

Review

INTRODUCTIONS OF NON-INDIGENOUS FISH SPECIES FOR  
RELEASE AND CULTURE IN THE NETHERLANDS

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ABSTRACT

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A total of 27 non-indigenous fish species has been introduced into the waters of The Netherlands, mainly during the 19th and 20th centuries: 12 European, 11 North American, 3 Asian and 1 South American species. Most of the introductions were made deliberately, some accidentally. Nearly all of the introduced fish are true freshwater species (23), the others are anadromous (4). The introductions were made with the aims of restocking declining populations of commercially important species, introducing new species as substitutes for the former, establishing new fisheries or for culture to produce fish for consumption, ornament and game. The extensive and prolonged attempts to restock inland waters with various salmonids have never met with success. The introduction of non-indigenous salmonids (e.g. chinook, lake whitefish) was also a failure. Even at the beginning of this century the inland waters of The Netherlands had become unsuitable for salmonids because of environmental deterioration although that was not understood at the time. The release of rainbow trout into natural waters is unsuccessful as they will not reproduce. Apart from the carp, the most successful introduction since mediaeval times has been the pikeperch (1901) which at present is the second most important freshwater species for fisheries. Four North American species, probably accidentally released, are fully acclimatized in our waters, and are even locally common. These are the eastern mudminnow, the black and the brown bullhead and the pumpkinseed.

INTRODUCTION

The problems associated with introductions and transfers of non-indigenous organisms have been studied since 1969 by the International Council for the Exploration of the Sea (ICES). The same problems related to freshwater fishes are studied by the European Inland Fisheries Advisory Commission (EIFAC) of the FAO. Several successful introductions have produced unexpected ecological and detrimental side effects, e.g. the introduction of piscivorous species, the introduction of seaweeds, and spread of involuntarily introduced diseases.

The ICES Working Group on Introductions and Transfers of Marine Organisms (Mariculture Committee) is dealing with the consequences of introducing and transferring marine organisms in the ICES member states (Anon., 1972, 1982). Recently, to reduce the risks of adverse effects arising from the introduction of species, the ICES published the "Guidelines for implementing the ICES code of practice concerning introductions and transfers of marine species" (Anon., 1984c).

The present study attempts to provide a documented overview of the introduction of non-indigenous fish species into The Netherlands. However, during the literature search it became evident that enough source material could be found to start similar studies in the other ICES member states. In fact an Irish study is already well under way (N.P. Wilkins, personal communication, 1984). Not only were fish introduced from the United States at the end of the last century, but European species have also been exported to the United States. In the present paper introductions of fish species are also described for the countries bordering The Netherlands (Belgium, Germany), and for those whose rivers ultimately flowing into The Netherlands (France).

The literature survey by Vooren (1972) dealt with ecological aspects of the introduction of fish species into natural habitats in Europe, with special reference to The Netherlands. Valuable as it is in its main conclusions, it covers only the literature between 1950 and 1970, and did not search the literature in depth. Aquaculture in The Netherlands, since its beginning in 1853 with the official report to King William III (Anon., 1853) who took the initiative, until the present day, has been described by Nijssen and De Groot (1985). It was possible to trace the reasons for fish introductions, and their success or failure.

In the framework of aquaculture, several non-indigenous species have been introduced into The Netherlands. This paper will deal only with fin-fish introductions.

#### NON-INDIGENOUS FISH SPECIES INTRODUCED INTO THE NETHERLANDS

##### 1. *Allis shad* — *Alosa alosa* (Linnaeus)

The rearing of shad in the United States drew the attention of Van Bemelen (1883) who visited the American representation at the International Fisheries exhibition in London. It was understood that it was a different species from the European one, but still it would offer a "cheap food for the working class". The allis shad fetched high prices in The Netherlands, and when the catches from the river fisheries of the Meuse and Rhine were rapidly declining, a full-scale experiment was set up in 1923. In that year a hatchery was built on an old fishing vessel anchored in the river Meuse. Eggs obtained from fish caught in the Loire (France) were artificially fertilized. The experiments were guided by the Rijksinstituut voor Biologisch

Visserijonderzoek (Netherlands Institute for Biological Fisheries Research) and the Heidemaatschappij (a private agency for land development and soil improvement). The results were disappointing and the experiment was abandoned (Anon, 1923a,b).

## 2. *Sea trout* — *Salmo trutta trutta* *Linnaeus*

In the early nineteen-twenties juvenile sea trout were released for the first time in the rivers Meuse and Gelderse IJssel, and in the Alkmaarder Lake (Brouwer, 1925b). In the winter of 1936/37 400 000 fertilized sea trout eggs were obtained in Denmark for release as juvenile fish (2–3 cm) in the same rivers (Anon., 1937a). Danish hatcheries still provide sea trout fry for export and release in several European countries.

## 3. *Rainbow trout* — *Salmo gairdneri* *Richardson* (Table I)

The rainbow trout is one of the most successful introduced and transferred species. Indigenous in North America, the species was imported into Japan back in 1877, and fully acclimatized in 1880. The first rainbow trout shipment to Europe was to France in 1882. Between 1884 and 1890 some 156 000 fertilized eggs were exported from France to Germany and 260 500 eggs were imported directly from the United States. Presumably the first rainbow trout imported into The Netherlands came from Germany. They were stocked as fry in Hasselbeek's fish farm at Zwaanspreng (province Gelderland). In 1898 1500 1-year-old fish were released in the moat of a fortress near Spaarndam north of Amsterdam under "government" supervision. Since then rainbow trout strains have regularly been imported and reared in Dutch waters. At present (1984) about 250 t/year is produced in fish farms (Von dem Borne, 1890a; Anon., 1898, 1907a; Steinmetz, 1969; Vooren, 1972).

