Alien Species In Finland

Petri Nummi
Case studies by Arto Kurtto, Jyrki Tomminen, Erkki Leppäkoski and Petri Nummi
Ministry of the Environment 2000

Contents

Case studies

Introduction

Biological invasions coupled with environmental modification and climatic changes are a major threat to global biodiversity. Human-caused habitat deterioration and fragmentation promote the loss of those local species that cannot tolerate impacts from human activities. At the same time, new invasion corridors and increased global transport facilitate the spread of non-indigenous species. Many of these alien species do best in human-disturbed environments, mainly affecting species composition . Some, however, can invade undisturbed natural habitats which thus are homogenized on regional, intercontinental and even global scales (Dukes & Mooney 1999, McKinney & Lockwood 1999, Williamson 1999).

Because alien species may affect local biotas strongly, more and more actions are needed to prevent unintentional introductions, to analyze possible intentional introductions, and to study the ecological and economic effects of already established aliens in order to assess the need for control.

COP decisions

The Fifth Conference of the Parties (COP 5) to the Convention on Biological Diversity (CBD) in Nairobi (15 to 26 May 2000) urged parties to submit case studies to the Executive Secretary, focusing on alien species that threaten ecosystems, habitats or species (decision V/8). The outline for the case studies is provided in UNEP/CBD/COP/5/3 Annex II. Case studies are an important tool in invasion biology since the outcome of a certain introduction is difficult to predict (Kareiva 1996, Williamson 1996).

Underlying the decision is the objective of the CBD to “prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species”. To help this, the Scientific Committee on Problems of the Environment (SCOPE) has launched the Global Invasive Species Programme (GISP) with support from the United Nations (the Global Environment Facility, GEF; the United Nations Environment Programme, UNEP), the World Conservation Union (IUCN) and others (Williamson 1999).

Nordic report

The Nordic Council of Ministers has recently published a report "Introduced species in the Nordic countries" (Weidema 2000) to clarify the situation concerning introduced species. Also, an Internet based "Nordic Network on Introduced Species" (NNIS 2000) has been established. The website contains a list of administrators and scientits working within the field of introduced species.

Additionally, the network includes databases on marine, freshwater and terrestrial biomes. Earlier, a risk assessment for marine alien species in the Nordic area was made (Gollash & Leppäkoski 1999).

The "Introduced species" report identifies over 1350 species that have been introduced either intentionally or unintentionally to the Nordic countries. The report also contains 17 detailed descriptions of the more invasive introductions in the marine (e.g. Sargassum muticum, Balanus improvisus), freshwater (Elodea canadensis, Salmo salar), and terrestrial (Rosa rugosa, Nyctereutes procyonoides) biomes (Weidema 2000).

The report also contains recommendations to the Nordic Council of Ministers. Recommendations are given for each of the three biomes and are grouped under three headings (Weidema 2000).

1) Legal and institutional needs:
Unintentional introductions should be prevented, e.g. international conventions should be implemented nationally, and vectors of introduction must be identified and controlled. Intentional introductions should be controlled, e.g. national legislation should be reviewed, national authorities in charge of control of introductions should be established, and risk assessment before and monitoring after an intentional introduction is to be established.

2) Management and control:
Monitoring and dissemination of information should be improved, e.g. introduced species should be included in monitoring programmes (also regional co-operation), and “early warning systems” should be developed to enable early detection of alien species. Control methods must be developed, e.g. appropriate efficient and environmentally sound control methods are needed.

3) Knowledge and research:
Research on introduced species should be funded and encouraged, groups involved in preventive work should be informed and educated, and the public should be given more information on introduced species and their impacts.

Invasive species and their success in Finland

"All communities are invasible, perhaps some more than the others" states Williamson in his book "Biological Invasions" (1996). He notes that what seems obvious a priori is often irrelevant when introductions are concerned. But, nevertheless, he identifies some factors to consider as causes of a successful invasion. Of them, climatic matching and abundance in native habitat are considered here.

Two contradictory features may influence the establishment of non-indigenous species in Finland. On one hand, the harsh climate prevents invasion of most southern species. On the other hand, the relatively low number of species in Finnish ecosystems allows new species to establish themselves quite easily – if they are physiologically adapted to northern conditions (Moulton & Pimm 1986, Brown 1989, Nummi 1996a). And – especially concerning plants – new species encounter barren soils here (A. Kurtto, pers. comm.).

The aquatic environment can buffer climatic conditions; hence, the conduct of organisms living in or by the water is often especially unpredictable. For example, species of relatively southern origin – such as the zebra mussel Dreissena polymorpha, the spiny water flea Cercopagis pengoi, an opossum shrimp Hemimysis anomala and the round goby Neogobius melanostomus, all native to the Ponto-Caspian region – have invaded the Baltic Sea (Salemaa & Hietalahti 1993, Leppäkoski 1993, Gollash & Leppäkoski 1999).

Typically, invaders are originally widely distributed and are abundant (Moulton & Pimm 1986, Erlich 1989, Williamson 1996). In Finland, American mink Mustela vison, white-tailed deer Odocoileus virginianus, muskrat Ondatra zibethica, Canadian beaver Castor canadensis, Canada goose Branta canadensis and ring-necked pheasant Phasianus colchicus exemplify this (Nummi 1996a; for muskrat, see also Danell 1996).

But also the opposite can be true. For example, the Himalayan balsam Impatiens glandulifera has a restricted (800 km x 50 km) natural range in the western Himalayas. However, it is the most invasive species of its genus, and has invaded much of Europe and North America (Williamson 1996), and also Finland (Kurtto 1996) (see Case studies).

Non-indigenous organisms brought to Finland by man could be classified into three categories:

1) ancient unintentional introductions (species that came along with early agriculture; many plants, house mouse)

2) historical intentional introductions (species that were brought here for economic benefit; mainly fish and game, garden plants)

3) modern, predominantly unintentional introductions (species whose dispersal is facilitated by modern technology and trade; ballast water species, genetically modified organisms, agricultural and forestry pests)

This is by no means a clearcut classification. But it may help in discriminating between the present alien species problem and the the organisms that have been in Finland quite long without doing much harm.

Ancient alien species

About 200 alien plants have spread to Finland with traditional agriculture practices during the last three or four thousand years (Suominen & Hämet-Ahti 1993). They have mostly been confined to agricultural areas and are not notoriously invasive in more natural habitats. Moreover, their survival is often linked with traditional agricultural practices, for example, grazing and haymaking. Many of these species are in fact declining along with modernization of agriculture (Lappalainen 1998). On the other hand, many of them replace native plants in strongly human-influenced habitats, such as annual knawel Scleranthus annuus and common bent Agrostis capillaris on trampled rock outcrops (A. Kurtto, pers. comm.).

It is not known when the house mouse Mus musculus spread to Finland, but it undoubtedly came with man (Myllymäki 1997). Likewise, the time of the introduction of the black rat Rattus rattus is unknown but it most likely arrived in Finland a few centuries after it arrived in Europe around time of the Middle Ages (subspecies R. r. rattus) (Marcuzzi 1990).

The Norway rat, on the other hand, came to Finland only in the early 19th century. Its invasion through the country in the 20th century - when it also outcompeted the black rat - is rather well documented. The house mouse and Norway rat live in close proximity with man, especially during winter. In summer rats may move to luxuriant wetlands (Myllymäki 1972).

Historical alien species

Game were the first animals imported on utilitarian grounds into Finland starting in 1901 with the release of over one hundred pheasants Phasianus colchicus in the vicinity of Helsinki. After that, nine additional alien "game" birds and mammals have established a wild population.

Table 1. Introduced "game" species which have wild established populations in Finland (Nummi 1988, 1996). No mark = wide distribution, * = restricted distribution. (Species, Area of origin and Time of introduction).

Mink (Mustela vison), North America, 1930s
Raccoon dog (Nyctereutes procyonoides), East Asia, 1930s
Fallow deer* (Dama dama), Turkey, 1930s, 1950s
White-tailed deer (Odocoileus virginianus), North America, 1934, 1948
Mouflon* (Ovis musimon), Europe, 1939, 1949
Rabbit* (Oryctolagus cuniculus), Iberian peninsula, 1990s
Canadian beaver (Castor canadensis), North America, 1933-37
Muskrat (Ondatra zibethicus), North America, 1920s
Canada goose (Branta canadensis), North America, 1964
Mute swan (Cygnus olor), Asia minor, 1934
Pheasant (Phasianus colchicus), East Asia, 1901

Of the introduced game, minks have escaped from fur farms, the raccoon dog population originates from introductions made in the former USSR, and the origin of the feral rabbit population in Helsinki is not known (Pietilä 1999). Other introductions have been deliberate (Nummi 1988). The beaver is a special case, because the original purpose was to reintroduce a vanished species (see Case studies).

In game introductions made in the Nordic countries, a high success rate (about 80% of the species introduced have established themselves) has been found (Nummi 1996a). This resembles the 100% success rate of mammal introductions into Ireland and Newfoundland (Williamson & Fitter 1996), and reinforces the fact that the success rate can be much higher than the general "tens" rule. The tens rule roughly predicts that 1 in 10 of those imported appear in the wild, 1 in 10 of those introduced become established, and that 1 in 10 of those established become invasive or even a pest in the recipient area (Williamson & Fitter 1996). One obvious reason for the success of game introductions in Finland is that the species have been selected on the basis of their natural distribution, hence species adapted to cold climate (see above; see also Climatic matching, Williamson 1996).

Animals have also been released into waters for economic purposes. Of many fishes, brook trout Salvelinus fontinalis (introduced in 1965), peled whitefish Coregonus peled (1965), brown bullhead Ictalurus nebulosus (1922), and brook stickleback Culaea inconstans (1958) have established reproducing populations in Finnish waters (Koli 1997, Makkonen et al. 2000).

Likewise, the American signal crayfish Pasifastacus leniusculus was introduced into Finland in 1967. This release is, in fact, an indirect result of a previous unintentional invasion by crayfish plague caused by the fungus Aphanomyces astaci. This fungus spread to Europe in the 1860s, probably with American crayfish introductions. It reached Finland via Russia in 1893, devastating the best crayfish waters in 1907-1909 (Järvenpää et al. 1986, Westman 2000).

Among the garden plants, the most aggressive ones have been giant hogweeds Heracleum mantegazzianum, H. persicum, Himalayan balsam Impatiens glandulifera (see Case studies), lupin Lupinus polyphyllus and Japanese rose Rosa rugosa. The lupin has recently been spreading fast along roadsides, but it is quite restricted to human-modified areas. The other above-mentioned species, on the other hand, seem to be capable of invading natural habitats, especially shores (Kurtto 1996, Koponen et al. 1997, Suominen 1997, Lappalainen 1998).

Recently Japanese knotweed Fallopia japonica, white dogwood Cornus alba, butterbur Petasites hybridus and giant butterbur P. japonicus have also shown a growing tendency towards invading natural habitats. Additional cases (Glyceria maxima, Aster × salignus etc.) concerning wetlands and shores are discussed below in ‘Competition’. In other kinds of environments, recently or relatively recently introduced garden plants are - at least for the time being - less invasive, for example, red-leaved rose Rosa glauca on rocks, hautbois strawberry Fragaria moschata in fertile forests, and garden shadblow Amelanchier spicata and shiny cotoneaster Cotoneaster lucidus both in woodland and on rocks (A. Kurtto, pers. comm.).

