

Introduced carnivores in Europe with special reference to central and northern Europe

Author: Kauhala, Kaarina

Source: Wildlife Biology, 2(3) : 197-204

Published By: Nordic Board for Wildlife Research

URL: <https://doi.org/10.2981/wlb.1996.019>

BioOne Complete (complete.BioOne.org) is a full-text database of 200 subscribed and open-access titles in the biological, ecological, and environmental sciences published by nonprofit societies, associations, museums, institutions, and presses.

Your use of this PDF, the BioOne Complete website, and all posted and associated content indicates your acceptance of BioOne's Terms of Use, available at www.bioone.org/terms-of-use.

Usage of BioOne Complete content is strictly limited to personal, educational, and non - commercial use. Commercial inquiries or rights and permissions requests should be directed to the individual publisher as copyright holder.

BioOne sees sustainable scholarly publishing as an inherently collaborative enterprise connecting authors, nonprofit publishers, academic institutions, research libraries, and research funders in the common goal of maximizing access to critical research.

Introduced carnivores in Europe with special reference to central and northern Europe

Kaarina Kauhala

Kauhala, K. 1996: Introduced carnivores in Europe with special reference to central and northern Europe. - *Wildl. Biol.* 2: 197-204.

The American mink *Mustela vison*, raccoon dog *Nyctereutes procyonoides* and raccoon *Procyon lotor* are introduced carnivores in Europe. The first American minks were brought to European fur farms in the late 1920s, when also the first raccoons were released, and raccoon dogs were released in the 1930s. The numbers of American minks and raccoon dogs increased rapidly, and today they are widely distributed in Europe. The range of the raccoon is restricted to Germany and adjacent countries and Belorussia. Minks are generalist predators whereas raccoon dogs and raccoons are omnivorous. Thus, e.g. birds and their eggs form part of the diet of these species. Minks are known to have caused damage to colonial ground-nesting sea-birds. Some bird populations have, however, adapted to the presence of mink in a few years. The American mink may also have played a role in the decline of the European desman *Galemys pyrenaicus* in Spain and the water vole *Arvicola terrestris* in England. It may also compete with the otter *Lutra lutra*, European mink *Mustela lutreola* and polecat *M. putorius*. Male American minks can mate with female European minks whose embryos may die. Hence, the American mink may be one of the reasons behind the decline of the European mink. Raccoon dogs can be locally harmful to waterfowl colonies and frogs, but their overall significance to the native fauna seems to be slight. Little is known about the predation or competition of the raccoon with the native fauna in Europe. The raccoon dog and raccoon can, however, be vectors of rabies; e.g. in Finland, the raccoon dog was the main vector of rabies during the epizootic in 1988-1989. The raccoon dog can also be a vector of e.g. sarcoptic mange and trichinosis.

Key words: American mink, raccoon dog, raccoon, introductions, Europe

Kaarina Kauhala, Finnish Game and Fisheries Research Institute, P.O. Box 202, FIN-00151 Helsinki, Finland

Of the 118 introduced mammalian species 23 belong to Carnivora (Ebenhard 1988). Carnivores have been introduced to all zoogeographical regions excluding the Ethiopian region (Ebenhard 1988), although feral dogs *Canis familiaris* and cats *Felis catus* may be found even there. Many of the introductions have failed, especially in Eurasia, either because of unsuitable conditions or because the number of individuals introduced was too low (de Vos et al. 1956).

A wish for a new fur animal is one of the most common reasons behind introductions of carnivores. Sometimes there was a need for biological control of a pest animal. The small Indian mongoose *Herpestes auropunctatus* was introduced to the West Indies in order to control rats in sugar-cane plantations (Pimentel 1955, Vilella & Zwank 1993), and to the Adriatic islands to control horned vipers *Vipera ammodytes* (Tvrtković & Kryštufek

1990). Weasels *Mustela nivalis* and stoats *Mustela erminea* were imported to the island of Terschelling off the coast of the Netherlands in order to control water voles *Arvicola terrestris* (de Vos et al. 1956, van Wijngaarden & Bruijns 1961). Many introductions have been accidental; carnivores have escaped from fur farms or domestic mammals have become feral after they have escaped from captivity or been abandoned by man; the domestic cat is a good example.

Introductions of carnivores may have several unfortunate consequences. An introduced carnivore may compete with native carnivores. Predation may even cause extinctions of native animals, especially on islands. Among the worst examples is the small Indian mongoose which has caused extinctions of endemic vertebrates on the Caribbean Islands (Myers 1931, Lewis 1953, Pimentel 1955). Also the horned viper vanished from at least one Adriatic

ic island after the introduction of the mongoose (Tvrtković & Kryštufek 1990). Introduced animals can bring diseases or parasites with them. Rinderpest which spread from cattle to native antelopes, had major effects on the whole community in East Africa after 1890 (Sinclair & Norton-Griffiths 1979). The small Indian mongoose proved to be an important reservoir and vector of rabies in Puerto Rico (Pimentel 1955). Introduced species can cause genetic changes in closely related native populations. Kamchatka sable *Martes zibellina kamtschadalis*, introduced to western Siberia, interbred with the native sable *M. zibellina* resulting in changes of pelt quality (Lindemann 1956). The Siberian weasel *Mustela sibirica* was introduced to Japan (Hokkaido), where it interbred with the native weasel *M. sibirica itatchi* (de Vos et al. 1956).