## 4. *Arctic charr* — *Salvelinus alpinus* *Linnaeus*

The arctic charr is indigenous in Europe to Norway, Finland, the U.S.S.R. and mountain lakes in the Alps (Bauch, 1955). De Selys Longchamps (1887) mentions that arctic charr occasionally wanders from the Vosges into Belgian waters. In 1887 an attempt was made to release them in a stowlake of the Gileppe. Mulier (1900) states that the species was introduced into The Netherlands. It must have been on a very limited scale and failed, as no mention of it has been made in any ichthyological publication since then.

## 5. *Brook charr* — *Salvelinus fontinalis* *Mitchill*

The brook charr was first introduced into Europe in 1868 from the United States where it is indigenous (Von dem Borne, 1890a). Mulier (1900)

TABLE I

The number of American salmonid eggs and individual bullheads introduced between 1877 and 1900 into The Netherlands (N), Germany (D), Belgium (B) and France (F), based for those years on the Report of the Commissioner of U.S. Commission of Fish and Fisheries, Washington

	1877	1878	1879	1880	1881	1882	1883	1884	1885	1886	1887	1888	1889	1890	1891	1892	1894	1897	1898	1900
Rainbow trout eggs ( $\times 10^3$ )	N	-	-	-	-	-	-	12	10	-	-	-	-	10	10	-	-	-	10	-
	D	-	-	-	-	-	-	-	-	-	-	-	-	25	-	-	-	10	-	-
	B	-	-	-	-	-	-	3	10	30	-	+	15	-	+	-	+	10	25	-
	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Brook charr eggs ( $\times 10^3$ )	N	-	-	-	12	20	25	25	40	-	-	-	-	20	-	-	-	-	-	-
	D	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lake trout eggs ( $\times 10^3$ )	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	D	-	-	-	40	+	100	25	50	-	-	-	-	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	50	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebago salmon eggs ( $\times 10^3$ )	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	D	-	-	-	20	10	25	-	40	60	-	40	-	40	20	-	-	10	-	-
	B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	F	-	-	40	20	10	15	-	-	-	25	20	-	-	-	-	-	-	-	-
Chinook salmon eggs ( $\times 10^3$ )	N	100	100	200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	D	50	250	150	380	300	-	-	-	-	-	-	-	-	-	-	-	50	-	-
	B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	F	58	100	150	2	+	-	-	-	-	-	-	100	100	90	-	100	25	20	-
Lake whitefish eggs ( $\times 10^3$ )	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	D	-	-	250	312	300	500	1000	2000	3000	1000	-	-	-	100	-	-	-	-	-
	B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	250	200	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bullhead ?	N	-	-	-	-	-	-	-	30	-	-	-	3	-	-	-	-	-	-	-
	D	-	-	-	-	-	-	50	-	-	-	-	-	-	-	76	-	-	-	-
	B	-	-	-	-	+	-	100	-	-	-	-	-	-	502	-	-	-	-	-
	F	-	-	-	-	-	-	-	100	-	-	-	-	-	-	-	-	-	-	-

? = Black and brown bullhead combined, cannot be distinguished.

+ = Introductions took place, numbers not known.

states that the species was introduced into Belgium in 1879, whereas Vooren (1972) mentions that the species has never been imported into Belgium (and Portugal and Ireland). Poll (1949) also refers to the brook charr occurring in Belgium. Since 1880 the brook charr has been fully acclimatized in Germany and France and can be considered as an indigenous species according to Von dem Borne (1890a). Between 1884 and 1890 Germany imported 620 000 eggs, and itself produced 390 000 eggs. In 1890 the hatcheries in Germany produced 750 000 brook charr eggs. At that time the species inhabited several mountain lakes and brooks in Bavaria (the Lahn near Carlsbad) and in Austria near the Hungarian border. Mulier (1900) refers to the introduction of brook charr into The Netherlands between 1895 and 1900. The introduction, far from the natural habitat, must have been a failure. Redeke (1941), in his very reliable study of Dutch fishes, makes no reference to the species. Recently, however, the species has been reintroduced from Belgium, even though it is illegal to import non-indigenous species without a licence and to release them into natural waters. Anglers released brook charr into the river Geul in the province of Limburg, near the Belgium—Dutch border. This introduction was based on a confusion between the Dutch vernacular name for arctic charr (*rid-dervis*) and a name given by Mulier (1900) to the brook charr (*beekridder-vis*) derived from a German vernacular name. This is a good example of the problem described by Jernudd and Thuan (1980, 1984) which arises when the scientific name is not used to establish the species being dealt with.