In Finland, as also widely elsewhere in Europe, greater celandine Chelidonium majus exemplifies plants which were introduced in ancient times for medical purposes and are now thoroughly naturalized in their secondary areas. In the Finnish wild flora ramsons Allium ursinum, field garlic A. oleraceum and sand leek A. scorodoprasum seem to belong to the same historical element (e.g. Pettersson 1942, 1943). Woad Isatis tinctorial, in turn, is an ancient dye plant, which originates from the steppes of easternmost Europe and Asia, but has completely naturalized on European, also Finnish, seashores. Although present also in more or less natural vegetation, the historical alien species mentioned above are considered to be rather harmless in Finnish nature, but alpine elder Sambucus racemosa may be regarded as harmful (see ‘Competition’ below).

Since the early 19th century fairly many unintentionally introduced plant species have become established in Finland. Their main vectors have been hayseed, foreign (mainly Russian) troops, ballast soil of sailing ships, grain imports and garden seed (see, e.g. Suominen 1979, Kurtto & Uotila 1999). Almost all of these relatively recent alien plant species (neophytes) are still strictly bound to waste land, railways, harbours, arable fields, cultural grassland and other man-made or strongly human-influenced habitats. In other words, they are not capable of invading areas of natural or even semi-natural vegetation.

However, there are some exceptions. The three North American willowherb species Ebilobium adenocaulon, E. ciliatum and E. glandulosum were first discovered in Finland in the 1910s and 1920s. Since then especially the E. adenocaulon has rapidly become common in southern and sentral Finland. It and E. ciliatum have invaded natrural shore and spring habitats, too. The hayseed immigrant sneezewort Achillea ptarmica is nowadays quite common as a seemingly native plant on shore meadows, particularly on stony seashores. The closely related A. salicifolia, brought by Russian troops, has locally invaded alluvial vegetation in and around the town of Hämeenlinna in the south (Uotila 1978). Still more local cases include the ballast immigrant pale toadflax Linaria repens and the grain immigrant Russian lettuce Lactuca tatarica (Erkamo 1976) on seashores of the south.

Some of the neophytes have proved to be detrimental to their native relatives due to hybridization (see below).

Modern alien species

Although intentional introductions are nowadays more or less controlled, an increasing number of invasive propagules are crossing former distribution barriers and reaching new areas. The reason is increased trade. Woody material, seeds, food products and various garden plants are transported between continents. They may harbour many kinds of organisms that thus are unintentionally introduced into new biogeographical areas (Marchant & Borden 1976, Simberloff 1986). In a study comprising fourteen lots of pine pulpweed, three new species not found in Finland originating from Siberian samples were found (Siitonen 1990). The control of forest pests is based on human economic interests, but they, of course, pose an ecologic threat, too.

Some alien agricultural pests have also invaded open fields, for example, the yellow potato cyst nematode Globodera rostochiensis (Smith et al. 1997, J. Tomminen, pers. comm.). In 1998, the strongest invasion so far of the Colorado beetle Leptinotarsa decemlineata was seen in southeastern Finland. The beetle was successfully repelled from all infested fields (Tomminen 1999). The snail Arion lusitanicus also invaded Finland in 1990 (Kivipelto 2000). Of forest pests, the pinewood nematode Bursaphelechus xylophilus is considered a major threat. It has been carefully studied

(Tomminen 1993) and, based on this risk assessment, stringent phytosanitary regulations have been issued to prevent its introduction into Finnish forests. Rigid border control inspections of commodities most likely to carry the pinewood nematode have resulted in numerous findings of this organism, and the commodities in question were intercepted (see Case studies).

Even more alien species are spread in the ballast water of ships. This invasion route is becoming more common because the speed of ships is increasing, the number of ship visits is increasing and because of higher amounts of ballast water are being discharged. Both the quality of the ballast water as well as the quality of water in the area of uptake have ameliorated which again increases the number of viable organisms shipped to new areas. In fact each ship may contain several million specimens of macrofauna and hundred million specimens of smaller organisms. The number of species transported by ships is estimated to be 3000-4000 at any time (Carlton 1985, Gollasch & Leppäkoski 1999).

Ballast water aliens along in the Finnish coast include a barnacle Balanus improvisus (arrived already in the 19th century), the New Zealand mud snail Potamopyrgus antipodarum, polychaete worms Polydora redeki (1960s) and Merenzelleria viridis (1980s), the zebra mussel (1995), as well as the spiny water flea (1995) (see Case studies) (Leppäkoski 1995, Leppäkoski & Olenin 2000). These marine invaders have typically spread at a rate of 50 km per year, although Merezelleria widened its range at a rate of 480 km per year. Many of the introduced species have also moved to lower depths. They live in shallow bottoms in their native range, but have penetrated to depths of 40-50 m in the Baltic Sea. Some of the alien species, for example, Balanus and Potamopyrgus can also survive in fresh water (see also Cercopagis in Case studies) (Leppäkoski & Olenin 2000).

There are also many common disease and parasitic organisms of domestic animals which have been kept outside Finland by strict control. They are not included in this report although some of them may spread from domestic animals to wildlife and vice versa (Watson & Charleston 1985).

Impacts of alien species in Finland

As anywhere, invasive species can affect Nordic ecosystems in many ways. At least six factors can be considered (Ebenhard 1988, Nummi 1996a, Olenin & Leppäkoski 1999):
1) Herbivory
2) Predation
3) Competition
4) Diseases
5) Hybridization
6) Change in habitat structure

Herbivory

The muskrat is known to affect vegetation success patterns (Danell 1977), and it has changed species dominance relations in small lakes in Finland: Phragmites and Typha have increased at the expense of Equisetum and Schoenoplectus (Toivonen & Meriläinen 1980). Along with the vegetation thinning, the muskrat affects invertebrate assemblages apparently by changing the fish predation rate (Malinen 1997).

Little is known about the effects of other alien herbivores. Mute swans, which are known to affect the amount of submerged vegetation (Cobb & Harlin 1980), live in high densities in the southwestern archipelago. The density-dependent decline in breeding success found in the growing population points to the possibility of overpopulation, or even vegetation degradation (Nummi & Saari 2000).

Predation

The effect of predation is not easily shown, if it is not as dramatic as it has been on oceanic islands or in Australia (Ebenhard 1988, Dickman 1996). According to Kauhala (1996a), the raccoon dog in Finland mainly eats small mammals, plants and carcasses and does not seem to affect native biota strongly. She notes, however, the heavy predation by raccoon dogs on waterfowl nests in Estonia (Naaber 1971). The predation studies also often meet with technical difficulties in the crucial breeding time of birds.

The mink probably has affected native species more than the raccoon dog (Kauhala 1996a). This is because it has also colonized the outer archipelagos of the Baltic Sea, where such a predator has not existed earlier. The indigenous European mink apparently did not cross large waters (Westman 1968, Maran et al. 1998).

Seabirds appear to differ in their ability to adapt to mink predation. In some areas common eider ducks have gradually returned to islands near the mainland, where they disappeared during the initial colonization by mink (Gerell 1985). In other areas eider populations have increased in spite of the mink (Niemimaa & Pokki 1990). The black guillemot Cepphus grylle and the razorbill Alca torda, which feed their young in crevice nests for several weeks, are more vulnerable than eiders. Hario et al. (1986) noted a clear decline in the numbers of breeding black guillemot in the Finnish archipelago as a result of heavy nest predation in several successive years; in some years a considerable number of hens also were killed.

Competition

There are at least three species pairs in which the American counterpart seems to outcompete the Eurasian species: signal crayfish and noble crayfish Astacus astacus, European and American mink and European and Canadian beaver (see Case studies).

The North American signal crayfish is a stronger competitor than the native noble crayfish in many ways. It is more aggressive and has greater fecundity and a faster growth rate than the native species (Westman et al. 1993, Westman 2000). The aggressiveness affects, for example, predation because the noble crayfish is excluded from refuges giving protection from the predation by European perch Perca fluviatilis (Söderbäck 1994). To protect the noble crayfish, the introductions of the signal crayfish is, according to the management plan by the fisheries officials (fisheries units in local agriculture offices) allowed only in southern Finland (Kalataloushallinnon rapustrategia 2000).
In Finland the American mink apparently has hindered the recovery of the European mink - the decline of which, however, started already before the population of the American species increased (Maran & Henttonen 1995). At least some degree of food competition seems to exist between the European otter Lutra lutra and the American mink (Clode & Macdonald 1995). The two species seem to be able to coexist, and it seems that the generalist mink is more or less excluded from the habitat of the specialist otter: the density of mink is low in dense otter areas in Finland (Kauhala 1996b).

The possible competition between white-tailed deer and roe deer Capreolus capreolus has also been discussed (Nummi 1988). The two species have rather similar ecological niches: the white-tail is the smallest member of the deer guild in North America, while the roe holds a similar position in Eurasia. The size difference between these deer is probably large enough to permit coexistence of the two species. The white-tailed deer appears to feed more on juniper than the roe deer (Anderson & Koivisto 1980, Helle 1980).

Likewise, the greylag goose Anser anser and the Canada goose seem to be able to coexist since they both have increased in the same areas during the last decades (Fabricius 1983). The situation is, however, becoming more complicated as the barnacle goose Branta leucopsis is also entering the

Baltic Sea (Forslund & Larson 1991), and Finland as well (Hilden & Hario 1993, Väänänen & Nummi 2000).

In brackish waters with low species number, the alien invertabrates are generally thought to occupy vacant niches. The polychaete Marenzelleria, for example, lives deeper in the sediments than the native polychaetes and oligochaetes (Leppäkoski & Olenin 2000). The outcomes of alien invasions are hard to predict, however, since aliens may even develop a new kind of niche in their novel environment (Olenin & Leppäkoski 1999). The effects of the spiny water flea on food webs of the Baltic Sea, for example, are still unknown (see Case studies).

The competition between alien and native plants has not been studied in detail in Finland. The effect of alien plants can be enormous. The European purple loosestrife Lythrum salicaria, for example, is spreading at a rate of 115 000 ha per year in North America (Pimentel et al. 1999). As a result, it is changing the structure of most of the invaded wetlands. The monotypic stands of purple loosestrife have reduced the biomass of 44 native plants and endangered wildlife that depend on them (Gaudet and Keddy 1988, Malecki et al. 1993).

In Finland parallel, though more local wetland cases include reed sweet-grass Glyceria maxima (first introduced in the 1760s; see Linkola 1942) with its extensive monotypic stands on shores and in shallow water of many southern lakes and rivers (e.g. Uotila 1971), and the group of several garden escapes, which has replaced natural vegetation in long sections of the river corridors of the Vantaanjoki water system in the south (e.g. Ranta 1990). The most invasive species of the group are Aster × salignus, a vigorous hybrid of two North American asters or daisies, and hedge bindweed Calystegia sepium. In both cases the success of the alien species is greatly promoted by water pollution, especially through higher nutrient input. Himalayan balsam, which is becoming a true nuisance of wetlands in Finland, is apparently able to outcompete its native relative touch-me-not Impatiens noli-tangere both by invading its habitats and by more effectively attracting insect pollinators (see Case studies). Locally in southwestern Finland, the originally North American orange balsam Impatiens capensis has taken over at least potential habitats of touch-me-not (for the species' history of introduction, see Krogerus 1977).