Carnivores introduced into Europe include fur animals, like the American mink *Mustela vison*, the raccoon dog *Nyctereutes procyonoides* and the raccoon *Procyon lotor*. The American mink and the raccoon originate in North America, the raccoon dog in the Far East. Alaskan silver foxes *Vulpes vulpes* were also imported to Finland in 1938, and North American silver foxes to European Russia with the idea that they would interbreed with the native red foxes and improve fur quality (Voipio 1948, Schmidt 1954, de Vos et al. 1956). The North Siberian arctic fox *Alopex lagopus* was introduced to the Kola Peninsula to improve fur harvest (Lindemann 1956). In addition, the small Indian mongoose was introduced on the Adriatic islands in 1910 (Tvrtković & Kryštufek 1990, Cavallini & Serafini 1995), the Indian grey mongoose *Herpestes edwardsii* in central Italy around 1960 (Carpabetto 1990, Tvrtković & Kryštufek 1990) and the Egyptian mongoose *H. ichneumon* in Portugal, southern Spain and on the Adriatic island of Mljet (Macdonald & Barrett 1993). Also feral dogs are found especially in Italy (Boitani & Fabbri 1983) and feral cats are common, e.g. in Britain (Lever 1985).

The aim of this review is to present a short distribution history of the American mink, the raccoon dog and the raccoon in Europe and to discuss the possible consequences of these introductions to the native fauna of Europe.

Introductions, population growth and present distribution

The American mink

The spread of the American mink in Europe was strongly connected with mink farming (Dunstone 1993, Bevanger & Henriksen 1995), even though minks have also been released deliberately in Russia, e.g. in Karelia and

on the Kola Peninsula since 1933 (Novikov 1962, Danilov et al. 1973). The first American minks were brought to Europe in the 1920s (Westman 1966, Gerell 1967, Dunstone 1993, Bevanger & Henriksen 1995), and minks were seen in the wild soon afterwards: in 1928 in Sweden (Gerell 1967), 1930 in Norway (Bevanger & Henriksen 1995), 1932 in Finland (Westman 1966), 1938 in Scotland (Cuthbert 1979), the 1930s in England and Wales (Dunstone 1993) and 1961 in Ireland (Deane & O'Gorman 1969). In Iceland, the first evidence of minks in the wild is from 1937 (Skirnisson 1980), in Latvia from 1944 (Ozoliņš & Pilāts 1995), in Germany from 1950 (Heidemann 1983) and in Poland from 1962 (Ruprecht et al. 1983 according to Dunstone 1993).

In Sweden, mink populations increased rapidly during the 1940s and 1950s, and again during the 1980s (Gerell 1967, 1993). The annual catch increased from about 1,000 to more than 40,000 in about four decades (from 1944/47 to 1986/89, Gerell 1993). In Finland and Norway, mink numbers increased rapidly in the 1960s, 1970s and early 1980s (Bevanger & Henriksen 1995, Kauhala 1996a). The annual catch increased from 6,300 to 69,000 in about two decades in Finland (from 1972 to 1993, Finnish Game and Fisheries Research Institute, unpubl. data). In Norway, the hunting bag exceeded 30,000 in the mid-1980s (Bevanger & Henriksen 1995). In England, minks were first observed breeding in the wild in 1956; in 1962, 5,000 minks were trapped in England and Wales, and by the 1970s minks occurred all over the country (Dunstone 1993). Apart from the British Isles and Fennoscandia, minks are found today in northern Spain, France (Brittany), the Netherlands, Denmark, Germany (Schleswig-Holstein), Ireland, Iceland, Poland and in the countries of the former Soviet Union (Lever 1985, Lafontaine 1988, Dunstone 1993, Ozoliņš & Pilāts 1995).

The raccoon dog

Raccoon dogs were introduced into the former Soviet Union, mainly the European parts, between 1929 and 1955 (Lavrov 1971). They were released in e.g. Estonia in 1950, near Pihkova in 1947, Novgorod in 1935, St. Petersburg in 1936, Karelian Isthmus in 1953 and on the Kola Peninsula in 1936 (Lavrov 1971, Helle & Kauhala 1991). A few individuals also escaped from captivity e.g. in Sweden (Markgren 1988). The raccoon dog expanded its distribution area at an average annual speed of 40 km, in some areas even 120 km per year (Lavrov 1971, Helle & Kauhala 1987).

The first verified observation of a raccoon dog in the wild is from the mid-1930s in Finland (Siivonen 1958), the 1940s in Sweden (Notini 1948), 1983 in Norway (Wikan 1983), 1943 in Latvia (Ozoliņš & Pilāts 1995), 1955 in Poland (Nowak & Pielowski 1964), 1960 in Germany

(Röben 1975), and 1979 in France (Artois & Duchêne 1982). A raccoon dog was seen in Romania in 1951, Czechoslovakia in 1959, Hungary and Austria in 1962, and Bulgaria in 1967 (Nowak & Pielowski 1964, Lever 1985). Between 1935 and 1984 an area of 1.4×10^6 km² was colonised (Nowak 1984).

The present distribution area of the raccoon dog in Europe includes Finland (excluding most of Lapland), the Baltic countries, Poland, most of Germany, Romania, parts of Bulgaria, Hungary, Russia, Belorussia, Moldova and Ukraine. Raccoon dogs are occasionally seen in Sweden, Norway, the Netherlands, France, Switzerland and Austria (Nowak 1984, Lever 1985).

Today the raccoon dog is among the most common carnivores e.g. in Finland and the Baltic countries (Helle & Kauhala 1991, Ozoliņš & Pilāts 1995). In Germany, the raccoon dog is classified as 'not common', but it is found almost everywhere in the former Eastern Germany and their numbers and distribution area are supposed to be increasing. Little is known about raccoon dog density in Sweden, although observations have been made all over the country (E. Lindström, pers. comm.).

The raccoon dog population increased in numbers very quickly. In Finland the annual catch increased from 818 in 1970/71 to 61,000 in 1985/86 (Helle & Kauhala 1991). Especially in southern Finland the population increased according to an S-shaped curve, reached a peak in the mid-1980s and declined slightly thereafter (Helle & Kauhala 1991, Kauhala & Helle 1995).