#### 6. *Grayling* — *Thymallus thymallus* (Linnaeus)

After an absence of about 80 years (if we overlook a few stray specimens collected in small rivers and brooks near the eastern borders), this species has been back in The Netherlands since 1980. We owe this to an initiative, comparable to the one with the brook charr, taken by a few salmonid farmers near Valkenswaard in the province of Noord Brabant. In 1980, ignoring the regulations, they released 150 fry bought in West Germany in the Keersop brook. In 1983 these fish reached a length of 40 cm. It is estimated that at present about 120 of these fishes are still alive, forming a couple of schools. However, the stock is not able to reproduce, and will die out if not restocked (Nijssen and De Groot, 1985).

#### 7. *Salmon* — *Salmo salar* Linnaeus (Table I)

The salmon was a native species when the river Rhine was still the largest salmon river in Europe. Between 1875 and 1886 eggs of the land-locked "Sebago" salmon variety were imported from the United States (Von den Borne, 1890a). Germany imported 255 000 of these eggs and France 130 000. In 1887 10 000 Sebago eggs were introduced into Belgium.

It is not unlikely that some of these, in juvenile stages, reached Dutch waters. From 1861 until 1939 juvenile salmon were released in varying numbers in Dutch waters. Interesting is the recovery of two tagged salmon from a Swedish sea-ranching experiment in inland waters of The Netherlands in 1970 and 1972. They were released as smolts in Sweden (Larsson, 1984).

#### 8. *Chinook salmon* — *Oncorhynchus tshawytscha* (Walbaum) (Table I)

Interest in this Pacific salmonid was aroused in Europe after a visit by the German Minister of Agriculture to the Centenary Exhibition in the United States in 1876. A German request was made, supported and followed by The Netherlands, France and the United Kingdom, to buy chinook eggs for release. In 1877 the first transport of 200 000 eggs reached Europe. The Netherlands received 100 000 of these eggs. The transport of these eggs is well documented by Mather (1879). C.J. Bottermanne received these eggs for The Netherlands, and they were kept in the aquarium of the Amsterdam Zoo (Artis). The first experiences were described by Bottermanne (1882). Practically all eggs and fry died in the hatchery. The experiment was repeated with a further 100 000 eggs and this time it was crowned with success: 61 000 juvenile chinook salmon were released into natural waters, due to lack of space, in January 1879. In the river Meuse 50 000 juveniles were released near Venlo, in the brook Zwaanspreng (province of Gelderland) 5000, and near Hattem (same province) in a pond about 5000 juvenile. In the following year (1880) young chinook with a length of 14 cm were caught in the river Meuse near Tegelen. In 1879 and 1880 eggs were also imported and the juveniles were released after a year of captivity. In Germany and France experiments on the release of chinook were continued. Even today France imports eggs, e.g. 20 000 in 1983. The French also imported 20 000 chum salmon, *Oncorhynchus keta* (Walbaum) eggs in 1983 (Anon., 1984d).

In December 1922 chinook eggs were again imported into The Netherlands from the United States. They were kept in the hatchery of The Nederlandse Heidemaatschappij, near Arnhem. What ultimately happened to the fry could not be traced (Anon., 1923c; Brouwer, 1925b).

#### 9. *Coho salmon* — *Oncorhynchus kisutch* Walbaum

A specimen of the coho salmon was first caught in The Netherlands on 16 December 1982 in brackish water of the Calandkanaal, Europoort, Rotterdam, by an angler. Another specimen was caught a few days later. Both were female, with well developed gonads. On 6 January 1984 another female coho was caught, this time near IJmuiden. These and the four specimens caught by anglers in August and September 1983 near the sluices of Nieuwpoort (Belgium) are probably related to releases by a private party in the Somme Estuary in Picardy (France) in 1981 and 1982 (Anon., 1984d).

## 10. Whitefishes — *Coregonidae* (Table I)

In 1881 eggs of the American species, the lake whitefish, *Coregonus clupeaformis* (Mitchill), were transferred to Germany and France, in 1886 to the United Kingdom and in 1887 to Switzerland (Von dem Borne, 1890a). The first rearing trials in The Netherlands date from 1907, when 50 000 fry were released in the rivers Meuse and IJssel (Anon., 1907b). In the following year, 400 000 1-month-old fry were released in the same rivers (Anon., 1908). For many years it has been a routine operation to release whitefish fry in our rivers. It is striking that from the beginning no increase in the catches of whitefish, which were on the decline, was observed. In 1927 and 1929 1-year-old whitefish from Lake Peipus (U.S.S.R.) were imported (Anon., 1931). The last mass release took place in 1937. In the winter of 1936/37 more than 500 000 whitefish eggs were bought, half in Poland, half in Germany. They were of the Baltic variety of the powan, *Coregonus lavaretus*. About 400 000 eggs were released in the IJsselmeer and 50 000 in six smaller lakes, again with no significant result. It is sad to read of the enthusiasm with which the few captures of an individual fish were recorded in the press and the requests for more observations (Anon., 1937a,b,c, 1938). Klein Breteler (1983) gives an overview of whitefish releases between 1922 and 1939 and of catches between 1916 and 1939. Dutch waters were restocked with the houting (*Coregonus oxyrinchus*) and the powan. The introductions and transfers of whitefish all over Europe led to hybridization on a very large scale, which makes it difficult at present to find a "pure-bred" species. Vooren (1972) reviews the varieties of whitefish to be found in Europe.