Canadian pondweed Elodea canadensis, which was introduced into Finland in 1884, is extremely abundant in some years in many lakes and ponds of southern and central parts of the country (for the species in general, see Weidema 2000). Observations of a lake in southwestern Finland (A. Kurtto) point to the possibility that the alien is capable of outcompeting several native submerged plants, among them one of the world's rarest aquatics Najas tenuissima.

Japanese rose (cf. Weidema 2000) is continuing to take over Finnish seashores, especially beaches. Its extensive, dense stands easily outcompete populations of native pioneer plants, such as sea sandwort Honckenya peploides and sea pea Lathyrus japonicus. In the future, Scots lovage Ligusticum scoticum, which was first discovered in Finland as late as in 1968, may prove to be a threat to native plants of stony seashores.

Alpine elder Sambucus racemosa has been cultivated in Finland since the Middle Ages, but it began to naturalize much later, apparently at the very end of the 19th century. Nowadays, the species is common and often abundant in fertile forests in the south – so abundant that it must have outcompeted at least some native bushes (A. Kurtto, pers. comm.).

Parasites and diseases

Crayfish plague is the disease having the most detrimental effect on a native species, mainly the noble crayfish. Upon spreading in Finland at the beginning of the 20th century, the fungus also ruined the country's important crayfish export trade (Westman 2000). Because the plague is not fatal to the signal crayfish, the alien species can act as a reservoir for the plague and pose a chronic threat to the noble crayfish (Kalataloushallinnon rapustrategia 2000).

The introduction of white-tailed deer into Finland met with good luck because the meningeal worm Parelaphostrongylus tenuis did not become established in Finland (Andersson et al. 1968). The parasite is not very harmful to the white-tail but moose Alces alces usually die of complications associated with the meningeal worm (Karns 1967). The population level importance of this is under discussion (Nudds 1990, Gilbert 1992). Most likely the worms did not invade Finland because they died out during the time when there were very few deer as hosts for the parasite (V. Haukisalmi, pers. comm.).

The deer-worm system represents a case where a species will gain advantage by leaving its parasite behind; this is more likely to happen with parasites with indirect life cycles (Dobson & May 1986). Similarly, the American mink has left some of its parasites behind (A. Tolonen, pers. comm.). Barberry Berberis vulgaris was introduced to Finland for ornamental purposes in the late 18th century at the latest and has locally naturalized in the south. The species may serve as an alternate host of black rust Puccinia graminis, a parasite infecting grasses, also cereals. To better protect cereal fields from the parasite, the commercial cultivation of barberry is nowadays forbidden by decree in Finland (A. Kurtto, pers. comm.).

Hybridization

Hybridization is a very difficult part of the alien species problem because it is often hard to even detect (Simberloff 1996). Concerning plants, Jalas (1961) published a survey of hybridisation cases between native and alien taxa in the wild Finnish flora. From the point of view of the native flora protection, two cases of secondary introgression must be considered highly alarming, also for the future. Artemisia campestris subsp. bottnica is endemic to the seashores of the northernmost part of the Gulf of Bothnia. On the Finnish side of the gulf, it is nowadays very difficult to find genetically pure plants of the taxon, since almost all populations are more or less affected by field wormwood A. campestris subsp. campestris, which is a newcomer in the area.

At species level, the most alarming case is that of lady’s bedstraw Galium verum, a native of dry grassland and fertile rock outcrops. Though the species once gained much additional habitats in traditional agricultural landscapes, its genetically pure stands have become more and more rare on the Finnish mainland and larger islands. The decline is partly due to the loss of suitable habitats. However, a much more important cause is the introgression with the newcomer upright bedstraw Galium album, one of the most successful of the hayseed immigrants which have invaded Finland from the 19th century on. Evidently the introgression is leading to the genetic merging of lady’s bedstraw into upright bedstraw in extensive areas; only on the outer islands does lady’s bedstraw still survive as a pure species.

In addition, hybridisation has occurred between the native crab apple Malus sylvestris, which is a quite rare southwestern species in Finland, and the cultivated apple M. domestica. According to Murto (1985), the hybridization is especially threatening single trees and small groups of crab apple in the margins of its distribution.

A Finnish example of hybridization between an ancient immigrant and a native plant is the recently discovered case of celery-leaved crowfoot Ranunculus sceleratus and R. reptabundus, a rare and vulnerable species belonging to the eastern taiga. Another plant of the same element, Stellaria fennica, is threatened both by the regulation of water level and hybridization with lesser stitchwort S. graminea on the shores of the Kemijoki river and its tributaries in the north. Lesser stitchwort is so far predominantly a relatively recent immigrant in the north.

Because local gene pools should also be protected, the introduction of southern forms of mallards Anas platyrhynchos for hunting purposes was not a good policy (Siekkinen & Nummi 1992), and, should no longer be practised.

Likewise, the hybridization of a domestic animal, such as the pig Sus scrofa domesticus and its wild relative Sus scrofa, should be forbidden to prevent possible genetic mixing of the wild species. In some cases, such as wiht the dog and wolf Canis lupus, other problems may also arise. The present legislation does not take into account these.

There is an increasing interest to grow wildflowers, both in private and public areas. This is risky since foreign seed sources may pollute the gene pools of truly indigenous or in ancient times introduced strains of the plants concerned. So far, this and other problems (Pykälä 1995) related to wildflower seed mixtures have received very little attention in Finland.

Change in habitat structure

New ecosystem functions of alien species are mainly reported from the Baltic Sea. Examples include the mud snail Potamopyrgus, which is a surface deposit feeder on extremely soft bottoms, the barnacle Balanus, which is a suspension filter feeder in the uppermost littoral, and the polychaete Merenzelleria, which bioturbates deep in the sediment (Olenin & Leppäkoski 1999). Intensive new kind of herbivory can also affect vegetation structure. At least the muskrat represents a case of novel effect on wetland plants (e.g. Danell 1996).

Legislation

Section 43 of the Nature Conservation Act (1096/1996) restricts the introduction of non-native species into Finland. Non-native plant species without an established range in the Finnish wild are not to be planted or sown outside gardens, fields or other sites designated for special purposes, nor in natural waters, in so far as there is cause to suspect that the species may become established permanently. This shall not apply, however, to the planting or sowing of trees for the purpose of forestry.

If a non-native plant or animal species is known to spread rapidly in the wild, and there is reasonable cause to suspect that it might constitute a health hazard or have a detrimental effect on indigenous Finnish species, the Ministry of the Environment may issue any regulations as prove necessary for preventing the spread of such a species. Measures for preventing the spread of animal disease are set forth in the Animal Diseases Act.

Non-native species falling outside the purview of the Hunting Act or Fishing Act are not to be released into the wild if there is cause to suspect that the species may become established permanently.

The Plant Protection Law (1203/1994) lays down provisions to prevent the introduction into Finland of pests and diseases of plants. Additionally, plant pests and diseases which are present in Finland (introduced or native), but which are not widely distributed are controlled in order to prevent their further spread. Secondary legislation lays down detailed provisions for import, monitoring, eradication and control (containment) and is enforced by a central service (Plant Production Inspection Centre = KTTK). The main functions of this authority are the monitoring of borders and the territory of Finland in order to detect at an early stage possible introduced species which are pests or diseases of plants.

In accordance with Article 42 of the Hunting Act (615/1993; 1268/1993), wild bird or mammal species of foreign origin, as well as game species of foreign origin, cannot be imported or released in the wild without the permission of the Ministry of Agriculture and Forestry. A statement on a permit application must be requested from the Ministry of the Environment. If import or release into the wild would cause significant harm to the natural environment or animals dependent upon the same, the permit application will be refused. However, if permission is granted, the permit may contain stipulations on how importing and releasing into the natural environment are to be carried out. The same regulations apply to the bringing of an animal from the Åland islands for release into the wild in some other area of Finland.

In accordance with Article 94 of the Fishing Act (286/1982; 252/1998), fish or crayfish species (or strains or gametes of them) not found in the wild in Finland cannot be imported without the permission of the responsible ministry. The ministry may also stipulate conditions for import. If the import would cause significant harm to the natural environment or animals dependent upon the same, permission will be refused.

Research and education

Studies concerning introduced species in Finland have been separate projects, most often directed to unravel aspects of a single species' ecology or biology (e.g. doctoral theses by Artimo 1960, Pankakoski 1986, Kauhala 1992, Tomminen 1993, Westman 2000). No general research programme has dealt with introduced species, but some studies focusing on the Baltic Sea have taken an ecosystem approach (Olenin & Leppäkoski 1999).

To gain background information for management of introduced species, Finnish researchers have organized international meetings or taken part in the risk assessment of special aspects of the problem.

In 1996, the Department of Applied Zoology (Univ. Helsinki) together with the Department of Animal Ecology (Swedish Univ. Agr. Sci.) and the OECD organized a workshop focusing on the management of introduced wildlife. Among other things, the workshop emphasized the Nordic aspect of the matter (Nummi 1996b) and produced a set of recommendations (Sjöberg & Hokkanen 1996). The Dept. Appl. Zool. has also partizopated in OECD research programme "Biological Resource Management". The themes of the programme include the benefits and risks of introducing agents for biocontrol of insects and weeds (Hokkanen & Lynch 1995, Ehlers & Hokkanen 1996). The Department of Environmental and Marine Biology (Åbo Akademi Univ.) has compiled a risk assessment of alien species in Nordic coastal waters in collaboration with Institut f?r Meereskunde, Kiel. A semi-quantitative model was developed for the assessment and applied to five representative ports from St. Petersburg, Russia to Bergen area in Norway (Gollash & Leppäkoski 1999). The Åbo Akademi also organized a Nordic post-graduate course in marine invasion biology in 1997.

To increase public awareness, the University of Helsinki (Dept. of Appl. Zool. and the Finnish Museum of Nat. Hist.) put on an exhibition ALIENS in 1999. In association with the exhibition a national symposium was organized which brought together experts in various fields of research and management and which served as training for students at the same time.

Control

New intentional or unintentional introductions are controlled by laws and orders (see Legislation) and imported plant material is checked according to EU-legislation. Of already established organisms, active control is used in the case of the raccoon dog and especially the mink (see below) to protect other game and archipelago birds. Additionally, the hunting of Canada goose, Canadian beaver and white-tailed deer serves to prevent economic damages.

To control unintentional introductions, new methods are needed and planned for the elimination of ballast water animals (Gollasch & Leppäkoski 1999). In the case of garden plants, again, probably new provisions are needed in the legislation to prevent the introduction of new species.
An action plan is needed to protect the noble crayfish, and for studies on the control of crayfish plague and interactions between the noble crayfish and signal crayfish (Westman 2000).

Special mink eradication project in Finland

In the Archipelago National Park in southwestern Finland a mink eradication project covering a 12 x 6 km area has been carried out to protect birds (Nummelin & Högmander 1998).

In the Park, minks have been hunted with the aid of a portable air blower (normally used for leaf collection) and a dog. The dog locates the mink's hiding place, and high pressure air is blown into crevices to scare the mink out (Nummelin & Högmander 1998).