The raccoon

In 1934 two pairs of raccoons were released in Hessen, Germany, and a year later more raccoons were introduced near Berlin (Röben 1975, Lutz 1984, 1995), but few raccoons may have been released as early as in the 1920s (Lutz 1996). During the Second World War raccoons were released from fur farms (Lutz 1995) and in 1945, some animals escaped from captivity east of Berlin (Lever 1985). The population first started to increase in Hessen where it had increased to about 20,000 by 1970 (Lever 1985). By 1980 most of (East and West) Germany had been colonised (Lutz 1984). Today the city states of Berlin and Hamburg are the only areas in Germany in which raccoons have not been observed (Lutz 1984, Stubbe 1990), and the 1992/1993 hunting bag consisted of about 2,000 individuals (Lutz 1995).

The most rapid increase in Germany took place during 1960-1975 (Lutz 1995). After 1975 the population declined, but increased again in the late 1980s, according to hunting bags in Germany (Lutz 1995). However, based on captures, killing rates and wildlife observations, Stubbe (1990) found that the population also increased between 1975 and 1984.

The first raccoons were observed in France as early as in 1934, in the Netherlands in 1960, in Luxemburg in 1979, in Austria in 1974 and in Switzerland in 1975 or 1976 (Lutz 1984, Stubbe 1993). Raccoons have been observed also in Denmark (Jensen 1994), Belgium, the former Czechoslovakia and Poland (Lutz 1984). In 1954 and 1958 a total of 130 raccoons were introduced also in Belorussia where they spread slowly and today are common only locally (Lever 1985). Wide rivers, the Alps and unsuitable habitats have probably prevented the spread of the raccoon in central Europe (Lutz 1984).

Reasons behind the successful introductions

The raccoon and raccoon dog are truly omnivorous (Kauhala et al. 1993, Lutz 1996) and the American mink is a generalist predator taking both aquatic and terrestrial prey (e.g. Gerell 1968, Chanin & Linn 1980, Dunstone & Birks 1987). Furthermore, these carnivores have high reproductive potential: the mean litter size of the raccoon dog is 9-10 in southern Finland (Helle & Kauhala 1995), that of the mink is around 5 or 6 (Chanin 1983) and the raccoon usually has 1-6 young (Stubbe 1993), sometimes as many as 10 (Fritzell et al. 1985). Both the raccoon dog and the raccoon are able to accumulate large fat reserves during autumn and spend part of the winter dormant. All three species are also able to live near human settlements.

These carnivores have been part of the European fauna for about six decades. Today the distribution areas of the mink and the raccoon dog are very large, whereas the raccoon is restricted to Germany and adjacent countries and to Belorussia. One reason behind this difference may be that raccoons were introduced into fewer places. It may, however, also have narrower habitat requirements than the other two species; the raccoon dog lives in many different habitats ranging from subtropical rainforests to boreal coniferous forests, and also the mink can live in various habitats if there is enough shelter and shallow, slow-moving or stationary bodies of water (Dunstone 1993). The raccoon prefers deciduous forests, especially oak forests, and swamps, marshes and flood forests, but it is relatively scarce in dry forests, e.g. in pine forests (Kaufmann 1982, Macdonald & Barrett 1993, Lutz 1996).

The mink seems to be least sensitive to harsh winters as it has expanded its range to cover even the northernmost parts of Europe. The raccoon dog can live in areas where the annual mean temperature is a little above zero, the duration of snow cover about 175 days and growing season about 135 days (Lavrov 1971, Helle & Kauhala 1991). The raccoon dog has not spread to Italy, although it was seen in Austria as early as in 1962. This may be

due to the Alps which form an efficient geographical barrier for the raccoon dog.

Harsh winters and thick snow cover in northern Europe may prevent the raccoon from spreading northwards. In North America, however, the raccoon has spread northwards recently; one reason may be climatic changes leading to increasing temperatures (Macdonald 1989).

Consequences of the introductions

Predation

The American mink

Having evolved in the Nearctic region, the American mink is not a natural part of the European fauna, and therefore e.g. sea-birds which are not adapted to mink predation may be very vulnerable to this (Hario 1979, Gerell 1985). On Söderskär (the outer archipelago of the Gulf of Finland), the population of the black guillemot *Cephus grylle* has declined since 1976. The first minks were seen on Söderskär in 1970, and in 1976 42% of the breeding population of black guillemot was lost due to mink predation (Hario 1979). In about 10 years the colony decreased from 384 breeding pairs to 145 pairs (Hario et al. 1986). Also in Iceland and Sweden minks are known to have caused damage to sea-birds (Gerell 1985, Dunstone 1993). In Latvia, the American mink is considered the most serious predator of waterfowl (Ozoliņš & Pilāts 1995).

Colonial ground-nesting sea-birds in the outer archipelago are particularly endangered because of a poorly developed defensive behaviour due to the previous lack of terrestrial predators (Dunstone 1993), but bird fauna may adapt to a new predator in a few years. Off the Swedish west coast sea-bird colonies suffered heavy predation by the mink during the 1950s, and the colonies moved to the outer islands. Later bird populations moved back to the islands closest to the mainland, indicating that coexistence with mink is possible (Gerell 1968, 1985). On other islands in southern Sweden, minks were found to take only 1.4% of the eider *Somateria mollissima* population (Gerell 1985). Although minks frequently prey on eiders, eider population increased in the Gulf of Finland until the mid-1980s (Hario & Selin 1986, 1988). Gerell (1985, 1993) concludes that eiders may learn how to avoid predation when nesting in the proximity of minks; on islands visited only occasionally by minks, female eiders have less experience with mink and eider survival is lower (Gerell 1985). Furthermore, the low survival rate of the eggs and nestlings of young eiders points to the same conclusion (Gerell 1985). Dunstone (1993) suggests that the mink's territoriality may also prevent very heavy exploitation of birds; surplus killing by a mink which is used to colonial prey is unlikely.