## 11. Eastern mudminnow — *Umbra pygmaea* (De Kay)

The eastern mudminnow is only to be found in The Netherlands in a confined area, the Peel, on the border with Belgium in the province Noord Brabant. The species originates from eastern North America. According to Kleijn (1968) the species already occurred in that area before 1939; however, it could not be traced at the time of its introduction. Vooren (1972), quoting Kleijn, states that this would be 1920. However, this year is not mentioned by Kleijn. Kleijn suggests that the fish farm exploited by the Heidemaatschappij near Valkenswaard was responsible. The records of this fish farm were lost during the 2nd World War, and so we cannot find out if the species was ever kept there. Another suggestion offered by Kleijn, is that pet-fish keepers released these fish. According to Poll (1949), mudminnows entered Belgium from The Netherlands and became a native species. However that may be, a more likely explanation seems to me that the eastern mudminnow was imported to serve as "natural" live food for piscivorous species also imported from the United States (e.g. salmon or charr). This is supported by the fact that in 1891 M. Von

dem Borne imported 80 specimens of the "American minnow" (white shiner — *Notropis albedus* Jordan) for use as food in his trout farm (Mulier, 1900). At present it remains an open question whether the eastern mudminnow was initially released in Belgium or in The Netherlands. It is notable that there is a Dutch fish farm more or less in the middle of its distribution area.

### 12. Carp — *Cyprinus carpio* Linnaeus

Many varieties "races", of carp can to be distinguished in its natural habitat (king or wild, leather and mirror carp), besides the cultured forms. In central Europe well known culture varieties are the Bohemian, Lausitzer, Galician, Aischegründer and Franconian carp, "hybrids" between these forms, as well as a golden variety, the golden carp (Bauch, 1955). In The Netherlands in 1899 Galician carp was introduced from Austria (Bilitz), and a hybrid between the Bohemian and Lausitzer carp from Hannover, Germany (Pennekamp, 1899). These are just examples to indicate the extent of carp transfers. It is difficult, nearly impossible, to find a "pure-bred" line of the most domesticated fish species in the world.

### 13. Grass carp — *Ctenopharyngodon idella* (Valenciennes)

The grass carp is native to the lowland rivers of China and the Amur region of the U.S.S.R. The species spawns naturally when the water temperature is 27–29°C, a temperature seldom reached in waters of western Europe, and this limits natural spread. However, during the summer of 1984, for example, grass carp with well developed gonads were caught after a warm period in The Netherlands.

The species is a herbivore, used in ditches and small canals to graze on weeds developing too luxuriantly in eutrophicated waters. It was introduced for the first time in Germany (G.D.R.) in 1965 as 2-year-old fish. The trials were repeated in the following year (Scheer and Jähnichen, 1967). In 1966 the first grass carp were introduced into The Netherlands by the Organisatie ter Verbetering van de Binnenvisserij (OVV) (Organization for the Improvement of Inland Fisheries), a semi-governmental institution. This organization is responsible for the experiments, and releases the fish only in confined waters. Escapes are always a possibility; however, the few fish will die in time and will not reproduce. Since 1978 large-scale introductions have taken place; an average of 30 t/year of grass carp is released. At present 700 ha of inland waters have been stocked with the species. The release in natural waters has a direct influence on the whole ecosystem. The species diversity and composition are drastically changed by this herbivorous species, and the numbers of species, plants as well as animals, are dropping.

14. *Silver carp* — *Hypophthalmichthys molitrix* (*Valenciennes*)

Silver carp has nearly the same geographical distribution as the grass carp. It is a plankton feeder. For that reason the species was introduced into The Netherlands in 1966 by the OVB. The enrichment of the environment by the excrements of feeding grass carp causes a bloom of phytoplankton, this could serve as food for the silver carp. The Ministry of Public Works and Transport also experimented on a laboratory scale with the species. The experiments were abandoned. Occasionally specimens of silver carp are still caught. These probably will have escaped from hatcheries across our borders (Anon., 1984a; Cazemier, 1984).

15. *Bighead carp* — *Aristichthys nobilis* (*Richardson*)

The bighead carp inhabits the rivers of southern China. It is used in polyculture in eastern Europe, together with silver carp and sometimes grass carp. High river levels in the winter may enable fishes to escape from rearing facilities. This is the likely explanation of the first record in The Netherlands on the 24 July 1983 of a 41-cm-long fish in a fyke net along the shore of the IJsselmeer (Anon., 1984b). As for grass and silver carp, the water temperatures in western Europe are too low for natural spawning.

16. *Golden ide* — *Leuciscus idus* (*Linnaeus*)

The golden ide was cultured on a large scale in The Netherlands at around the end of the nineteenth century. The fish were imported from France and Germany until the Heidemaatschappij took over the production of this ornamental pond species. The advantage of the fish over the goldfish, *Carassius auratus* (Linnaeus), is that the golden ide always swims near the surface of the pond instead of only during the summer months as the goldfish does (Anon., 1903a, 1904).

17. *Asp* — *Aspius aspius* (*Linnaeus*)

The asp is a central European species. On the 9 May 1984 the first specimen was caught in The Netherlands, in the province of Limburg near the German border (Cazemier, 1984). It proved that this specimen, with others, had escaped from a fishing lake in Germany (G.F.R.) near the Dutch border, where they were stocked for game fishing. These fish were bought in Denmark. Due to high water levels, the fish swam away into the nearby river Roer system and entered Dutch inland waters (P. Dohmen, personal communication, 1984).