In the first year, 65 minks were taken. Since then only 5-7 minks needs to be taken yearly to control the population. The numbers of many birds species have increased after the control started. Among them are black guillemot Cepphus grylle, velvet scoter Melanitta fusca, tufted duck Aythya fuligula, mallard Anas platyrhynchos and black headed gull Larus ridibundus. On the other hand, common eider Somateria mollissima, the greylag goose Anser anser, common merganser Mergus merganser and large gulls did not respond to mink eradication (Nummelin & Högmander 1998, Nummi 1999).

Conclusions and recommendations

Measures should be taken both in research and management:

- clear authority concerning alien species on the national level needed (actions and resources)
- a national working group on invasive aliens should be established
- more public awareness and education needed of alien species impacts (e.g. private import of aliens and eradications)
- more research of ecological effects and management of invasive alien species should be funded and encouraged: preparation of a national research programme on alien species
- legislation changes, e.g. who is responsible for intentional introductions
- new approach might be needed, e.g. in control of garden plants
- collaboration is needed on the international level and between different agreements on alien species

Acknowledgements: Kari Heliövaara, Heikki Hokkanen, Sauli Härkönen, Christian Krogell, Ralf Lopian, Ari Mannonen, Elina Nikkola, Marina von Weissenberg, Kai Westman gave valuable comments and/or important references. The contribution of Arto Kurtto and Erkki Leppäkoski on plant aliens and invertebrate aliens in the Baltic Sea, respectively, is especially acknowledged. Likewise, thanks are due Sauli Härkönen, Ralf Lopian and Marina von Weissenberg who provided the legislation texts. Terry Forster kindly checked the language.

References

Anderson, E. & Koivisto, I. 1980. White-tailed deer's winter food and diurnal rhythm (in Finnish with English summary). – Suomen Riista 27: 84-92.
Anderson, E. et al. 1968. New studies on Pneumostrongylus tenuis in Finland (in Finnish with English summary). – Suomen Riista 20: 102-104.
Artimo, A. 1960. The dispersal and acclimatization of the muskrat, Ondatra z. zibethicus (L.) in Finland. – Pap. Game Res. 21: 1-101.
Baker, S. 1999. Eradication of Myocastor coypus in United Kingdom. - Workshop on the control and eradication of non-native terrestrial vertebrates. Malta, 3-5 June 1999. – Council of Europe. Environmental encounters 41: 83-88.
Brown, J. H. 1989. Patterns, modes and extents of invasions by vertebrates. – In: Drake, J. A. et al. (eds), Biological invasions. A global perspective. John Wiley & Sons, Chichester: 85-109.
Carlton, J. T. 1985. Transoceanic and interoceanic dispersal of coastal marine organisms: the biology of ballast water. – Oceanogr. and Marine Biol. Ann. Rev. 23: 313-371.

Clode, D. & Macdonald, D. W. 1995. Evidence for food competition between mink (Mustela vison) and otter (Lutra lutra) on Scottish islands. – J. Zool. 237: 4345-444.
Cobb, J. S. & Harlin, M. M. 1980. Mute swan (Cygnus olor) feeding and territoriality affects diversity and density of rooted aquatic vegetation. – Am. Zool. 20: 882.
Council of Europe. 1999. Workshop on the control and eradication of non-native terrestrial vertebrates. Malta, 3-5 June 1999. - Environmental encounters 41.
Danell, K. 1977. Short-term plant succession following the colonization of a Northern Swedish lake by the muskrat, Ondatra zibethica. – J. appl. Ecol. 14: 933-947.
Danell, K. 1996. Introductions of aquatic rodents: lessons of the muskrat Ondatra zibethica. – Wildl. Biol. 2: 213-220.
Dickman, C. R. 1996. Impact of exotic generalist predators on the native fauna of Australia. – Wildl. Biol. 2: 185-195.
Dobson, A. P. & May, R. M. 1986. Patterns of invasions by pathogens and parasites. – In: Mooney, H. A. & Drake, J. A. (eds), Ecology of biological invasions of North America and Hawaii. Springer Verlag, New York,: 65-79.
Dukes, J. S. & Mooney, H. A. 1999. Does global change increase the success of biological invaders? – TREE 14: 135-139.
Ebenhard, T. 1988. Introduced birds and mammals and their ecological effects. – Swedish Wildl. Res. 13: 1-107.
Ehlers, R.-U. & Hokkanen, H. (eds).1996. OECD workshop on the introduction of non-endemic nematodes for biological control: scientific and regulatory issues. – Biocontrol Sci. and Tech. 6 (3).
Erkamo, V. 1976. Lactuca tatarica becoming established in Finland (in Finnish with English summary). – Luonnon Tutkija 80: 47-51.
Erlich, P. E. 1989. Attributes of invaders and the invading processes: vertebrates. – In: Drake, J. A. et al. (eds), Biological invasions. A global perspective. John Wiley & Sons, Chichester: 315-328.
Fabricius, E. 1983. The Canada goose in Sweden (in Swedish with English summary). – Statens naturvårdsverk, PM 1678, Solna.
Forslund, P. & Larson, K. 1991. Breeding range expansion of barnacle goose in the Baltic area. – Ardea 79: 343-346.
Gaudet, C. L. & Keddy, P. A. 1988. Predicting competitive ability from plant traits: a comparative approach. – Nature 334: 242-243.
Genovesi, P. 1999. Conservation of Sciurus vulgaris and eradication of Sciurus carolinensis in Italy. - Workshop on the control and eradication of non-native terrestrial vertebrates. Malta, 3-5 June 1999. Council of Europe. Environmental encounters 41: 115-117.
Genovesi, P. 2000. On the invasive alien species issue: guiding principles for planning eradication projects. – Council of Europe. www.nature.coe.int/cp20/
Gerell, R. 1985. Habitat selection and nest predation in a common eider population in southern Sweden.- Ornis Scand. 16: 129-139.
Gilbert, F. F. 1992. Retroductive logic and the effects of meningeal worms: a comment. – J. Wildl. Manage. 56: 614-616.
Gollasch, S. & Leppäkoski, E. 1999. Initial risk assessment of alien species in Nordic coastal waters. – Nordic Council of Ministers. Copenhagen.
Hario, M. et al. 1986. Population trends among archipelago birds in Söderskär bird sanctuary 1963-86 (in Finnish with English summary). – Suomen Riista 33: 79-90.
Helle, P. 1980. Food composition and feeding habits of the roe deer in winter in Central Finland. – Acta Theriol. 25: 395-402.
Hilden, O. & Hario, M. 1993. Muuttuva saaristolinnusto. – Forssa.
Hokkanan, H. & Lynch, J. M. (eds) 1995. Biological control: benefits and risks. – Cambridge Univ. Press, Cambridge.
Hughes, B. et al.1999. The status of the ruddy duck (Oxyra jamaicensis) in the western Palaerctic and an action plan for eradication, 1999-2002. - Report by the Wildfowl & Wetlands Trust to the Council of Europe. T-PVS/Birds (99) 9.
Härkönen, S. 1999. Forest damage caused by the Canadian beaver (Castor canadensis) in South Sava, Finland. – Silva Fennica 33: 247-259.

Järvenpää, T. et al. 1986. The effect of the crayfish plague fungus Aphanomycetes astaci on the haemolymph of Astacus astacus adn Pacifastacus leniusculus. – Freshwater Crayfish 6: 223-233.
Kalataloushallinnon rapustrategia 2000. (In press).
Kareiva, P. 1996. Developing predictive ecology for non-indigenous species and ecological invasions. – Ecology 77: 1651-1652.
Karns, P. D. 1967. Pneumostrongylus tenuis in deer in Minnesota and implications for moose. – J. Wildl. Mange. 31: 299-303.
Kauhala, K. 1992. Ecological characteristics of the raccoon dog in Finland. – PhD thesis. Dept. Zool., Univ. Helsinki.
Kauhala, K. 1996a. Introduced carnivores in Europe – a review. – Wildl. Biol. 2: 197-204.
Kauhala, K. 1996b. Distributional history of the American mink (Mustela vison) in Finland with special reference to the trends in otter (Lutra lutra) populations. – Ann. Zool. Fennici 33: 283-291.
Kivipelto, A. 2000. Tappajaetana leviää Suomeen vääjäämättä. – Helsingin Sanomat 15.8./2000/Kotimaa.
Koli, L. 1997. Istutuksia ja rehevöitymistä – ihminen säätelee kalakantoja. – Luonnon Tutkija 5/1996: 59-66.
Koponen, T. et al. 1997. Minne niityt kadonneet – kasvillisuuden ja kasviston muutoksia Lohjan seudulla. – Luonnon Tutkija 5/1996: 211-220.
Krogerus, H. 1977: Impatiens capensis (Balsaminaceae) införd till Lojo-området i sydvästra Finland. – Memoranda Soc. Fauna Flora Fennica 53: 99-100.
Kurtto, A. 1996. Impatiens glandulifera (Balsaminacea) as an ornamental and escape in Finland, with notes on the other Nordic countries. _ Symp. Bot. Ups. 31: 221-228.
Kurtto, A. & Uotila, P. 1999: Kaupunkien kasvisto muutosten kourissa. – Luonnon Tutkija 103: 173–182.
Lappalainen, I. (ed.). 1998. Suomen luonnon monimuotoisuus. – SYKE/Edita.
Leppäkoski, E. 1993. Non-indigenous species in the Baltic Sea. – In: Boudouresque, C. F. et al. (eds), Introduced species in European coastal waters. European Commission. Ecosystem Research Report 8: 67-73.
Leppäkoski, E. 2000. Främmande arter I Östersjön – kulturföljeslagare och skadeorganismer. – Finska Vetenskaps-Societeten. Årsbok 1999-2000: 37-46.
Leppäkoski, E. & Olenin, S. 2000. Non-native species and rates of spread: lessons from the brackish Baltic Sea. – Biological Invasions 2. In press.
Linkola, K. 1942: Ison sorsimon, Glyceria maxima (Hn) Holmb., leviämishistoriaa Suomessa. – Ann. Bot. Soc. Vanamo 16(6): 1-39.
Makkonen, J. et al. 2000. Viljelykantarekisteri. – RKTL. Kala- ja riistaraportteja 200.
Malecki, R. A. et al. 1993. Biological control of purple loosestrife. – BioScience 43: 680-686.
Malinen, J. 1997. Piisamilaidunnuksen vaikutus kasvillisuuteen ja vesiselkärangattomiin – kokeellinen tutkimus. – Unpubl. MSc. thesis. Univ. Helsinki.
Maran, T. & Henttonen, H. 1995. Why is the European mink (Mustela lutreola) disappearing? – Ann. Zool. Fennici 32: 47-54.
Maran, T. et al. 1998. Diet of two species of mink in Estonia: displacement of Mustela lutreola by M. vison. – J. Zool., London 245: 218-222.
Marchant, K. R. & Borden, J. H. 1976. Worldwide introduction and establishment of bark and timber beetles (Coleoptera: Scolytidae and Platypodidae). – Dept. Biol. Sci., Simon Fraser Univ., Pest Mgmt. Papers 6/1976.
Marcuzzi, G. 1990. Migratory phenomena in European animal species. – In: di Castri, F. et al. (eds), Biological invasions in Europe and the Mediterranean basin. Kluwer Academic Publishers, Dordrecht: 217-228.
McKinney, M. L. & Lockwood, J. L. 1999. Biotic homogenisation: a few winners replacing many losers in the next mass extinction. – TREE 14: 450-453.
Moulton, M. P. & Pimm, S. L. 1986. Species introductions to Hawaii. – In: Mooney, H. A. & Drake, J. A. (eds), Ecology of biological invasions of North America and Hawaii. Springer Verlag, New York: 231-249.
Murto, R. 1985. Metsäomenapuun (Malus sylvestris) nykytila ja levinneisyys Suomessa. – Sorbifolia 16: 87-95.