Minks are also accused of affecting salmonid populations, but little evidence has been found to support this (Dunstone 1993). Minks may have some effect on grayfish *Astacus astacus* populations, as they are known to feed on grayfish, especially in summer (Gerell 1967). In England, minks frequently prey on rabbits *Oryctolagus cuniculus*, but rabbits are very abundant and not threatened by the mink (Dunstone 1993). In the Tvärminne archipelago, off the southern coast of Finland, minks prey on mountain hares *Lepus timidus* but no effect on the hare population has been noticed (Niemi & Pokki 1990). However, the European desman *Galemys pyrenaicus* population has declined in Spain probably due to mink predation, although other reasons, such as pollution of mountain streams, may be involved (Dunstone 1993, Macdonald & Barrett 1993). Also water vole populations in England and Wales have declined since the 1980s, and the mink probably has played a part in this decline (Dunstone 1993).

The raccoon dog

Raccoon dogs have caused damage to waterfowl colonies in Estonia (Naaber 1971, 1984); in some areas raccoon dogs robbed up to 85% of the nests. Ivanova (1962) found remains of birds (mainly waterfowl) in 45% of the faeces collected in a river valley in Voronez (European Russia).

Excluding waterfowl colonies, the raccoon dog seems to be rather harmless to game birds: in Finland only 1% of raccoon dog faeces collected in May and June contained remains of waterfowl, and none contained remains of gallinaceous birds (Kauhala et al. 1993). In early summer, raccoon dogs frequently forage on shores, mainly on frogs and lizards (Kauhala et al. 1993, Kauhala 1996b). Remains of gallinaceous birds were found in 10%, and remains of passerines in 13% of raccoon dog stomachs collected from August to April (Kauhala et al. 1993). However, about half of the gallinaceous birds were introduced pheasants *Phasianus colchicus*. Furthermore, grouse populations started to decline in southwest Finland as early as in the 1960s (Finnish Game and Fisheries Research Institute, unpubl. data), i.e. before the raccoon dog invaded the area (Helle & Kauhala 1991). In Poland, Reig & Jedrzejewski (1988) found that while the red fox frequently preys on birds, the raccoon dog does so only occasionally. Naaber (1971) concluded that raccoon dogs are not harmful to grouse or hare populations in Estonia. In fact, the raccoon dog is very clumsy and most probably has great difficulties in catching an adult bird or hare.

Raccoon dogs may, especially on small islands, threaten frog populations. Frogs have vanished from some islands off the southwest coast of Finland after raccoon dogs arrived in the 1970s, but frog populations have not declined on the outer islands where raccoon dogs are not found (J. Nummelin, pers. comm.). The principal prey of the raccoon dog in many areas is, however, small rodents

(e.g. Ivanova 1962, Naaber 1974, Nasimovic & Isakov 1985, Kauhala et al. 1993). Thus, the raccoon dog may be locally (mainly on some islands) harmful to native birds and frogs, but most probably its overall impact on native fauna is insignificant.

The raccoon

The diet of the raccoon consists of both animals and plants, and sometimes of eggs and young birds (Lutz 1996, Macdonald & Barrett 1993). The raccoon may threaten native birds more than the mink or the raccoon dog because it is partly arboreal, and thus, able to feed on tree-nesting birds, too. Raccoons may also feed on hares and other small mammals. In Germany, raccoons were suspected to threaten native grouse populations, but there is little evidence to support this (Lutz 1996).

Competition

The American mink

The American mink has been blamed for the decline of otter *Lutra lutra* populations in Europe (e.g. Lever 1985). However, the decline of the otter population may be connected with environmental pollutants and human disturbance (Dunstone 1993, Olsson & Sandegren 1993). In England, the use of insecticides (dieldrin and aldrin) may have caused the decline, because after they were banned otter populations started to recover, and now the mink is probably giving way to the returning otter (Birks 1989).

Otter populations have declined also along the Baltic coast since the 1950s (Olsson & Sandegren 1991, Stjernberg & Hagner-Wahlsten 1994, Kauhala 1996a) which may be partly due to e.g. PCBs (Olsson & Sandegren 1993).

However, Clode & Macdonald (1995) suggest that mink and otter compete for food; niche breadth was wider on Scottish islands for both species when they co-existed in comparison to allopatric populations.

Competition might be strongest in winter when fish make up a large proportion of mink diet (Erlinge 1969). Dunstone (1993) suggests, however, that because the otter is a fish specialist and better adapted to hunting in water, the mink will suffer more. In some areas in Sweden there is an inverse correlation between the density of the otter and the mink; Erlinge (1972) suggests that the generalist mink is excluded from the preferred habitat of the specialist otter (see also Kauhala 1996a). If there is direct competition between the otter and mink, e.g. for den sites, the otter will most probably win because it is much larger than the mink.

Competition with the American mink may have played a role in the decline of the European mink *Mustela lutreola* population; indeed, in Estonia the decline seems to coincide with the spread of the American mink (Maran &

Henttonen 1995). However, in continental Europe the decline most probably can be ascribed to habitat changes; also in Finland the major decline of the European mink population took place well before the spread of the American mink (Granqvist 1981, Maran & Henttonen 1995). Several factors were probably involved in the decline, and the factors involved may have been different in different areas. Maran & Henttonen (1995) conclude that before the arrival of the American mink, habitat changes or the crash in the preferred food source (crayfish) may have been most important, but after the arrival of the American mink the European mink loses even without the environmental change. Also Sidorovich (1993) predicts that the European mink will not recover because of the competition with the American mink.

It is also possible that the American mink competes with the polecat *Mustela putorius* and the stoat; in England all three species prey frequently on rabbits (Day 1968, Walton 1968 according to Dunstone 1993). Rabbits are, however, abundant, and probably not a limiting factor for these mustelids (Dunstone 1993). Furthermore, the polecat is expanding its range in England into areas which are inhabited by the mink (Birks 1986). In Sweden, although minks have been observed to chase polecats away from their territories, polecats have increased during the last few years (Gerell 1993).