*Tench* — *Tinca tinca* (*Linnaeus*)

The culture of the indigenous tench began in 1900, when the Heide-

maatschappij ordered a German firm to design and build two rearing ponds (3 ha) for their hatchery at Vaassen (Anon., 1901). Earlier attempts had been made in the province of Friesland (Anon., 1896, 1897). The growth of the fish was slow, and so the Heidemaatschappij imported from East Prussia (nowadays Poland) a faster growing variety known as the "Masurian tench" (Pennekamp, 1905). The more elongated body and the green colour were said to be characteristic. The fish, 125 specimens, were bought from A. Hübner of Thalmühle near Frankfurt/Oder, the owner of the fishing rights of the Masurian Lakes. In 1906 the Heidemaatschappij produced 65 000 2-year-old Masurian tench for release in natural waters (Anon., 1906). In 1907 this was repeated. It was established that when these Masurian tench were 4 years old, they had an average length of 27 cm and a weight of 300 g (Anon., 1909). According to Vooren (1972), citing a personal communication, the "Masurian tench" can still be found in our inland waters. It is doubtful whether the variety is a valid subspecies; it is more likely just a variety inhabiting the Masurian Lakes.

#### 19. *Wels* — *Siluris glanis* Linnaeus

In 1970 the OVB imported from Hungary wels to be used in rearing trials at their hatchery in Lelystad. The aim was to release them in natural waters as a predator of cyprinids, in order to regulate the number of the latter via "natural" predation instead of catching them with nets. The normal predator, the pike (*Esox lucius* Linnaeus), is overfished by anglers, but the indigenous wels, a relic population in a few lakes, did not respond by expanding its area of distribution in The Netherlands. Furthermore, the native wels is a species protected by law. In 1972 the OVB was successful in obtaining fry of the wels artificially. The experiments were continued with varying success until 1980. In the meantime it was concluded that hatchery products would escape in time, and might endanger our own population of wels. In fact fish did escape and were recaptured from sites scattered over the country, in areas where the wels was never found before (Boeseman, 1975). The species is also cultured in West Germany, and fish from there may escape into The Netherlands as long as they are cultured in waters of the river Rhine system.

#### 20. *Black and brown bullhead* — *Ictalurus melas* (Rafinesque) and *I. nebulosus* (Le Sueur) (Table I)

The first specimens of the bullhead were imported in 1871 into France from the United States. In 1884 Belgium followed and in the next year Germany (Von dem Borne, 1890b; Anon., 1904). In Germany the bullhead was displayed at the fisheries exhibition in 1880 by the American participants (Haack, 1903). The first French specimens were reared in Paris by P. Carbonier. He was very successful and presented a few specimens

to the Musée d'Histoire Naturelle. Here, for some reason, they were washed away in the sewer system and reached the river Seine. In 1879 black bullheads were captured near the Pont d'Austerlitz in the Seine, and again in 1894. On the second occasion the specimens were used in rearing experiments. C. Poutain imported the first specimens into Belgium direct from the United States. The fish were released in ponds at Lommel (Belgian province of Limburg) and in the Meuse canal. Von dem Borne imported 50 specimens from the United States into Germany in 1885. These fish provided the descendants of "German" bullheads, that were imported into The Netherlands in 1905 by the Heidemaatschappij for their hatchery at Vaassen (Pennekamp, 1905). At present the bullheads in The Netherlands originate either from Belgian releases in the Meuse canal or from the rearing experiments at Vaassen. The fishes are fully acclimatized. Next to these major sources there have been a few minor releases by aquarium keepers who wanted to get rid of them.

Kendall (1910), in his review paper on American catfish, gives many examples of imports of the bullhead into Europe, e.g. that 45 specimens were shipped to the Amsterdam Zoo Aquarium for rearing purposes in 1886. It is not clear why the fish was reared as the species was and is not eaten or kept as ornamental fish.

The introduction of the bullhead into Europe is an extreme example of carelessness. The fact that not one but two species were introduced into The Netherlands came to light 50 years after the first introduction (Redeke, 1941).

### 21. *Guppy* — *Lebistes reticulatus* (Peters)

The guppy, indigenous to the northern part of South America, is a very popular aquarium species. For many years a population has existed in the cooling water outlet of the iron works at IJmuiden (Hoogovens). They must originate from cast-away fishes. They reach lengths of 10–12 cm. The risk of their spreading to other waters is minimal as the temperature of the surrounding water is too low in winter (Nijssen and De Groot, 1985).

### 22. *Pumpkinseed* — *Lepomis gibbosus* (Linnaeus)

The pumpkinseed is an aquarium species imported from the United States for that reason in about 1885 in France. Probably from around that time it was also released or escaped into natural waters. Germany imported the species from France as well as from the United States in 1886 (Mather, 1889). Max Von dem Borne received 125 specimens for his hatchery in Berneuchen (Germany). Mather expressed doubt about importing a voracious species, only to be kept in aquaria and not for release into natural waters. Of interest is his mention of an attempt to trans-

fer American pike (*Esox masquinongy*) to Europe. All specimens died during transport; however, the "cyprinids" added to serve as food for underway survived. Were they released or destroyed? In 1881 Von dem Borne imported 500 pumpkinseed for rearing experiments (Von Wengen, 1892; Von dem Borne, 1893; Anon., 1902c). In 1903 there were 50 pumpkinseed in The Netherlands in the Vaassen hatchery (Anon., 1904). Whence they were imported and for what purpose is not known. At a fisheries exhibition they were shown by the Heidemaatschappij and were mentioned in their report with the curious words "As they are aquarium fish we will not further mention them" (Nengerman, 1905).

