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INTRODUCED FISH SPECIES IN POLAND: PROS AND CONS

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"... one fact remains certain: only few species are generally accepted as having been beneficial introductions ..." (Holčik, 1991)

A B S T R A C T. The paper reviews the history of introductions, the occurrence of exotic fishes in inland waters of Poland, and costs and benefits of introductions. 23 exotic fish species occur permanently or seasonally in natural water bodies (rivers, lakes), which constitutes about 30 % of the whole Polish ichthyofauna. In the absolute majority of introductions a negative influence of exotic species has been recorded, both on the native fish communities and aquatic environment. The introductions of merely a few species (rainbow trout, carp, herbivorous fishes) can be regarded as fully successful as only in their case the increase in fish production obatined was considerable (mainly in aquaculture).

Key words: POLAND, FRESHWATER ICHTHYOFAUNA, NATIVE, EXOTIC SPECIES

1. INTRODUCTION

The current freshwater ichthyofauna of Poland comprises 79 fish and lamprey species (Tab.1) (Witkowski 1992, 1995), of which, 23 species have been introduced accidentally or deliberately. Intense introductions occured during past 30 years; as many as 15 exotic species have newly appeared, constituting 65.2% of all the introduced species in Poland to date.

As in other regions of the world (Welcomme 1988), introductions of exotic species into Polish waters were for: aquaculture, sport, improvement of wild stock, control of unwanted organisms, and, finally, some were introduced accidentally.

In this paper, the history of the occurrence of the exotic and the costs and benefits of introductions will be reviewed.

TABLE 1

List of Polish freshwater lamprey and fish (according to Witkowski 1996)
(N - native species, I - introduced)

PETROMYZONIDAE:	
Petromyzon marinus L.	N
Eudontomyzon mariae Berg	N
Lampetra fluviatilis (L.)	N
Lampetra planeri (Bloch)	N
ACIPENSERIDAE:	
Acipenser sturio L.	N
Huso huso (L.) x *Acipenser ruthenus* L.	I
ANGUILLIDAE:	
Anguilla anguilla (L.)	N
SALMONIDAE:	
Salmo salar L.	N
Salmo trutta m. trutta L.	N
Salmo trutta m. lacustris L.	N
Salmo trutta m. fario L.	N
Oncorhynchus gorbuscha (Walb.)	I
Oncorhynchus mykiss (Walb.)	I
Salvelinus fontinalis Mitch.	I
Hucho hucho (L.)	N
COREGONIDAE:	
Coregonus albula (L.)	N
Coregonus lavaretus L.	N
Coregonus peled Gmel.	I
Coregonus muksun (Pall.)	I
THYMALLIDAE:	
Thymallus thymallus (L.)	N
Thymallus arcticus baicalensis (Dyb.)	I
OSMERIDAE:	
Osmerus eperlanus (L.)	N
UMBRIDAE:	
Umbra krameri Walb.	I
Umbra pygmaea De Key	I
ESOCIDAE:	
Esox lucius L.	N
CYPRINIDAE:	
Rutilus rutilus (L.)	N
Leuciscus leuciscus (L.)	N
Leuciscus cephalus (L.)	N
Leuciscus idus (L.)	N
Phoxinus phoxinus (L.)	N
Moroco percnurus (Pall.)	N

Scardinius erythrophthlamus (L.)	N
Ctenopharyngodon idella (Val.)	I
Leucaspius delineatus (Heck.)	N
Aspius aspius (L.)	N
Alburnoides bipunctatus (Bloch)	N
Alburnus alburnus (L.)	N
Abramis brama (L.)	N
Blicca bjoerkna (L.)	N
Abramis ballerus (L.)	N
Abramis sapa Pall.	N
Chondrostoma nasus (L.)	N
Vimba vimba (L.)	N
Pelecus cultratus (L.)	N
Tinca tinca (L.)	N
Rhodeus sericeus amarus (Bloch)	N
Pseudorasbora parva Schl.	I
Gobio kessleri Dyb.	N
Gobio albipinnatus Luk.	N
Gobio gobio (L.)	N
Barbus barbus (L.)	N
Barbus meridionalis petenyi (Heck.)	N
Barbus cyclolepis waleckii Rolik	N
Carassius carassius (L.)	N
Carassius auratus gibelio (Bloch)	I
Cyprinus carpio L.	I
Hypophthalmichthys molitrix (Val.)	I
Aristichthys nobilis (Rich.)	I
CATOSTOMIDAE:	
Ictiobus niger Raf.	I
HOMALOPTERIDAE:	
Orthrias barbatulus (L.)	N
COBITIDAE:	
Misgurnus fossilis (L.)	N
Cobitis taenia L.	N
Sabanejewia aurata (De Fil.)	N
SILURIDAE:	
Silurus glanis L.	N
CLARIDAE:	
Clarias gariepinus Bursch.	I
ICTALURIDAE:	
Ictalurus nebulosus (LeSuer)	I
GADIDAE:	
Lota lota (L.)	N
GASTEROSTEIDAE:	

Pungitius pungitius (L.)	N
Gasterosteus aculeatus L.	N
ELEOTRIDAE:	
Percottus glehni Dyb.	I
GOBIIDAE:	
Neogobius gymnotrachelus Kessl.	I
COTTIDAE:	
Cottus gobio L.	N
Cottus poecilopus Heck.	N
CENTRARCHIDAE:	
Micropterus salmoides Lecep.	I
Lepomis gibbosus (L.)	I
PERCIDAE:	
Perca fluviatilis L.	N
Gymnocephalus cernuus (L.)	N
Stizostedion lucioperca (L.)	N
CICHLIDAE:	
Oreochromis niloticus (L.)	I

2. HISTORY OF INTRODUCTIONS

Deliberate introductions of exotic species in Polish waters can be divided into three temporal periods. The first introductions occured as early as the medieval ages, the second wave took place during the end of the last century and beginning of the present century, the last period includeds the second half of our century (Tab. 2).