The raccoon dog

The raccoon dog is an omnivorous carnivore which potentially competes with the red fox and the badger *Meles meles*. In the Far East, which is the raccoon dog's original distribution area, these species are partly sympatric and, thus, may have adapted to coexistence which may reduce competition. However, although competition does not take place in one area, it might occur elsewhere.

The Finnish badger population has expanded its range a little northwards and the range has become more continuous during the last few decades when raccoon dogs colonised the country (Kauhala 1995). This may lead to the conclusion that no severe competition takes place between the badger and the raccoon dog in Finland. Although the diets of the raccoon dog, the badger and the red fox partly overlap, the badger specialises more on invertebrates, the raccoon dog more on plants and small mammals including shrews, and the red fox is mostly carnivorous feeding also on larger prey (e.g. Ivanova 1962, Kauhala et al. 1993, Kauhala 1996c).

In areas where winters are harsh, raccoon dogs and badgers are dormant in winter; this probably prevents them from competing severely with each other and with the red fox; winter is the critical season when food is scarce and competition most severe. Thus, competition might take place, but it is unlikely that it is very severe leading to competitive exclusion of either of the native species.

Diseases and parasites

The raccoon dog is a vector of sylvatic rabies; in Finland the rabies outbreak in 1988 was most probably due to the dense raccoon dog population because 74% of the observed cases occurred in raccoon dogs (Westerling 1991). Also in the Baltic countries and in Poland raccoon dogs are important vectors of the disease (Cerkasskij 1980); in the Baltic countries, the raccoon dog is the second most important vector after the red fox.

The raccoon may also spread rabies; raccoon rabies is known e.g. in southeast USA (McLean 1975). In some areas of continental Europe foxes, raccoon dogs and raccoons occur today. Thus, the number of species which potentially may spread rabies has increased. The relationship between these species and the dynamics of rabies are not yet fully understood. It is not clear, whether e.g. the raccoon dog develops its own cycle of rabies or whether it depends on the fox as a reservoir.

Raccoon dogs are also frequently infected by sarcoptic mange which is a common disease among foxes (e.g. Novikov 1962). Thus, raccoon dogs may play a part in the spread of mange, too. Also raccoons carry several infectious diseases and parasites which may infect other animals in their new range (Lutz 1996).

Raccoon dogs are also known to be infected by *Trichinella* sp.; in Finland 72% of the examined adult males and 53% of adult females were infected (Mikkonen et al. 1995). The infection was more common in adults than in young individuals. In addition to domestic pigs *Sus scrofa*, Norway rats *Rattus norvegicus* are commonly infected by *Trichinella* in Finland. There may be a connection between the raccoon dog and the rat, and it is possible that the raccoon dog is one of the vectors between the sylvatic and synanthropic cycle (Mikkonen et al. 1995). The American mink, too, has been found to be infected by *Trichinella* in Finland (Hirvelä-Koski et al. 1985). Thus, it may be one of the vectors. Fur animal carcasses should therefore always be destroyed, otherwise they may form a massive source of trichinellosis to animals feeding on carrion (Hirvelä-Koski et al. 1985). Raccoon dogs may also be vectors of piroplasmiasis, helminths and ixodid ticks, e.g. *Ixodes tanuki* (Novikov 1962, Fujimoto et al. 1986, Cheng & Ye 1988).

The American mink is also known to carry several parasites, e.g. the sinus worm *Skrjabinogylus nascicola* in America and Sweden (Dunstone 1993). Henttonen & Tolonen (1983) suggested that the American mink brought some disease to Europe which was not fatal to this, but very dangerous for the European mink. The disease probably spread much faster than the American mink affecting the decrease in European mink populations.

Genetic consequences

There should be no risk that raccoon dogs or raccoons hybridise with native species in Europe because they do not have close relatives. But the American mink may mate with the European mink, leading to embryos being resorbed (Ternovskij 1977). Thus, it is possible that male American minks copulate with female European minks which do not get viable offspring (Simberloff 1996). This may have been one reason behind the decline of the European mink, but it does not result in introgression because the hybrids are not viable.

References

- Artois, M. & Duchêne, M.-J. 1982: Première identification du chien viverrin (*Nyctereutes procyonoides* Gray, 1834) en France. - *Mammalia* 46: 265-266. (In French).
- Bevanger, K. & Henriksen, G. 1995: The distributional history and present status of the American mink (*Mustela vison* Schreber, 1777) in Norway. - *Annales Zoologici Fennici* 32: 11-14.
- Birks, J.D.S. 1986: Mink. - *The Mammal Society & Anthony Nelson Ltd, Oswestry, Shropshire*, 24 pp.
- Birks, J.D.S. 1989: What regulates the numbers of feral mink? - *Nature in Devon* 10: 45-61.
- Boitani, L. & Fabbri, M.L. 1983: Censimento dei cani in Italia con particolare riguardo al fenomeno del randagismo. - *Ricerche di Biologia della Selvaggina* 73: 1-50. (In Italian with English summary).
- Carpaneto, G.M. 1990: The Indian grey mongoose (*Herpestes edwardsii*) in the Circeo National Park: a case of incidental introduction. - *Mustelid & Viverrid Conservation* 2: 10.
- Cavallini, P. & Serafini, P. 1995: Winter diet of the small Indian mongoose, *Herpestes auropunctatus*, on an Adriatic island. - *Journal of Mammalogy* 76: 569-574.
- Cerkasskij, V.L. 1980: The role of the raccoon dog in the epizootiology of rabies. - *Rabies Bulletin Europe/World Health Organization* 3: 11-13.
- Chanin, P.R.F. 1983: Observations on two populations of feral mink in Devon. - *Mammalia* 47: 463-476.
- Chanin, P.R.F. & Linn, I.J. 1980: The diet of the feral mink (*Mustela vison*) in southwest Britain. - *Journal of Zoology, London*, 192: 205-223.
- Cheng, Y.D. & Ye, L.Y. 1988: [A survey of parasitic helminths in wild *Nyctereutes procyonoides*.] - *Chinese Journal of Veterinary Science and Technology* 8: 25-27. (In Chinese).
- Clode, D. & Macdonald, D.W. 1995: Evidence for food competition between mink (*Mustela vison*) and otter (*Lutra lutra*) on Scottish islands. - *Journal of Zoology, London* 237: 435-444.
- Cuthbert, J.H. 1979: Food studies of feral mink (*Mustela vison*) in Scotland. - *Fisheries Management* 10: 17-25.
- Danilov, P.I., Ivanov, P.D., Novikov, G.A. & Timofeeva, E.K. 1973: Sovremennoe rasprostranenie nekotorykh vidov zveri na severo-zapade evropeiskoi chasti SSSR. - *Bjulleten' Moskovskogo obščestva ispytatelej prirody. Otdel biologiceskij* 78: 5-20. (In Russian).
- Day, M.G. 1968: Food habits of stoats (*Mustela erminea*) and weasels (*Mustela nivalis*). - *Journal of Zoology, London*, 155: 485-497.