Occasionally pumpkinseed are caught in our inland waters, mainly in the province of Noord Brabant, e.g. in moorland pools. These fish probably originally entered our waters from Belgium. It seems they are adapted to their new environment. Brouwer (1925a) states that pumpkinseed inhabit canals and rivers in Belgium just south of the province of Noord Brabant (the Kempen).

It is known that the species is common in Lake Lugano (Switzerland). Alessio (1984) reviews the success of the species in Italy.

### 23. *Large-mouth bass* — *Micropterus salmoides* (Lacépède)

It is likely that in an attempt to introduce 18 black bass into The Netherlands in 1884, the fish were in fact large-mouth bass. They all died during transport. The attempt was repeated and 5 so-called black bass were kept in the Amsterdam Zoo Aquarium (Anon., 1886; 1887, 1930; Kerbert, 1889).

Von dem Borne (1888) imported 45 large-mouth bass into Germany from Greenwood Lake near New York. Ten of these fish survived and provided enough fry, as Von dem Borne states "to stock within 10–20 years all suitable German inland waters" — expectations never to be followed by facts. Also in Belgium large-mouth bass were released in natural waters, where they seemed to survive in small numbers (Poll, 1949): specimens caught in the Meuse (Netherlands) probably originate from there. Vooren (1972) quotes the release of large-mouth bass in Belgium around 1900 in the rivers Ourthe and Semois, the only Belgian literature he could find.

### 24. *Small-mouth bass* — *Micropterus dolomieu* Lacépède

In 1883 Von dem Borne (1888) imported 7 small-mouth bass, together with large-mouth bass, from the United States. He stocked these fish at Berneuchen (Germany). In East Germany (GDR) the descendants of these specimens have survived in small numbers (Bauch, 1955); in West Germany (GFR) the species disappeared (Ladiges and Vogt, 1965). Poll (1949) mentions capture of a specimen in Belgium. Mulier (1900) states that the species has

been introduced into The Netherlands. There was some interest around that time (Anon., 1903b,c); however, no factual information could be found. Interesting is the remark by Ladiges and Vogt (1965) that large- and small-mouth bass are often confused, which made their records unreliable. This might explain why Vooren (1972) informs us that small-mouth bass were introduced "with some success" in The Netherlands.

#### 25. Pikeperch — *Stizostedion lucioperca* (Linnaeus)

The pikeperch, native east of the river Elbe (Germany) and in the U.S.S.R., was transferred west of the Elbe at the end of the last century by the Deutsche Fischerei Verein (German Fisheries Association). In 1883 pikeperch was released in the rivers Main and Rhine as well as in Lake Constance. The hatchery of A. von Gostkossky at Tomice near Wadowice in Galicia, the present-day Poland, supplied the fish. In 1884 pikeperch was regularly caught in the German Rhine (Kerbert, 1887). In 1887 a few specimens were kept in the Amsterdam Zoo Aquarium. On 16 January 1888 the pikeperch was caught in Dutch waters in the Rhine near Nijmegen (Kerbert, 1888). In 1897 fish farmers were already discussing the advantages of introducing pikeperch into The Netherlands. For that reason in 1901 the Heidemaatschappij imported 50 000 fertilized eggs from a hatchery at Wittingen (Germany) to be stocked in their hatchery at Vaassen (Anon., 1902a). This was repeated the following year (Anon., 1902a) and in subsequent years. It became an overwhelming success. In 1980, for examples about 133 t of pikeperch was caught in the IJsselmeer with a value of Dfl. 1 125 000. At present pikeperch is the second most important fresh-water species in The Netherlands. It is curious to note that no studies were undertaken to evaluate the effect of releasing this non-indigenous species into the environment. The concept of an "ecosystem" had still not been formulated when the introductions took place.

#### NON-INDIGENOUS FISH SPECIES CONSIDERED FOR INTRODUCTION INTO THE NETHERLANDS

##### 1. *Redbreast sunfish* — *Lepomis auritus* (Linnaeus)

In 1891 Von dem Borne imported the redbreast sunfish from the United States into Germany (Von Wengen, 1892; Von dem Borne, 1893). It is an aquarium species. Bauch (1955) refers to the species, but does not mention whether it can still be found in East Germany. Ladiges and Vogt (1965) do not mention any occurrence in West Germany. However, they mention the green sunfish, *Lepomis cyanellus* (Rafinesque), locally common near Frankfurt/Main. In The Netherlands the introduction of the redbreast sunfish was only discussed (Mulier, 1900; Anon., 1902b).

## 2. *Rock bass* — *Ambloplites rupestris* (*Rafinesque*)

The rock bass was introduced into Germany (Berneuchen) in 1887 from the United States (Von dem Borne, 1880c; Von Wengen, 1892). Of the 20 specimens imported, 12 were still alive in 1889 and spawned with success. Nevertheless, the species has now disappeared from German inland waters. However, an introduction of this species into the United Kingdom was successful. In a lake in Oxfordshire the rock bass can still be found today (Wheeler, 1969). The introduction of the species into The Netherlands was only discussed in the literature (Mulier, 1900; Anon., 1902c).

