not found in the area

area III is eastern Finland where mink density is highest and area IV is Lapland.)

4. Discussion

4.1. Reasons behind the rapid increase of the mink

The increase of the mink population is clearly connected with mink farming, both in Finland and in Scandinavia. In Finland, the mink started to spread first in the western and southern coast where most mink farms were (Westman 1966). The rate of spreading was rather slow in western Finland because, excluding the coast and archipelago, SW Finland is mainly agricultural land with rather few lakes. Thus, it is not an ideal habitat for the mink.

Minks were also introduced in Russian Karelia between 1935 and 1965; more than 300 specimens were released (Atlas Karel'skoj ASSR 1989). In 1962, 64 minks were released very near Finnish border. This probably contributed to the rapid increase in mink populations in North Karelia and Kymi in the late 1960's. Another reason behind the fast rate of spreading in eastern Finland may have been the suitable habitat with many lakes and streams.

Minks were released also in the Murmansk area: more than 3 700 minks were released by 1948 at more than 50 places (Lever 1985). Some of these may have wandered to Lapland which may explain the occurrence of minks in the early 1970's at the Finnish/Russian border. Some minks may also have wandered to western Lapland from northern Sweden.

The mink well fulfils the criteria of a rapidly colonizing carnivore: it is relatively small, has high reproductive capacity, is a generalist predator, is generally adaptable and can live near human settlements (Ebenhard 1988). The typical litter size of the mink is from 4 to 7 (e.g. Macdonald 1993). The mink can take many kind of animal prey, even carrion, and it can hunt both in water and on land. The diet of the mink varies much between areas and seasons (e.g. Gerell 1968, Chanin & Linn 1980, Dunstone 1993, Tolonen 1982, Pulliainen 1984, Niemimaa & Pokki 1990). The mink can live in many kinds of habitats, but everywhere it is to some extent dependent on water. The mink may also benefit from the introduced/reintroduced beaver (*Castor* sp.) and muskrat (*Ondatra zibethicus*); it can use their dens and it also preys on muskrats (Dunstone 1993).

Besides, minks can wander long distances, especially males during the mating season in March (Dunstone 1993). In March the ice cover is at its thickest facilitating the spreading of the mink even to the archipelago. Dispersal of the young starts in July, and males in particular can move long distances. Because the mink is a good swimmer water is not a barrier for it; it can cross a body of open water up to 5 km (Bevanger & Henriksen 1995).

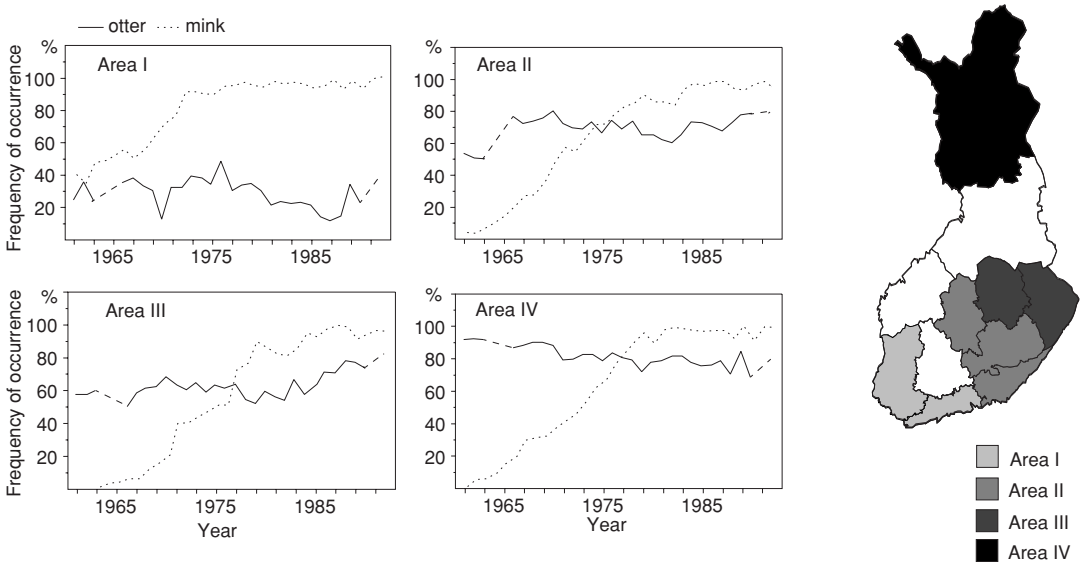

Fig. 8. The frequency of occurrence of the American mink and the otter in some areas in Finland since 1961, based on game inquiries.

4.2. Methods used in monitoring mink populations

Frequency of occurrence from the game inquiries should be quite reliable, because it is easy to detect/to get knowledge whether any minks live in the area or not. The abundance index, however, presents some problems, especially when different areas are compared. AI is based on opinions, and what is 'rare', 'common' or 'abundant' is a matter of taste. Thus, unless the reliability of AI can be tested for the species concerned, it should be used very cautiously.