- Deane, C.D. & O'Gorman, F. 1969: The spread of feral mink in Ireland. - *Irish Naturalists' Journal* 16: 198-202.
- de Vos, A., Manville, R.H. & van Gelder, R.G. 1956: Introduced mammals and their influence on native biota. - *Zoologica* 41: 163-194.
- Dunstone, N. 1993: The mink. - T. and A.D. Poyser Ltd, London, 232 pp.
- Dunstone, N. & Birks, J.D.S. 1987: The feeding ecology of mink (*Mustela vison*) in a coastal habitat. - *Journal of Zoology, London*, 212: 69-83.
- Ebenhard, T. 1988: Introduced birds and mammals and their ecological effects. - *Swedish Wildlife Research* 13: 1-107.
- Erlinge, S. 1969: Food habits of the otter *Lutra lutra* L. and the mink *Mustela vison* Schreber in a trout water in southern Sweden. - *Oikos* 20: 1-7.
- Erlinge, S. 1972: Interspecific relations between otter *Lutra lutra* and mink *Mustela vison* in Sweden. - *Oikos* 23: 327-335.
- Fritzell, E.K., Hubert, G.F., Meyen, B.E. & Sanderson, G.C. 1985: Age-specific reproduction in Illinois and Missouri raccoons. - *Journal of Wildlife Management* 49: 901-905.
- Fujimoto, K., Yamaguti, N. & Takahashi, M. 1986: Ecological studies on ixodid ticks: Ixodid ticks on vegetation and wild animals at the low mountain zone lying in the south-western part of Saitama Prefecture. - *Japanese Journal of Sanitary Zoology* 37: 325-331.
- Gerell, R. 1967: Dispersal and acclimatization of the mink (*Mustela vison* Schreb.) in Sweden. - *Viltrevy* 4: 1-38.
- Gerell, R. 1968: Food habits of the mink, *Mustela vison* Schreb., in Sweden. - *Viltrevy* 5: 119-211.
- Gerell, R. 1985: Habitat selection and nest predation in a common eider population in southern Sweden. - *Ornis Scandinavica* 16: 129-139.
- Gerell, R. 1993: Lär känna minken. - Svenska Jägareförbundet, Spånga, 48 pp. (In Swedish).
- Granqvist, E. 1981: Flodillern (*Mustela lutreola*) i Finland samt den troliga orsaken till dess tillbakagång. - *Memoranda. Societatis pro Fauna et Flora Fennica* 557: 41-49. (In Swedish).
- Hario, M. 1979: Minkin vahingollisuudesta merilinnustolle. - *Tringa* 2/79: 58-59. (In Finnish).
- Hario, M. & Selin, K. 1986: Mitä pesinnän ajoittuminen kertoo haahkan menestymisestä Suomenlahdella (In Finnish with English summary: A 30 year change in the breeding time of the common eider in the Gulf of Finland). - *Suomen Riista* 33: 19-25.
- Hario, M. & Selin, K. 1988: Thirty year trends in an eider population: timing of breeding, clutch size, and nest site preferences. - *Finnish Game Research* 45: 3-10.
- Hario, M., Komu, R., Muuronen, P. & Selin, K. 1986: Saaristolintukantojen kehitys Söderskärillä vuosina 1963-86 ja eräitä poikastuotantoon vaikuttavia tekijöitä (In Finnish with English summary: Population trends among archipelago birds in Söderskär bird sanctuary 1963-86). - *Suomen Riista* 33: 79-90.
- Heidemann, G. 1983: Über das Vorkommen des Farnnerzes (*Mustela vison* f. dom.) in Schleswig-Holstein. - *Zeitschrift für Jagdwissenschaft* 29: 120-122. (In German with English summary).
- Helle, E. & Kauhala, K. 1987: Supikoiran leviämishistoria ja kantojen nykytila Suomessa (In Finnish with English summary: Distribution history and present status of the raccoon dog in Finland). - *Suomen Riista* 34: 7-21.
- Helle, E. & Kauhala, K. 1991: Distribution history and present status of the raccoon dog in Finland. - *Holarctic Ecology* 14: 278-286.