Myllymäki, A. 1972. Isorotta. – In: Siivonen, L.. (ed.), Suomen nisäkkäät 1. Otava, Helsinki: 452-464.
Myllymäki, A. 1997. Kotihiiri. – In: Nummi, P. (ed.), Suomen luonto. Nisäkkäät. Weilin & Göös, Porvoo: 128-131.
Naaber, J. 1971. Kährikkoer. – Eesti Loodus 14: 449-455.
Niemimaa, J. & Pokki, J. 1990. Food habits of the mink in the outer archipelago (In Finnish with English summary). – Suomen Riista 36: 18-30.
NNIS 2000. Nordic Network on Introduced Species. – http://www.sns.dk/natur/nnis/indexuk.htm
Nudds, T. D. 1990. Retroductive logic in retrospect: the ecological effects of meningeal worms. – J. Wildl. Manage. 54: 396-402.
Nummelin, J. & Högmander, J. 1998. Uusi menetelmä minkin poistamiseksi ulkosaaristosta on tuottanut tuloksia. – Metsästäjä 1/98: 16-18.
Nummi, P. 1988. The non-indigenous game animals of Finland (In Finnish with English summary). – Univ. Helsinki. Dept. Agr. Forest Zool., Rep. 9.
Nummi, P. 1996a. Wildlife introductions to mammal-deficient areas: the Nordic countries. – Wildl. Biol. 2: 221-226.
Nummi, P. (ed.).1996b. Proceedings from the OECD workshop ”Ecology of introduced, exotic wildlife: fundamental and economic aspects. – Wildl. Biol. 2 (3).
Nummi, P. 1999. Control of non-native terrestrial vertebrates in Finland. - Workshop on the control and eradication of non-native terrestrial vertebrates. Malta, 3-5 June 1999. Council of Europe. Environmental encounters 41: 115-117.
Nummi, P. & Saari, L. 2000. Density-dependent decline of breeding success in an introduced, increasing mute swan population. – Manuscript.
Orueta, J. F. & Ramos, Y. A. 1998. Methods to control and eradicate non native terrestrial vertebrate species. – Council of Europe T-PVS (98) 67.
Pankakoski, E. 1986. Ecological morphology of Finnish muskrat populations. – PhD thesis. Dept. Zool., Univ. Helsinki.
Pettersson, B. 1942: Sannolika kulturspår i den nyländska kustfloran. – Nordenskiöld-samf. Tidskr. 2: 72-108.
Pettersson, B. 1943: Av människan införda växter i floran kring våra fornborgar och medeltidsfästen. – Nordenskiöld-samf. Tidskr. 3: 33-84.
Pietilä, H. 1999. Helsingin eläinatlas. – Helsingin kaupungin ympäristökeskuksen julkaisuja 8/99.
Pimentel, D. et al. 1999. Environmental and economic costs associated with non-indigenous species in the United States. – http://www.fs.fed.us/r2/nebraska/gpng/exotic_costs.html
Pykälä, J. 1995. Tekoniityt – luonnon monimuotoisuuden lisääjiä vai uusi vaara luonnollemme. – Luonnon Tutkija 99: 157-161.
Ranta, P. 1990: Vantaanjoen vesistöalueen jokikäytäväkasveista Vantaalla ja Helsingissä. [On the flora and vegetation of the river corridors of the Vantaanjoki water system, southern Finland]. – Lutukka 6: 99-115.
Roughgarden, J. 1986. Predicting invasions and rates of spread. – In: Mooney, H. A. & Drake, J. A. (eds), Ecology of biological invasions of North America and Hawaii. Springer Verlag, New York: 179-188.
Siekkinen, J. & Nummi, P. 1992. The captive breeding and release of waterfowl – a review (In Finnish with English summary). – Suomen Riista 38: 45-55.
Siitonen, J. 1990. Potential forest pest beetles conveyed to Finland on timber imported from the Soviet Union. – Silva Fennica 24: 315-321.
Simberloff, D. 1986. Introduced insects: a biogeographic and systematic perspective. - In: Mooney, H. A. & Drake, J. A. (eds), Ecology of biological invasions of North America and Hawaii. Springer Verlag, New York: 3-26.
Simberloff, D. 1996. Hybridization between native and introduced wildlife species. – Wildl. Biol. 2: 143-150.
Smith, I. M. et al. (eds). 1997. Quarantine pests for Europe. – CAB International, Wallingford.
Suominen, J. 1979: The grain immigrant flora of Finland. – Acta Bot. Fennica 111: 1-108.
Suominen, J. 1997. Asutun ja viljellyn maan kasvit – toiset taantuvat, mutta muita työntyy tilalle. – Luonnon tutkija 5/96: 221-230.

Suominen, J. & Hämet-Ahti, L. 1993: Kasvistomme muinaistulokkaat: tulkintaa ja perusteluja. [Archaeophytes in the flora of Finland]. – Norrlinia 4: 1-90.
Söderbäck 1994. Interactions among juveniles of two freshwater crayfish and a predatory fish. – Oecologia 100: 229-235.
Toivonen, H. & Meriläinen, J. 1980. Impact of the muskrat (Ondatra zibethica) on aquatic vegetation in small Finnish lakes. – Developments in Hydrobiol. 3: 131-138.
Tomminen, J. 1993. An assessment of the pinewood nematode and related species in wood products and their potential risk to Finnish forests. – Univ. Helsinki. Dept. Appl. Zool. Rep. 18.
Tomminen, J. 1999. Koloradokuoriainen – uusi perunantuholainen maassamme? – Kasvinsuojelulehti 1/99: 4-6.
Uotila, P. 1971: Distribution and ecological features of hydrophytes in the polluted Lake Vanajavesi, S Finland. – Ann. Bot. Fennici 8: 257-295.
Uotila, P. 1978: The distribution and history of Achillea salicifolia in Finland. – Memoranda Soc. Fauna Flora Fennica 54: 21-28.
Watson, T. G. & Charleston, W. A. 1985. The significance of parasites in farmed deer. – In: Fennessy, P. F. & Drew, K. R. (eds), Biology of deer production. The Royal Society of New Zealand: 105-118.
Weidema, I. R. (ed.). 2000. Introduced species in the Nordic Countries. Nordic Council of Ministers. – Nord 2000. 13.
Westman, K. 1968. On the occurrence of American and European mink in Finland (In Finnish with English summary). – Suomen Riista 20: 50-61.
Westman, K. et al. 1993. A comparative study on the growth and moulting of the noble crayfish, Astacus astacus (l.), and the signal crayfish, Pacifastacus leniusculus (Dana), in a small forest lake in southern Finland. – Freshwater Crayfish 9: 451-465.
Westman, K. 2000. Comparison of the crayfish Pacifastacus leniusculus Dana, a species introduced in Finland, with the native species, Astacus astacus L., in allopatry and sympatry. – Finnish Game and Fisheries Res. Inst. Helsinki.
Williamson, M. 1996. Biological invasions. – Chapman & Hall, London.
Williamson, M. 1999. Invasions. – Ecography 22: 5-12.
Williamson, M. & Fitter, A. 1996. The varying success of invaders. – Ecology 77: 1661-1666.
Väänänen, V-M. & Nummi, P. 2000. Valkoposkihanhia Helsingin nurmilla. – Helsingin Sanomat 17.9.2000: D18.

CASE STUDIES

Himalayan balsam (Impatiens glandulifera)

Arto Kurtto
Finnish Museum of Natural History, Univ. of Helsinki

History and impacts

Himalayan balsam Impatiens glandulifera, a native of the western Himalayas, was introduced into Europe in the 19th century (Coombe 1956, Valentine 1971). In England the naturalization of the species had already begun in the 1850s (Britten 1900), but in continental Europe it began almost half a century later (Beger & Schmidt 1925). Now, the Himalayan balsam is known as an established alien in most of the European countries. The species has also been introduced into North America, where it is established as an escape, too.

The Finnish history of I. glandulifera as a widely popular and common ornamental seems to be short (Kurtto 1992, 1996). Up to the 1950s and 1960s the plant was apparently rarely cultivated, but its popularity grew in the 1970s and it soon reached the start of its heyday, which still continues. In the 1980s the cultivation increased rapidly, in some places even explosively, and also progressed towards more northern regions. This process is continuing, although the plant rather often invades gardens and yards to such an extent that it becomes a real nuisance instead of a beloved beauty.

The first observation of true naturalization of I. glandulifera in Finland dates back to the year 1947 (Erkamo 1949), though there are a few earlier records describing the species as weedy or subspontaneous. From the 1970s and, in particular, the 1980s onwards, records of naturalized or seminaturalized populations have increased considerably. Furthermore, the species is nowadays a conspicuous and evidently permanent member of the shore vegetation in some areas, especially by eutrophic lakes, rivers and brooks, and by inner bays of the Baltic Sea in the south.

The actual seed trade seems to have played only a minor role in the history of I. glandulifera in Finland, since seeds of this plant have been commercially imported only in small quantities and only recently. Seeds and seedlings have been brought from abroad and have been gathered from Finnish gardens and from escaped populations, mainly by private persons. They were then extensively transported further, along crisscrossing shorter and longer routes through southern and central Finland (see map in Kurtto 1996). This is, or has been, a common practice with many other ornamentals, and thus proves to be a major factor in the invasion of alien plants into seminatural or natural communities, both in Finland and elsewhere.

Despite it having an annual life-cycle, I. glandulifera is an invasive plant and also is able to grow among tall herbs and bushes, even with many strong competitors (for experimental data, see Beerling & Perrins 1993). As with its North American relative I. capensis (see Winsor 1983), I. glandulifera is restricted to a single, but competitively efficient regenerative strategy: the early and almost synchronous germination of a large number of seeds and rapid early growth to achieve sufficient biomass and height to suppress the performance of neighbouring species. Stems persist as litter until the following spring, helping to suppress seedlings of other species. The good shade tolerance of I. glandulifera (Beerling & Perrins 1993) and, in particular, its massive cotyledons (Kurtto 1992), seem to be important characteristics in its compitetive ability. In the competition for pollinators, I. glandulifera is superior to I. noli-tangere (Daumann 1967).

In the long run, the superiority of I. glandulifera in the competition for pollinators and also for space may accelerate the decline of the indigenous species I. noli-tangere, a decline partly caused by more direct human activities. This has actually happened, at least in some areas in Central Europe (Daumann 1967), and observations in Helsinki (A. Kurtto) point to phenomenon also in Finland. In the competition for space, I. glandulifera is obviously able to outcompete other native plants, too, but exact data from Finland are lacking.