The snow track index from wildlife triangles, the trap indices, the tracking tunnels and the size of the annual catch gave a rather similar picture of the relative abundance of the mink in different areas. However, the 3 areas which could be properly compared were all inland areas, and the density may be higher in the coast and archipelago of southern Finland. Also in other areas, e.g. Lapland, mink density can vary locally.

4.3. Mink and otter

The otter is one of Finnish native carnivores that has been suspected to suffer from the spreading of mink. The mink and the otter potentially compete for food. The otter preys mainly on fish, but the proportion of fish in mink diet usually varies between 20 and 60% (Chanin 1985). Minks prey on fish especially in winter (Gerell 1968, Wise *et al*. 1981) when dietary overlap is greatest (Erlinge 1969, 1972). Thus, competition for fish might be strong in winter (Erlinge 1969) or in suboptimal habitats, e.g. in oligotrophic streams. However, the mink will probably suffer more because the otter is better adapted to hunt in water (Chanin 1985, Dunstone 1993). Furthermore, the otter can take both large and small fishes, but the mink is restricted to smaller prey (Erlinge 1969). In Sweden, Erlinge (1972) found that otter diet in summer did not change in an eutrophic lake after the arrival of mink which means that at least in rich habitats there may be enough food for both.

Also the fact that minks consume a lot of terrestrial prey in summer probably reduces competiton between these species in summer. In winter at northern latitudes abundant terrestrial prey is not available for the mink because of the snow cover and competition may be stronger.

Besides food competition, minks and otters can compete for den sites, because both species can use e.g. beaver dens. But, if there is direct competition, the otter probably is the stronger one because of its much larger size. There is also some evidence from Russia that otters can even prey on minks (Chanin 1985).

In Sweden, there is an inverse correlation between the density of otters and minks in some areas; the mink is sparse in lakes where otter density is high (Erlinge 1972). Furthermore, Erlinge (1972) found that mink numbers declined in winter in one stream when otters moved to the area. It seems that the generalist mink is excluded from the preferred area of a specialist species, the otter. The highest otter density in Finland at present is in the provinces of Kymi, Mikkeli and Central Finland where mink density is rather low (Figs. 4, 5 and 6). Otter population declined in Finland in the 1970's, when mink population increased but increased again in the 1980's despite of the dense mink population (Fig. 8, see also Stjernberg & Hagner-Wahlsten 1994). Unfortunately, there are no wildlife triangles or trapping places in the archipelago to show the real relative mink and otter densities there. (In Fig. 8, area I includes inland areas and the picture for the coast and archipelago may be quite different.) However, in western Finland (the province of Satakunta) otter counts have been made in 1990, 1992 and 1995. These show a clear increase in otter density, but the otter still avoids most coastal areas (Game Management District of Satakunta, unpubl. data).

In England, the decline in otter populations in the 1960's and 1970's was formerly supposed to be caused by the mink (Lever 1985). However, there is little evidence to support this conclusion (Dunstone 1993). The decline of the otter can be connected with the use of two insecticides, dieldrin and aldrin (Dunstone 1993). Now, the use of these pesticides is banned and the otter populations are recovering even in rivers inhabited by mink. Dunstone (1993) suggests that the low otter population facilitated the rapid spread of mink, but the mink will probably give way to the returning otter. There is already evidence that this is happening in some areas in England (Birks 1989 according to Dunstone 1993).

In Finland, dieldrin was used until 1970 when the use of this insecticide was banned. Eleven otters from central Finland were examined for chlorinated hydrocarbons and PCBs in the 1980's, but the concentrations of these chemicals were generally low (Skarén 1988). However, nothing is known about the concentrations of these chemicals in otters in the 1960's and 1970's when otter populations declined. Furthermore, the otter started to recover about a decade after the use of dieldrin was banned; one would expect a time lag before the population recovers.

The concentrations of e.g. PCBs in otters may be higher in the coast and archipelago, including the Island of Åland, where otter populations have nearly vanished. In Sweden, PCBs have been blaimed for the decline of the otter (Olsson & Sandegren 1991ab, 1993), and it is known that levels of PCBs in Baltic seals increased in the 1950's and 1960's and have since then declined again (Helle 1985). Because PCBs affect the reproduction of mink (Aulerich & Ringer 1977, Kihlström *et al*. 1992, Osowski *et al*. 1995), and PCBs have also been connected with the reproductive failure of Baltic seals (Helle *et al*. 1976, Helle 1989, Olsson *et al*. 1994), it is likely that PCBs can have some effects on otters, too (Olsson & Sandegren 1993). Thus, reasons behind the decline of the otter in the coast and archipelago of SW Finland are not clear, but the high levels of e.g. PCBs may have a role in it. The mink may be among the reasons or it may not. One reason may be the increased disturbance by humans; because the otter suffers more from human interference the mink may benefit. In fact, the decline in otter populations since the 1950's may have been one reason behind the rapid increase in mink population in Finland.

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