- Helle, E. & Kauhala, K. 1995: Reproduction in the raccoon dog in Finland. - *Journal of Mammalogy* 76: 1036-1046.
- Henttonen, H. & Tolonen, A. 1983: Minkki ja vesikko. - In: Koivisto, I. (Ed.); *Suomen eläimet I*. Weilin+Göös, Espoo, pp. 228-233. (In Finnish).
- Hirvelä-Koski, V., Aho, M., Asplund, K., Hatakka, M. & Hirn, J. 1985: *Trichinella spiralis* in wild animals, cats, mice, rats and farmed fur animals in Finland. - *Nordisk Veterinär Medicin* 37: 234-242.
- Ivanova, G.I. 1962: Sravnitel'naja karakteristika pitanija lisicy, barsuka i enotovidnoj sobaki v Voronezkom zapovednike. - *Uchenye zapiski/Moskovskij gosudarstvennyj pedagogiceskij institut im. V.I. Lenina* 186: 210-256. (In Russian).
- Jensen, B. 1994: Suomen ja Pohjolan nisakkaat. - WSOY, Porvoo, 326 pp. (In Finnish).
- Kaufmann, J.H. 1982: Raccoon and allies. - In: Chapman, J.A. & Feldhamer, G.A. (Eds.); *Wild mammals of North America*. - The John Hopkins University Press, Baltimore, pp. 567-585.
- Kauhala, K. 1995: Changes in distribution of the European badger *Meles meles* in Finland during the rapid colonization of the raccoon dog. - *Annales Zoologici Fennici* 32: 183-191.
- Kauhala, K. 1996a: 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.
- Kauhala, K. 1996b: Habitat use of raccoon dogs, *Nyctereutes procyonoides*, in southern Finland. - *Zeitschrift für Säugetierkunde* 61: 269-275.
- Kauhala, K. 1996c: Reproductive strategies of the raccoon dog and the red fox in Finland. - *Acta Theriologica* 41: 51-58.
- Kauhala, K. & Helle, E. 1995: Population ecology of the raccoon dog in Finland. - *Wildlife Biology* 1: 3-9.
- Kauhala, K., Kaunisto, M. & Helle, E. 1993: Diet of the raccoon dog, *Nyctereutes procyonoides*, in Finland. - *Zeitschrift für Säugetierkunde* 58: 129-136.
- Lafontaine, L. 1988: Un nouveau venu sur le littoral: le vison d'Amérique. - *Penn-ar-Bed* 125: 77-82. (In French).
- Lavrov, N.P. 1971: Itogi introduksii enotovidnoj sobaki (Npg) vothel'nye oblasti SSSR. - *Trudy kafedry biologii MGZPI* 29: 101-166. (In Russian).
- Lever, C. 1985: *Naturalized mammals of the world*. - Longman Group Ltd., Essex, 487 pp.
- Lewis, C.B. 1953: Rats and the mongoose in Jamaica. - *Oryx* 2: 170-172.
- Lindemann, W. 1956: Transplantation of game in Europe and Asia. - *Journal of Wildlife Management* 20: 68-70.
- Lutz, W. 1984: Die Verbreitung des Waschbären (*Procyon lotor*, Linné 1758) im mitteleuropäischen Raum. - *Zeitschrift für Jagdwissenschaft* 30: 218-228. (In German).
- Lutz, W. 1995: Occurrence and morphometrics of the raccoon *Procyon lotor* L. in Germany. - *Annales Zoologici Fennici* 32: 15-20.
- Lutz, W. 1996: The introduced raccoon *Procyon lotor* population in Germany. - *Wildlife Biology* 2: 228.
- Macdonald, D. 1989 (Ed.): *The Encyclopaedia of Mammals*. - Unwin Hyman Ltd., London.
- Macdonald, D. & Barrett, P. 1993: *Mammals of Britain and Europe*. - Harper Collins Publishers, London, 312 pp.
- Maran, T. & Henttonen, H. 1995: Why is the European mink (*Mustela lutreola*) disappearing? - A review of the process and hypotheses. - *Annales Zoologici Fennici* 32: 47-54.
- Markgren, G. 1988: Mårdhunden - en presentation. - *Viltnytt* 26: 30-35. (In Swedish).
- McLean, R.G. 1975: Raccoon rabies. - In: Baer, G.M. (Ed.); *The natural history of rabies, Vol. 2*. - Academic Press, New York, pp. 53-77.