Control

In many European countries I. glandulifera is nowadays such an extremely invasive plant that it must be controlled by mechanical and chemical measures (e.g. Lhotská & Kopecký 1966, National Rivers Authority 1994). In Finland mechanical measures have been used in private yards and gardens, but probably not in public areas, and chemical measures are perhaps not at all recommendable due to possible hazardous effects on the ecosystems. Mechanical measures, such as mowing and uprooting, are in principle effective ways to reduce or even eradicate I. glandulifera, since it is an annual and has relatively weak roots. The work should be done before fruits of the plant begin to ripen. It may be necessary to repeat the mechanical control of a population in two or more subsequent years, since the species is able to maintain a seed bank (Beerling & Perrins 1993). Biological control methods are not known.

Mechanical and chemical measures are a waste of time, if the original sources of seeds are not simultaneously suppressed. As to shore populations of I. glandulifera, the sources are usually easy to discover: nearby or upstream areas of one-family houses, allotments, garden plots or block yards.

Garden refuse is often transported and dumped outside of these areas, for example, onto brook sides and river sides. As a vector of alien plants to more or less natural habitats, this kind of transport should be blocked much more efficiently than is customary today.

Future needs

The complete eradication of I. glandulifera from Finland is not any more realistic. However, its eradication, or at least diminishing it or preventing of its further spread, in the water systems in which it is threatening native vegetation is desirable. To realize this, small-scale experiments testing potential control methods are first needed. Studies on the autecology of the species, especially on the so-called bottlenecks of its life-cycle, in the Finnish circumstances could be of help in planning the control methods.

As already stated above, the transport of garden refuse should be controlled more effectively to hinder the direct dispersal of alien plants, including I. glandulifera, into natural communities. In this, as well as more generally, information campaigns are needed to make the public aware of the negative effects of introductions.

Finally, the Finnish legislation concerning alien plants in general should be re-evaluated and perhaps made more detailed, even to include a specific list of unwanted species. I. glandulifera is officially considered such a species in some parts of the United States.

References

Beerling, D.J. & Perrins, J.M. 1993: Biological flora of the British Isles. No. 177. Impatiens glandulifera Royle (Impatiens roylei Walp.). – Jour. Ecol. 81: 367-382.

Beger, H. & Schmidt, E. 1925: Balsaminaceae. Springkrautgewächse. – In Hegi, G. (ed.), Illustrierte Flora von Mittel-Europa V(1): 309-320.

Britten, J. 1900: Impatiens roylei in England. – Jour. Bot. 38: 50-51.

Coombe, D.E. 1956: Notes on some British plants seen in Austria. – Veröff. Geobot. Inst. Rübel Zürich 35: 128-137.

Daumann, E. 1967: Zur Bestäubungs- und Verbreitungsökologie dreier Impatiens-Arten. – Preslia 39: 43-58.

Erkamo, V. 1949: Salvinia rotundifolia Willd. ja Impatiens Roylei Walpers löydetty Suomesta vapaasta luonnosta. [Salvinia rotundifolia Willd. and Impatiens Roylei Walpers apparently growing wild in Finlan]. – Archivum Soc. Vanamo 2: 142-148.

Kurtto, A. 1992: Jättipalsami (Impatiens glandulifera) – kuriton, mutta kiinnostava. [Impatiens glandulifera as an ornamental and escape in Finland]. – Lutukka 8: 14-29.

Kurtto, A. 1996: Impatiens glandulifera (Balsaminaceae) as an ornamental and escape in Finland, with notes on the other Nordic countries. – Acta Univ. Ups. Symb. Bot. Ups. 31(3): 221-228.

Lhotská, M. & Kopecký, K. 1966: Zur Verbreitungsbiologie und Phytozönologie von Impatiens glandulifera Royle an den Flusssystemen der Svinita, Svratka und oberen Odra. – Preslia 38: 376-385.

National Rivers Authority 1994: Guidance for the Control of Invasive Plants near Water Courses.

Valentine, D.H. 1971: Flower-colour polymophism in Impatiens glandulifera Royle. – Boissiera 19: 339-343.

Winsor, J. 1983: Persistence by habitat dominance in the annual Impatiens capensis (Balsaminaceae). – Jour. Ecol. 71: 451-466.

Pinewood nematode (Bursaphelenchus xylophilus)

Jyrki Tomminen
Plant Production Inspection Centre, Helsinki

History and impacts

The pinewood nematode (PWN) (Bursaphelenchus xylophilus) has been under surveillance by Finnish plant health officials already since 1984 when pinewood nematodes were found in pine wood chips imported to Finland from North America for pulp (Rautapää 1986). The nematode has been killing vast areas of pine forests for decades, particularly in Japan but also to some extent in China (Evans et al. 1996).

PWN occurs also in the United States, Canada, Taiwan and Korea and it is believed to have originated in North America. It does not harm the indigenous conifer tree species either in the United States or Canada possibly due to long-term coevolution with the host trees. On the other hand, since it appearance in Asia it has caused massive mortality in Japan probably because of the host trees' apparent lack of adaptation to the nematode. Within forests, the pinewood nematode moves from one tree to another by help of a pine sawyer beetle (Monochamus spp.) (Linit 1988). Intensive studies have been done at the University of Helsinki into the potential introduction of PWN into Finnish coniferous forests and the possibility of its permanent establishment in Finland (Tomminen 1993). The results clearly indicated that Finnish pine forests would meet all the nematode's essential biological requirements for successful establishment. Finland has a perfect host tree, Scots pine (Pinus sylvestris), and suitable vector beetles. Even the northern climate with cold winters would not prevent the nematodes spread.

Control

In Finland plant quarantine and inspection falls within the authority of the Ministry of Agriculture and Forestry. The practical work is done by the plant health officials of the Plant Production Inspection Centre. The main objective of plant inspection is to prevent new harmful pests and diseases of plants in horticulture, agriculture or forestry from spreading into Finland from other parts of the world. The problem, therefore, is approached almost purely from the economical and anthropocentric point of view. There is little attention paid to whether an accidentally or intentionally introduced new organism will replace a native one, for instance.

In 1984-85 Finnish plant health authorities rapidly banned importation of conifer wood from countries where PWN was known to occur. In practice, the embargo has been in effect ever since, although when Finland joined the European Union the ban was somewhat modified to conform with the EU plant health legislation. At the present time, coniferous sawn wood, for instance, can be imported into Finland from countries with PWN only if it is heat treated at 56 C for 30 minutes to kill the nematodes.

While PWN is known to be vectored by pine sawyer beetles below the forest canopy, its spread from one country to another or from one continent to another results from human activities, that is international trading of wood and various other commodities. For instance, it is believed that PWN was introduced into Japan at the turn of the previous century in pine logs imported from North America. Rapidly, the nematode gained the status of being the most devastating forest pest ever in Japanese pine forests. The most recent reminder of the plant health risks associated with transportation of commodities in international trade is last year's finding of the pinewood nematode in Portuguese pine forests (Anon. 1999). It is hypothesized that the nematode came into Portugal in coniferous wood used for packing merchandise. For now, it seems as though the range of the nematode's occurrence in Portugal is restricted to areas near Lisbon.

For some years now the risks involved in using wood for packing commodities have been increasingly recognized. Frequently, the wood used for packing is of low quality with infestations of various timber pests and diseases. In 1990 Finnish plant inspection authorities intercepted live nematodes in wood used for packing onions and shipped to Finland from Canada. Although, the EU plant health legislation has recognized the risks associated with coniferous wood used for packing, the finding of PWN in Portugal quickly intensified discussions on whether there would be a need to tighten current EU plant health requirements with respect to such wood.

At the moment, in accordance with the EU plant health legislation, coniferous wood used for packing must be stripped of its bark before entering the EU countries, if the wood originates from a country where PWN is known to occur. The wood should be free from grub holes, caused by pine sawyer beetles in the genus Monochamus (non-European spp.), and should have a moisture content of less than 20%, achieved at the time of manufacture. These requirements, however, do not guarantee that the wood is of the nematode.

The Finnish plant inspection authority has since last December (1999) been taking samples to detect possible PWN infestations in coniferous packing case wood originating from PWN countries. The inspection statistics have so far demonstrated that there is and has been a steady inflow of PWN into Finland via coniferous packing case wood. Out of the 578 inspected lots of packing wood, 18 have contained living PWNs. Finland is the only EU member country that has adopted, beginning from the 31st of May 2000, a requirement that an international phytosanitary certificate is attached to each shipment of commodities containing coniferous packing wood and originating from a country where PWN is known to occur.

Requirements for wood treatment are as follows (Ministry of Agriculture and Forestry Decision No. 53/00):

- wood shall be stripped of its bark, and shall be free from grub holes, caused by the genus Monochamus (non-European spp.), and shall have a moisture content of less than 20%, achieved at the time of manufacture, OR
- wood shall be heat treated to reach a minimum core temperature of 56o C for at least 30 minutes, OR
- wood shall be kiln dried to below 20% moisture content, expressed as a percentage of dry matter, at time of manufacture, achieved through an appropriate time/temperature schedule OR
- wood shall be fumigated with an appropriate fumigant. The information on the active ingredient, the minimum wood temperature, the rate (g/m3) and the exposure time (h) of the fumigation procedure shall be indicated on the phytosanitary certificate.

In addition to these requirements, the wood naturally has to be free of the nematode PWN.

Assessment and future needs

At the moment, the EU Standing Committee on Plant Health is working on reevaluation and modification of the current plant health legislation concerning the risks associated with transport of coniferous wood packing material. Once the new regulations are ready to be enforced, Finland must bring its requirements into accord with reformed EU regulations. The present phytosanitary certificate requirement in Finland clearly shows how seriously the Finnish plant health authorities view the risk of PWN being introduced into Finland.

PWN surveys had to be carried out in pine forests in each EU member country in 2000. Another direct result of the finding of PWN in Portugal was that Finland is concerned that the nematode might have already in its forests, based on the evidence that the nematode has moved from country to country, and continent to continent, in coniferous wood. The results of the EU-wide survey will be ready by the end of the year.

Finland's objective has been to collect 1000 wood samples from coniferous forests focusing on sites around main ports and other import locations. The samples have been analysed for PWN in the Plant Inspection Laboratory. Of the 961 samples analysed so far, none have contained the nematode. In this respect, the situation appears promising. However, Finland must remain vigilant. Knowing that coniferous wood is still used for packing by various commodities originating in PWN regions, which enter the country each day, authorities must be constantly on the look out for the nematode.

In conclusion, the plant health authorities face many challenges in finding means to keep PWN out of the country. Legislation has to be designed rationally to be strict enough to guarantee that there is no risk of PWN introduction to new areas within coniferous wood. Yet, at the same time, requirements have to be well justified so to not restrict the world trade unreasonably. On the other hand, if there is a real cause for setting limits on international movement of certain kinds of plants because of plant health risks, the parties involved in trade business should accept that as a logical part of their business activities.

Public awareness campaigns about the risks of alien species are an important tool in preventing the spread of new pest species through human activities. With respect to PWN from the national standpoint, the ultimate goal is to protect Finland’s coniferous forests from being devastated by this forest pest, which, at its worst, can alter the forest structure completely by killing vast areas of pine trees.