## 3. *Lake trout* — *Salvelinus namaycush* (*Walbaum*)

Between 1881 and 1885 about 220 000 fertilized eggs were imported from the United States into France, Germany, the United Kingdom and Switzerland (Von dem Borne, 1890a). In Switzerland and Denmark the species can still be found at the present day. In The Netherlands only Mulier (1900) referred to the possibilities of the lake trout.

## 4. *Black crappie* — *Pomoxis nigromaculatus* (*Le Sueur*)

In 1887 the black crappie was introduced into France by A. Berthoule. The original 23 specimens produced 500 offspring in 1888 and the following years several thousands were kept. In France the species became a pest locally. From France the species was exported to Germany, but in The Netherlands introduction was only discussed (Von dem Borne, 1890d; Anon., 1902d; Brouwer, 1925a).

## 5. *Bowfin* — *Amia calva* *Linnaeus*

Von dem Borne imported 2 specimens of the bowfin into Germany in 1891. They spawned in captivity. The introduction of this species in The Netherlands was only discussed (Von Wengen, 1892; Mulier, 1900).

## DISCUSSION

When reviewing the introductions and transfers that took place in The Netherlands from the end of the last century until today, it is notable that most activities in this field were around the turn of the century. Most of the 27 species which could be traced were released, deliberately or accidentally, and a few just entered our waters. Nearly all introduced fish were true freshwater species (23), the others were anadromous (4). The continents of origin were Europe (12), North America (11), Asia (3), and South America (1). Five North American species were considered for introduction. The aims of all these activities were the restocking of declining populations of commercially important species, introducing new species as substitutes

for the former category, establishing new fisheries or for culture. The culture served to produce fish for consumption, ornament and game.

*(a) Restocking declining populations*

At the end of the nineteenth century the once important freshwater fisheries, mostly those on the large rivers forming the Rhine—Meuse estuary, were declining rapidly. The decline in catches of salmon and allis shad became the reason for great concern, but so did the declining catches of far less important species such as sea trout, and the coregonids, houting and powan. An unimportant species, the grayling, hardly a lowland fish, was also disappearing. The reason for the decline of these species must be found in the rapidly changing abiotic conditions as a result of hydro-engineering, what is currently known as pollution. It was not understood at that time that the living conditions of these salmonids (5) and clupeid (1) were affected (Hoek, 1891). The changes were caused by building numerous barrages, sluice systems to improve shipping on the rivers, dredging away the gravel of the spawning beds, increasing of turbidity, various chemical pollutants, changes in oxygen content and/or temperature. In the early days of this century major studies were undertaken to explain the decline of the river fisheries but, as we now see it, attention was focussed on marginal effects and a great number of biotic factors, e.g. reduced fecundity (Anon., 1916). Therefore the idea arose that mass releases of fertilized eggs or juvenile stages would counteract the negative effects (Table I). This was unsuccessful in all cases for the salmonids. Restocking the waters with eggs of the allis shad was abandoned after a few experiments, remarkable only for historical reasons; in fact on a mass scale it was never tried, but would have had the same result. Redeke (1938) gave as a possible explanation for the disappearance of the allis shad, hybridization with the twaite shad, *Alosa fallax* (Lacépède). Hence the reason for its disappearance would be neither pollution nor overfishing. This might explain its disappearance from clean rivers, for example in France (Rameye et al., 1976). The introduction of grayling on a very limited scale in 1980 was of no importance, as the fish was unable to spawn in its new habitat. If environmental conditions are not too bad, they will live their natural life and will disappear when restocking is abandoned for financial or other reasons. To place much emphasis nowadays on observations of an odd salmon, houting, powan or grayling is, in fact, misleading. In the present situation these species have no chance of a comeback in numbers as in the past.

*(b) Introduction of species to replace declining stocks*

When at the end of the last century the Dutch river fisheries were on the decline, it was thought that substitutes for the affected indigenous salmonids could be found. The salmonid species selected were the chinook

salmon and the lake whitefish, both originating from North America. They were released as fertilized eggs or in juvenile stages. It was hoped that they would acclimatize fully. However, they never did, but disappeared for the same reasons as did the species they were intended to replace.

*(c) Introduction of new species for inland fisheries*

Large- and small-mouth bass were introduced for a short time at the end of the last century. However, the trials were on an unimpressive scale, and it was understood even at an early stage that nothing could be gained. Going through the literature of introductions one cannot get rid of the idea that a considerable amount of money and energy was wasted by just imitating what was being done in other countries, before it was even proved a success in those countries. A quite different result was obtained with the transfer in Germany of pikeperch from one river system to another. The watershed between the rivers flowing to the Baltic and those flowing to the North Sea forms an insurmountable barrier to the westward spread of the species. Just by transferring the species to the waters west of the river Elbe, a vast area of expansion for the pikeperch was opened up. The abiotic and biotic factors were hardly if at all different. The spread of the species to The Netherlands was just a matter of time as there were no natural boundaries. In fact it took just 5 years before the pikeperch was found in Dutch waters. By introducing juvenile stages the spread of the species in the country was only accelerated. The pikeperch became the second really successful introduction, following the carp which had already been imported in mediaeval times.