- Mikkonen, T., Haukisalml, V., Kauhala, K. & Wihlman, H. 1995: *Trichinella spiralis* in the raccoon dog (*Nyctereutes procyonoides*) in Finland. - *Bulletin of the Scandinavian Society for Parasitology* 5: 100.
- Myers, J.G. 1931: The present position of the mongoose in the West Indies. - *Tropical Agriculture, Trinidad* 8: 94-95.
- Naaber, J. 1971: Kährikkoer. - *Eesti Loodus* 14: 449-455. (In Estonian).
- Naaber, J. 1974: Rebane ja kährikkoer meie looduses. - In: Merisalu, G. (Ed.); *Jaht ja ulukid. Eesti NSV jahimeeste seltsi aastaraamat 1969-1972. Eesti NSV Jahimeeste Selts, Tallinn*, pp. 102-115. (In Estonian).
- Naaber, J. 1984: Matsalu imetajatefauna olevikust ja tulevikust. - In: Paakspuu, V. (Ed.); *Eesti NSV Riiklike Looduskaitsealade Teaduslikud Tööd IV, Matsalu loodusest. Valgus, Tallinn*. (In Estonian).
- Nasimovic, A.A. & Isakov, J.A. (Eds.) 1985: *Pesec, lisica, enotovidnaja sobaka: Razmescenie zapazov, ekologija, ispol'zovanie i ohrana*. - *Nauka, Moskva*, 158 pp. (In Russian).
- Niemimaa, J. & Pokki, J. 1990: Minkin ravinnosta Suomenlahden ulkosaaristossa (In Finnish with English summary: Food habits of the mink in the outer archipelago of the Gulf of Finland). - *Suomen Riista* 36: 18-30.
- Notini, G. 1948: Nytt svensk pälsvilt. - *Svensk Jakt* 86: 68-70. (In Swedish).
- Nowak, E. 1984: Verbreitungs- und Bestandsentwicklung des Marderhundes, *Nyctereutes procyonoides* (Gray, 1834) in Europa. - *Zeitschrift für Jagdwissenschaft* 30: 137-154. (In German with English summary).
- Nowak, E. & Pielowski, Z. 1964: Die Verbreitung des Marderhundes in Polen im Zusammenhang mit seiner Einbürgerung und Ausbreitung in Europa. - *Acta Theriologica* 9: 81-110. (In German).
- Novikov, G.A. 1962: Carnivorous mammals of the fauna of the USSR. - *Israel Program for Scientific Translations, Jerusalem*, pp. 159-162.
- Olsson, M. & Sandegren, F. 1991: Is PCB partly responsible for the decline of the otter in Europe? - In: Reuther, C. & Röcher, R. (Eds.); *Proceedings of the V International Otter Colloquium. Habitat 6*. - *Hankensbuttel*: 223-227.
- Olsson, M. & Sandegren, F. 1993: *Lär känna uttern*. - *Svenska Jägareförbundet, Helsingborg*, 46 pp. (In Swedish).
- Ozoliņš, J. & Pilāts, V. 1995: Distribution and status of small and medium-sized carnivores in Latvia. - *Annales Zoologici Fennici* 32: 21-29.
- Pimentel, D. 1955: Biology of the Indian mongoose in Puerto Rico. - *Journal of Mammalogy* 36: 62-68.
- Reig, S. & Jedrzejewski, W. 1988: Winter and early spring food of some carnivores in the Białowieża National Park, eastern Poland. - *Acta Theriologica* 33: 57-65.
- Ruprecht, A.L., Buchalczyk, T. & Wojcik, J. M. 1983: Występowanie norek (Mammalia: Mustelidae) w Polsce. - *Przegląd Zoologiczny* 27: 87-99. (In Polish).
- Röben, P. 1975: Zur Ausbreitung des Waschbären, *Procyon lotor* (Linne, 1758) und des Marderhundes, *Nyctereutes procyonoides* (Gray, 1834), in der Bundesrepublik Deutschland. - *Säugetierkundliche Mitteilungen* 23: 93-101. (In German).
- Schmidt, F. 1954: Pelztierzucht in freier Wildbahn. - *Kosmos* 50: 73-77. (In German).
- Sidorovich, V. 1993: Reproductive plasticity of the American mink *Mustela vison* in Belarus. - *Acta Theriologica* 38: 175-183.
- Siivonen, L. 1958: Supikoiran varhaisimmasta historiasta Suomesa. - *Suomen Riista* 12: 165-166. (In Finnish).
- Simberloff, D. 1996: Hybridization between native and introduced wildlife species: importance for conservation. - *Wildlife Biology* 2: 143-150.
- Sinclair, A.R.E. & Norton-Griffiths, M. 1979: *Serengeti, Dynamics of an Ecosystem*. - *The University of Chicago Press, Chicago*, 389 pp.
- Skirnisson, K. 1980: The mink in Iceland, *Villt Spendyr*. - *Rit Landverndar* 7: 80-94.
- Stjernberg, T. & Hagner-Wahlsten, N. 1994: Saukon levinneisyys Suomessa vuosina 1975 ja 1985 (In Finnish with English summary: The distribution of the otter in Finland in 1975 and 1985). - *Suomen Riista* 40: 42-49.
- Stubbe, M. 1990: Der status des Waschbären *Procyon lotor* (L.) in der DDR (1975 bis 1984). - *Beiträge zur Jagd- und Wildforschung* 17: 180-192. (In German).
- Stubbe von, M. 1993: *Procyon lotor* (Linné, 1758) - Waschbär. - In: Stubbe, M. & Krapp, F. (Eds.); *Handbuch der Säugetiere Europas, Band 5/I Raubsäuger (Teil I)*. - *AULA-Werlag GmbH, Wiesbaden*, pp. 331-364. (In German).
- Ternovskij, D.V. 1977: *Biologia kuniceobraznyh (Mustelidae)*. - *Nauka, Novosibirsk*, 280 pp. (In Russian).
- Tvrtković N. & Kryštufek, B. 1990: Small Indian mongoose *Herpestes auropunctatus* (Hodgson, 1836) on the Adriatic Islands of Yugoslavia. - *Bonner Zoologische Beiträge* 41: 3-8.
- van Wijngaarden, A. & Bruijns, M.F.M. 1961: De hermelijnen *Mustela erminea* van Terschelling. - *Lutra* 3: 35-42. (In Dutch).
- Vilella, F.J. & Zwank, P.J. 1993: Ecology of the small Indian mongoose in a coastal dry forest of Puerto Rico where sympatric with the Puerto Rican nightjar. - *Caribbean Journal of Science* 29: 24-29.
- Voipio, P. 1948: Riistan laadun parantaminen ja sen biologiset edellytykset (In Finnish with English summary: Improving the quality of the game and the biological requirements therefore). - *Suomen Riista* 2: 7-76.
- Walton, K.C. 1968: Studies on the biology of the polecat *Putorius putorius*. - *M.Sc. Thesis, University of Durham*.
- Westerling, B. 1991: Raivotauti Suomessa ja sen torjunta Suomessa vuosina 1988-90 (In Finnish with English summary: Rabies in Finland and its control 1988-90). - *Suomen Riista* 37: 93-100.
- Westman, K. 1966: Minkin levinneisydestä Suomessa (In Finnish with English summary: Occurrence of feral American minks (*Mustela vison*) in Finland). - *Suomen Riista* 18: 101-116.
- Wikan, S. 1983: Mårdhund funnet död i Sör-Varanger - ny norsk pattedyrart. - *Fauna* 36: 103. (In Norwegian).