References

Anonymous 1999. Bursaphelenchus xylophilus found in Portugal. NPPO of Portugal (99/152), 1999-09.
Evans, H.F., Mc Namara, D.G., Braasch, H., Chadoeuf, J. & Magnusson, C. Pest Risk Analysis (PRA) for the territories of the European Union (as PRA area) on Bursaphelenchus xylophilus and its vectors in the genus Monochamus.
Linit, M.J. 1988. Nematode-vector relationships in the pine wilt disease system. Journal of Nematology 20:227-235.
Rautapää, J. 1986. Experiences with Bursaphelenchus xylophilus in Finland. Bulletin OEPP/EPPO Bulletin 16: 453-456.
Tomminen, J. 1993. An assessment of the pinewood nematode and related species in wood products and their potential risk to Finnish forests. University of Helsinki, Department of Applied Zoology, Reports 18.

Spiny water flea (Cercopagis pengoi)

Erkki Leppäkoski
Dept. of Biol. Environmental and Marine Biology
Åbo Akademi University, Turku

History

Cercopagis was first discovered in the Gulf of Riga and the Gulf of Finland in 1992 (first found along the southern coast of the Gulf of Finland in the port area of Muuga Bay; Ojaveer et al. 2000). In 1995, the species colonised the whole Gulf of Finland. At some stations, sampled in September 1995 in the Gulf of Riga, 25% of the total zooplankton biomass was Cercopagis (Ojaveer and Lumberg 1995; Ojaveer et al. 1998).

In 1997, the species was reported from the Stockholm archipelago and appeared in the Baltic proper (the Gotland Basin; Gorokhova et al. 2000). By the exceptionally warm summer of 1999, if was spreading further north (Gulf of Bothnia) and south (Gulf of Gdansk) took place (Uitto et al. 1999, Zmudzinski 1999, Ojaveer et al. 2000, K.-E. Storberg pers. comm.). It was recorded in both the Curonian and Vistula lagoons (Hornatkiewicz-Zbik 1999; Gasiunaite 2000; Naumenko 2000) as well as in the adjacent open sea (Karaseva 2000) in 1999. No quantitative data on its distribution and seasonal dynamics are yet available.

Description of Cercopagis pengoi

Cercopagis is a predatory zooplankton species native to the Caspian, Black, Azov and Aral Sea basins. Animals (< 2 mm body length) have a long ”tail” with a characteristic hook near the end (the tail spine can be up to 3-7 times as long as the body). As mass occurrences in summer, they hook together into masses that look like apple jam, and clog fishing nets. Dependening on meteorological conditions, the cladoceran is present in the zooplankton community of the Gulf of Riga for 7-20 weeks annually with several abundance peaks per year (Ojaveer et al. 2000). Cercopagis reproduces by means of cyclic parthenogenesis. For most of the growing season, only females are present that produce eggs asexually (parthenogenically), which allows them to establish fast-growing populations with a relatively small seed population. Under deteriorating living conditions the females begin producing male offspring. Once there are both males and females in the water, resting eggs will be produced. These eggs can hatch several years later (Krylov et al. 1998, Grigorovich et al. 2000).

Usually, the species appears in a pelagic mesozooplankton community at water temperatures over 15ºC and starts to disappear when the temperature falls below 8 ºC (Ojaveer et al. 2000). Cercopagis is an euryhaline species. It is more abundant at lower (3 to 8 %o) salinities in the northern Caspian Sea. Cercopagis not only tolerates fresh water but is able to establish permanent populations in freshwater reservoirs (Mordukhai-Boltovskoi and Rivier 1971, 1987). The wide range of optimal salinity (up to 10 psu) does not restrict the spreading of Cercopagis throughout most of the Baltic Sea (Ojaveer et al. 2000).

The average density of Cercopagis in the upper water layer off Kotka, eastern Gulf of Finland, was estimated at 300 ind. m-3 in 1997 (Uitto et al. 1999). Maximum abundances at 1800 ind. m-3 have been reported from the Gulf of Finland (Uitto et al. 1999) and 800 ind. m-3 from the Gulf of Riga (Ojaveer et al. 1998). In the Neva estuary, the highest Cercopagis densities (up to 305 ind m-3) were found near Berezovy Island on 17-23 August 1966 (GAAS 2000).

Although Cercopagis was present throughout the water column, its abundance in the upper 10 m strata was usually higher than deeper down in both day and night time (Krylov et al. 1999). The population showed a remarkable reproductive strategy, switching to sexual reproduction during summer months (GAAS 2000). In early August 1996 females bearing resting eggs constituted 13-67% of the total population. The start of the production of resting eggs corresponded with the period of elevated water temperature and with an increase in population density of Cercopagis. (Krylov and Panov 1998). In 1997-1998, the percentage of sexually reproducing Cercopagis decreased. It has been suggested, that this large pool of resting eggs in the Neva estuary population has enabled Cercopagis to achieve fast population growth in new environments and has increased the risk of Cercopagis being dispersed in ballast waters loaded in this area (Panov et al. 1996, Panov et al. 1997, GAAS 2000).

Impacts

The invasion of Cercopagis may increase the functional diversity of the pelagic system by adding a trophic link in the food web (Ojaveer et al. 2000). The appearance of Cercopagis in the eastern Gulf of Finland coincided with recent declines in total cladoceran density (Avinski 1997). Copepods (nauplii and copepodites of Acartia, Eurytemora and Temora), rotifers (Synchaeta) and cladocerans (Evadne) constituted 60%, 20% and 20%, respectively, in the diet of Cercopagis in the northern Baltic proper (Gorokhova 1998).

After the invasion of Cercopagis, the abundance of its potential prey, Bosmina coregoni maritima, decreased significantly (Ojaveer et al. 2000). Consequently, effects on ciliates, regulated by mesozooplankton predation in the Baltic Sea, can be expected at peak densities of Cercopagis (Uitto et al. 1999). Further, dietary overlap of the cladoceran with abundant planktivorous fish does occur. This may result in less available food resources for important commercial fish (herring and sprat) and lower planktivorous fish production (Ojaveer et al. 2000).

The mean percent contribution of Cercopagis in herring stomachs in the Gulf of Riga, in 1994-1998 varied from 0 - 0.1 % in June/July to 11 - 17% in August/September. In July 1999, Cercopagis made up 59% (wet weight) of herring diet; stomachs of 66% of herrings contained this species (Ojaveer et al. 2000). The most abundant pelagic fish (herring, sticklebacks and smelt) can prey on Cercopagis, potentially reducing its abundance However, Cercopagis remains a rare prey item in fish diet, accounting for an average of 7% of recovered prey items (Ojaveer et al. 2000).

The clogging of reels and fouling of nets makes Cercopagis a potential nuisance species in invaded waters. This may cause substantial economic loss in fisheries. The estimated loss in one fishery enterprise in the eastern Gulf of Finland averaged for 1996 -1998 at minimum USD 50 000. These losses were caused by the drastic decline in fish catches in the coastal zone due to fouling of fishing equipment by Cercopagis (Panov et al. 1999). By 1999, biofouling (clogging) of fishing equipment by Cercopagis became a serious problem, especially in whitefish fisheries, in the eastern Gulf of Finland (GAAS, 2000), in the inner parts of the Archipelago Sea (K. Häkkilä, pers. comm.), in the northern Bothnian Sea (K.-E. Storberg, pers. comm.) and in Lithuania (I. Olenina, pers. comm.).

Vectors of invasion

Cercopagis was most probably transferred to the Baltic Sea from its Ponto-Caspian area of origin accidentally with ballast water. Secondary within-basin introductions are assisted by currents. Cercopagis is also found in the North American Great Lakes, probably arriving from the Baltic Sea (Panov et al. 1999, Cristescu 2001; Black Sea is also possible, though very unlikely). The species was first observed throughout Lake Ontario during 1998. It has been impossible, though, to identify the site of its primary introduction, most likely invading the lake the same year or earlier (Grigorovich et al. 2000). In 1999, Cercopagis was observed in Lake Michigan and in five lakes in the finger lakes region of New York State (MacIsaac et al. 1999).

Actions considered to address the problem

No actions have been undertaken besides to monitoring the further spread of Cercopagis and studying its biology and ecology in the invaded parts of the Baltic Sea. With no way to eradicate the well-established population of Cercopagis or control its further spread in the Baltic Sea one can only try to prevent its spread to adjacent fresh-water bodies.

Implementation of measures, including assessment of effectiveness

See above. Strategies to implement the IMO Guidelines are needed. In the case of brackish water areas, such as the Baltic Sea, the ballast water exchange en route in open sea with fully oceanic conditions represents a practicable, even if not fully effective, method to reduce the risk of further introductions of fresh and brackish water organisms (Gollasch and Leppäkoski 1999).

Lessons learned from the operation and other conclusions

Cercopagis is native to warmer climatic conditions than those prevailing in the Baltic area. Global warming should favour its further spread in the Baltic, support further increases in abundance, and increase the risk of its invasion into the great lakes of Finland, Sweden, Estonia and north-western Russia (Ladoga), connected with the invaded parts of the Baltic by sea traffic. There is recent evidence of species introductions from the Baltic to the Finnish lake district where the mitten crab (Eriocheir sinensis) was first found in 1999 (Valovirta and Eronen 2000).

Given the linkages between the lakes and the Baltic Sea, it is likely that Cercopagis will spread throughout the lakes in time. Therefore, a risk assessment should be performed including both abiotic (temperature, pH) and biotic (food availability, predators) parameters that either facilitate or prevent Cercopagis' spread into lakes adjacent to the Baltic Sea.

Cercopagis appeared to be a successful invader in the Baltic Sea. Within 5-7 years after its first appearance, it was able to colonise the sea from the Gulf of Gdansk (54oN) to the northern Bothnian Sea (62oN). The appearance of Cercopagis in the early 1990s and the North American polychaete Marenzelleria viridis in the mid-1980s in the Baltic contributed widely to the common and scientific awareness of aquatic bio-invasions in the late 1990s (Leppäkoski and Olenin 2000). The further spread of Cercopagis will be monitored carefully (Gorokhova et al. 2000), the species being one of the few recent introductions, and obviously the most important one in both ecological and economic terms, into the pelagic subsystem of the Baltic Sea. Ongoing (e.g., Uitto et al. 1999, Ojaveer et al. 2000, Ojaveer et al. submitted) and future research will help us to understand the ecological role of this invasive species (specially the potential impacts that Cercopagis will have on the Baltic food web) and assess its economic impact in the Baltic Sea.

If the density of Cercopagis will not decrease significantly in the nearest future, it may seriously affect commercial fisheries. High-risk areas are the Gulf of Finland, the Gulf of Riga, the coastal lagoons and the German Boddens, known as centres of xenodiversity, that is, areas that host many well-established non-indigenous species (Leppäkoski and Olenin 2000). Considering the present intensive shipping activity, the future development of new ports in the eastern Gulf and creation of new international transport and invasion corridors, the Gulf of Finland can be identified as a "hot spot" area in the Baltic Sea in terms of vulnerability to alien species and high potential of established invaders to negatively affect the ecosystems (Panov et al. 1999).