*(d) Introductions for commercial culture*

*Fish for consumption*

The most successful introduction into The Netherlands and elsewhere in the past was the carp. The introductions in the nineteenth and twentieth centuries were in fact only subraces and varieties of a well established species, which can be considered as a domestic animal. The carp is hardly a consumption fish at present and mostly serves angling purposes.

The introduction of a variety of the tench is comparable with that of the carp. The tench is an indigenous species. It is not known quite what motives lay behind the release of this species into lakes and ponds at the beginning of the century. There is no activity in this field any more.

The Netherlands did not escape the world-wide spread of the rainbow trout. Fry production depends on hatcheries. The fish are either reared for consumption or released into ponds and lakes for angling. With a production of about 300 t/year the species leads the Dutch small aquacultural production.

For the sake of completeness it should be mentioned that at present

in The Netherlands the African catfish, *Clarias gariepinus* (Burchell), is cultured in heated water and hothouses for sale to restaurants. Fry production is possible only in hatcheries, and the temperature needed for the survival of this species is much higher than that of our natural waters in the winter time. Thus it is unlikely that many specimens will survive outside their culture environment. The species is comparable to other kept and reared exotic animals.

#### *Ornamental fish*

The golden ide and presumably also the black and brown bullhead are examples of non-indigenous species deliberately introduced and released in natural waters. When the fashion wore out of stocking ponds with the colourful variety of the ide, large-scale cultivation came to a halt. The success of these species for stocking ponds and lakes, and for keeping in aquaria, must have been minimal. The species were "forgotten" and came to inhabit waters of the provinces Noord Brabant, Limburg and Zuid Holland. Locally the species may be considered as common. There is no commercial or recreational interest in them.

Other ornamental fish such as the guppy and the pumpkinseed were accidentally released into natural waters. Guppies which have the luck to find heated effluents will survive, others will disappear. The pumpkinseed seems to have acclimatized locally, although many observations may concern specimens which have migrated from bordering countries into our waters.

#### *Game fish*

For recreational purposes (angling) and for management of inland waters (e.g. regulating the numbers of cyprinids or the growth of weed) a number of non-indigenous species have been introduced. For angling these were rainbow trout, brook charr (perhaps also at one time the arctic charr), grayling and carp. It is questionable whether the release of carp concerned a true indigenous species. However, the true non-indigenous rainbow trout was released in large numbers in natural waters and it became a regular practice to restock inland waters with them. The brook charr and grayling are just incidental releases of very local interest. Although the idea of releasing Hungarian wels into our natural waters was that they should control the numbers of cyprinids because the pike population was on the decline due to overfishing by anglers (the use of a dredge as hook was in many cases fatal to the caught pike), it was also hoped that the wels might be a good fish for angling. However, conservation of the indigenous relic populations which had survived the ice ages was thought to be more important than the benefit of regulating the number of cyprinids by a large piscivorous species. Hence the experiments were abandoned. Nevertheless, a number of hatchery products managed to escape during the experimental period into our natural waters. They may well acclimatize fully in their new surroundings. This is far more unlikely with the grass carp, now re-

leased in large numbers to control weed growth in a number of waters. They will never spawn, and will die out when the releases are stopped. The introduction of grass carp in combination with silver carp, a form of polyculture practised in Eastern Europe, has been discontinued after a few experiments. Occasionally specimens of the silver carp still stray into our waters from bordering countries. As with the grass carp, the likelihood that they will spawn with success is very small.

#### *Accidentally introduced or released species*

Several non-indigenous species have reached or were accidentally released into our waters. Examples are the coho salmon, eastern mudminnow, silver carp, bighead carp, asp, wels, guppy, pumpkinseed and large-mouth bass. Only one of these species was very successful in its new habitat, the eastern mudminnow. To some extent the pumpkinseed survives, but in small numbers. Guppy is only successful in effluents or ponds with warmed waste water; outside such habitats it is unable to survive in winter. Wels which have escaped from hatcheries in neighbouring countries may settle in their new surroundings if in sufficient numbers. The other observed species, coho salmon, silver carp, bighead carp, asp and large-mouth bass, occur in our waters only as rare individual specimens with little impact.

#### CONCLUSIONS

Summarizing and concluding, it can be stated that the extensive and prolonged attempts to restock our inland waters with various salmonids attractive for fisheries, and of which the natural stocks were on the decline, never met with any success or even observable impact. The changing environmental conditions were not recognized at that time. For the same reason attempts to replace the vanishing salmonids with non-indigenous species with similar characteristics (chinook, lake whitefish) also failed. As a substitute, inland waters are today stocked with rainbow trout on a regular basis as they do not spawn in the waters into which they are released. They serve only for game fishing. It might be a profitable enterprise to supply the fish.

The most successful introduction was the pikeperch which has become a valuable species for inland fisheries. The success may be attributed to the fact that only geographical barriers limited the natural distribution of this species: when released into a new habitat, with all the characteristics of its native habitat, it was able to flourish.

It is notable that the other non-indigenous species fully acclimatized in our waters (all from North America) have little or no value or use. These species are the eastern mudminnow, black bullhead, brown bullhead and pumpkinseed. It is likely that their native habitat hardly differs from the present one.

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