References and notes

Avinski, V. 1997. Cercopagis pengoi – a new species in the eastern Gulf of Finland ecosystem. In: Proceedings of the final seminar of the Gulf of Finland year 1996. March 17-18, Helsinki, Finland. Edited by J. Sarkkula. Suomen Ympäristökeskus, Helsinki. pp. 247-256.
Cristescu, M. Hebert, P.D.N., Witt, J., MacIsaac, H.J. and Girgorovich, I. 2001. An invasion history for Cercopagis pengoi based on mitochondrial gene sequences. Limnology and Oceanography. In press.
GAAS 2000. Cercopagis pengoi (Ostroumov, 1891). Group on Aquatic Alien Species. Zoological Institute of the Russian Academy of Sciences, St. Petersburg, Russia. http://www.zin.ru/projects/ invasions/cerpen.htm (downloaded 2000-05-16).
Gasiunaite, Z.R. 2000. Seasonal dynamics and spatial heterogeneity of the plankton crustaceans in the eutrophic coastal lagoon. Summary of Doctoral Dissertation. Klaipeda University, Klaipeda.
Gorokhova, E. 1998. Zooplankton spatial distribution and potential predation by invertebrate zooplanktivores. Second BASYS Annual Science Conference 23-25.09.1998, Stockholm, Sweden. Paper Abstracts. http://www.io-warnemuende.de/public/bio/basys/con2/con2pap.htm#SP2-4

Gorokhova, E., Aladin, N.and Dumont, H.J. 2000. Further expansion of the genus Cercopagis (Crustacea, Branchiopoda, Onychopoda) in the Baltic Sea, with notes on the taxa present and their ecology. Hydrobiologia 429: 207-218.
Grigorovich, I.A., MacIsaac, H.J., Rivier, I.K., Aladin, N.V. and Panov, V.E. 2000. Comparative biology of the predatory cladoceran Cercopagis pengoi from Lake Ontario, Baltic Sea and Caspian Sea. Archiv für Hydrobiologie 149: 23-50.
Hornatkiewicz-Zbik, A. 1999. Predacious cladocerans in the Vistula Lagoon. Kom. Ryb. IRS 5: 10-11 (in Polish).
Karaseva, E. 2000. The first finding of Cercopagis pengoi (Ostroumov, 1981) in the offshore part of the south-east Baltic. In: Scientific Seminar on Species Introductions in the European Seas of Russia. Murmansk, January 27-28, 2000. Abstract (in Russian).
Krylov, P.I. and Panov, V.E. 1998. Resting eggs in the life cycle of Cercopagis pengoi, a recent invader of the Baltic Sea. Archiwum für Hydrobiologie Special Issues Advanced Limnology 52: 383-392.
Krylov, P.I., Bychenkov, D.E., Panov, V.E., Rodionova, N.V. and Telesh, I.V. 1999. Seasonal dynamics and distribution of the Ponto-Caspian invader, Cercopagis pengoi (Crustacea, Cladocera), in the Neva Estuary (Gulf of Finland). Proceedings of the BMB 15 and ECSA 27 Symposium. Hydrobiologia (in press).
Leppäkoski, E. and Olenin, S. 2000. Non-native species and rates of spread: lessons from the brackish Baltic Sea. Biological Invasions 2: 00-00 (in press).
MacIsaac, H.J., Grigorovich, I.A., Hoyle, J.A., Yan, N.D. and Panov, V. 1999. Invasion of Lake Ontario by the Ponto-Caspian predatory cladoceran Cercopagis pengoi. Canadian Journal of Fisheries and Aquatic Science 56: 1-5.
Naumenko, E. 2000. Cercopagis pengoi (Ostroumov, 1981) - a new introducent into the Vistula Gulf of the Baltic. In: Scientific Seminar on Species Introductions in the European Seas of Russia. Murmansk, January 27-28, 2000. Abstract (in Russian).
Ojaveer, H. and Lumberg, A. 1995: On the role of Cercopagis (Cercopagis) pengoi (Ostroumov) in Pärnu Bay and the NE part of the Gulf of Riga ecosystem. Proceedings of the Estonian Academy of Science, Ecology 5(1/2): 20-25.
Ojaveer, H., Leppäkoski, E., Olenin, S. and Ricciardi, A. (submitted). Ecological impact of Ponto-Caspian invaders in the Baltic Sea, European inland waters and the Great Lakes: an inter-ecosystem comparison.
Ojaveer, E., Lumberg, A. and Ojaveer, H. 1998. Highlights of zooplankton dynamics in Estonian waters (Baltic Sea). ICES Journal of Marine Science.55: 748-755.
Ojaveer, H., Simm, M., Lankov, A. and Lumberg, A. 2000. Consequences of invasion of a predatory cladoceran. International Council for the Exploration of the Sea C.M. 2000/U:16.
Panov, V.E, Krylov, P.I. and Telesh, I.V. 1996. The Caspian predatory cladoceran Cercopagis pengoi invades the Gulf of Finland. Baltic Floating University Research Bulletin 2: 80-81.
Panov V.E., Alimov A.F., Balushkina E.V., Golubkov S.M., Nikulina V.N., Telesh I.V.and Finogenova, N.P. 1997. Monitoring of biodiversity of bottom and plankton communities in the Neva Estuary. - In: V.E.Sokolov, Yu.S.Reshetnikov and M.I.Shatunovski (eds) Monitoring of Biodiversity. Moscow: 288-294 (in Russian).
Panov, V., Ojaveer, H. and Leppäkoski, E. 1999. Introduction of alien species into the Gulf of Finland - an increasing environmental problem. In: Annual Assessment on the State of the Gulf of Finland. Web site: http://www.zin.ru/projects/invasions/ (issued in April, 1999).
Ricciardi, A. and MacIsaac, H.J. 2000. Recent mass invasion of the North American Great Lakes by Ponto-Caspian species. Trends in Ecology and Evolution 15: 62-65.
Uitto, A., Gorokhova, E. and Välipakka, P. 1999. Distribution of the non-indigenous Cercopagis pengoi in the coastal waters of the eastern Gulf of Finland. ICES Journal of Marine Science 56 (Suppl.): 49-57.
Valovirta, I. and Eronen, R. 2000. First record of Eriocheir sinensis from Finnish inland. Memoranda Societatis pro Fauna Flora Fennica 76: 23-25 (in Finnish, with English summary).
Zmudzinski, L., 1999. Cercopagis pengoi (Cladocera) conquered the southern Baltic Sea. Baltic Coastal Zone. Institute of Biology and Environmental Protection. University of Education, Slupsk, 1998/1999, 2: 95-96.

Canadian beaver (Castor canadensis)

Petri Nummi
Department of Applied Biology
University of Helsinki

History and impacts

As in most European countries, European beaver (Castor fiber) was hunted to extinction in Finland in 1868. In 1935-36, 19 European beavers of Norwegian origin were reintroduced in to northern, western, central and southern Finland. In 1937, seven Canadian beavers were brought from United States, and released into central and eastern Finland (Lahti & Helminen 1974). During that time, it was not known that the two beavers belonged to different species.

Until 1955 especially the population of Canadian beavers of eastern Finland had increased considerably; population size in that area was 200-250 individuals (Linnamies 1956). At that time, Canadian beavers were transported from eastern Finland to former European beaver areas in southern Finland and, in addition, to two northern areas (Lahti & Helminen 1969). In the late 1940s and early 1950s, Canadian beavers crossed the eastern border into Russian Karelia (Danilov 1995). Today, there are about 12 000 Canadian beavers and 1500 European beavers in Finland (Ermala et al. 1999).

In northern, central and southern Finland where both species were once brought, only the Canadian beaver exists today. With small populations, chance plays a role in whether they perish or start to increase (Roughgarden 1986). Therefore – and because there are only three replicates – we cannot be absolutely sure that it is the Canadian beaver that has caused the local extinction of the European species.

However, there are some features in the biology of the two species which points to this possibility. Apparently the Canadian beaver uses resources more effectively, and also has larger litters. In the Russian northwest, the mean litter size of Canadian beavers is 3.3, whereas that of the European species is only 1.9. About 66% of Canadian beaver settlements have a built dam and 75% a lodge; respective figures for the European beaver are only 45 % and 34% (Danilov 1995). In Finland, the differences in the building activity seemed to be even larger (Ruusila 1997). The Canadian beaver is causing forestry problems especially in southeastern Finland (Härkönen 1999).

Control

In principle, the populations of Canadian and European beavers should be prevented from coming into contact. They have, though. In western Finland, the two species live in close proximity (Ermala 1998). Moreover, during the last 10-15 years the Canadian beaver has spread from eastern Finland to the northwest at such a rate (Ermala et al. 1989, 1999) that if it continues the beaver will reach Sweden within the next ten years. The Ministry of Agriculture and Forestry has set a special goal (Dnro 4910/211/99, 26.1.2000) for the Lappland game district to eradicate the Canadian beaver there, and for other game districts to prevent the Canadian beaver from entering the range of the European beaver.

Future needs

More knowledge is required of the effort needed to keep an area empty of beavers. This empty sector is needed in many areas if both Canadian and European beavers are managed in Finland (and Russian Karelia).

The Finnish beaver problem resembles problems with the gray squirrel (invasive alien in England and Italy) Sciurus carolinensis andthe red squirrel S. vulgaris (Genovesi 1999), as well as the ruddy duck (invasive alien in northwestern Europe) Oxyra jamaicensis, and the white-headed duck O. leucocephala (Hughes et al. 1999). In these cases, the alien species outcompetes the native one. Thus, there are plans to eradicate the gray squirrel from Italy and the ruddy duck from Europe. Eradication has recently been suggested as nature conservation policy also in the European Union (Orueta & Ramos 1998, Council of Europe Publishing 1999, Genovesi 2000). The feasibility of large-scaled eradications should be carefully studied. Nevertheless in some cases they can be performed as shown in the eradication of Coypu Myocastor coypu from England (Baker 1999). Probably one should also study the possibility of eradicating the Canadian beaver altogether. This would be a large transboundary project since there also are Canadian beavers in Russian Karelia. When planning measures as radical as eradications, the public should be very well informed about the problem. This is because the true nature of alien invasions is not always understood early enough. In Italy, for example, the public is finding it hard to understand that the small gray squirrel Sciurus carolinensis population may eventually threaten the red squirrel Sqiurus vulgaris in the whole of Europe (Genovesi 1999). The situation is similar to that of the ruddy duck in England (Hughes et al. 1999).

References

Danilov, P. I. 1995. Canadian and European beavers in Russian northwest. – The third Nordic beaver symposium 15.-17.9.1992 Mekrijärvi. – Finnish Game and Fisheries Res. Inst. Helsinki.
Ermala, A. et al. 1989. Some aspects of the occurrence, abundance and future of the Finnish beaver population (in Finnish with English summary). – Suomen Riista 35: 108-118.
Ermala, A. et al. 1999. Majavakanta edelleen kasvussa – saalismäärä jo lähes 2500 yksilöä. – Metsästäjä 4/1999: 28-31.
Lahti, S. & Helminen, M. 1969. History of reintroduction and present population status of the beaver in Finland (in Finnish with English summary). – Suomen Riista 21: 67-75.
Lahti, S. & Helminen, M. 1974. The beaver Castor fiber (L.) and Castor canadensis (Kuhl) in Finland. – Acta Theriologica 19: 177-189.
Linnamies, O. 1956. Majavien esiintymisestä ja niiden aiheuttamista vahingoista maassamme. – Suomen Riista 10: 63-86.
Ruusila, V. 1997. Kanadanmajava on ahkerampi rakentaja – In: Nummi, P. (ed.) Suomen luonto. Nisäkkäät. Welin & Göös, Porvoo: 95