The carp (*Cyprinus carpio*) was the first exotic species to be introduced into Polish waters. At present it is difficult to say exactly when and from where it was introduced. Probably the Cistersian monks brought it from the Czech area in the 12th or 13th c. (Balon 1974). Historical records of that period mention its farming in monastery ponds (Rudziński 1963).

During the next 600? years there were no further attempts to enrich the native ichthyofauna. At the end of 19th c. angling and fishery organizations started to advertise and intensely introduce mainly North American fish species - sterlet (*Acipenser ruthenus*), rainbow trout (*Oncorhynchus mykiss*), chinook salmon (*O. tshawytscha*), brook trout (*Salvelinus fontinalis*), Arctic charr (*S. alpinus*), brown bullhead (*Ictalurus nebulosus*), largemouth bass (*Micropterus salmoides*). The main purpose of these introductions was to make the angling grounds more attractive (sport). Fortunately, most of those species proved unable to compete with the native ones, and when the stocking

TABLE 2

Period of introductions of fishes into Polish waters

Year	Species
1100 - 1200 ?	*Cyprinus carpio* L.
1881 - 1889	*Oncorhynchus mykiss* Rich.
1885	*Ictalurus nebulosus* (Le Sueur)
1890	*Salvelinus fontinalis* Mitch.
1912 ?	*Micropterus salmoides* Lecep.
1921, 1967	*Umbra krameri*
1927	*Lepomis gibbosus* (L.)
1930 - 1933	*Carassius auratus gibelio* (Bloch)
1964	*Ctenopharyngodon idella* Val.
1965	*Hypophthalmichthys molitrix* Val.
	Aristichthys nobilis (Rich.)
1966	*Coregonus peled* Gmelin
1973	*Thymallus arcticus baicalensis* Dyb.
1973 - 1975	*Oncorhynchus gorbuscha* (Walb.)
	Huso huso (L.) x *Acipenser ruthenus* L.
1984	*Coregonus muksun* (Pall.)
1989	*Ictiobus niger* Raf.
1990	*Clarias gariepinus* Bursch.
	Pseudorasbora parva (Schl.)
1993	*Percottus glehni* Dyb.
1994	*Oreochromis niloticus* (L.)
1995	*Umbra pygmaea* De Key
	Neogobius gymnotrachelus (Kessl.)

ceased, they disappeared or their occurrence became limited to local populations. Only some of these introduced species survived in natural waters tody, e.g. brook trout (*S. fontinalis*) in the Tatra Mts. lakes, or brown bullhead (*I. nebulosus*) in lowland rivers and some eutrophic lakes.

Between the wars, only three accidentally introduced species (European mudminnow - *Umbra krameri*, sunfish - *Lepomis gibbosus*, German carp - *Carassius auratus gibelio*) found their way to Polish waters. Their presence was probably associated with the import of stock material, mainly carp, from adjacent countries.

Since the beginning of the 1960s an increase in the number of exotic species in Poland has been observed. Increased water eutrophication (mainly lakes) prompted an

introduction of three Chinese herbivorous fishes (grass carp - *Ctenopharyngodon idella*, silver carp - *Hypophthalmichthys molitrix*, bighead - *Aristichthys nobilis*) and two coregonids (peled - *Coregonus peled*, muksun - *C. muksun*). In order to make the heated waters from power plants for aquaculture, another three species were introduced (black buffalo - *Ictiobus niger*, catfish - *Clarias gariepinus*, Nile tilapia - *Oreochromis niloticus*). During that last period a further seven species have appeared. These were introduced accidentally: they have been brought in with other introduced fishes (eg. stone moroco - *Pseudorasbora parva*), or penetrated through canals or natural river systems from the neighboring countries (eg. Baikal grayling - *Thymallus arcticus baicalensis*, pink salmon - *Oncorhynchus gorbuscha*, bester - *Huso huso* x *Acipenser ruthenus*, goad goby - *Neogobius gymnotrachelus*) or were released by aquarists (eg. *Percottus glehni*, eastern mudminnow - *Umbra pygmaea*) (Witkowski 1989).

3. OCCURRENCE OF EXOTIC SPECIES IN OPEN WATERS

Holčik (1991) reports that till the end of the 1980s as many as 134 fish and lamprey species were introduced in Europe (including 74 exotic). Regretfully Poland with its 23 species, occupies the 4th position.

Most introduced fishes escaped from fish farms to invade open waters, such as rivers, lakes or dam reservoirs. The zoogeographic integrity coefficient (Bianco 1990) for the freshwater ichthyofauna of Poland amounts to 0.71 which means that nearly 30% species are alien components of the ichthyofauna. The lowest values of this coefficient are observed in the western (upper and mid Odra River basin), southern (upper Vistula R. basin) and eastern (Bug R. basin) parts of Poland. This is associated with the presence of numerous fish farms in those areas; they often import stocking material (carp and salmonids) from other countries. In the remaining hydrographic regions natural or only slightly changed ichthyofaunistic communities have been preserved (Fig.1). Among the 65 largest rivers of Poland analyzed the following have the most numerous exotic species: Barycz and Bug R. (8 each), Nysa Kłodzka, Nida, Tanew, Warta R. (5 each), Dunajec, Bystrzyca Lubelska and Wieprz R. (4 each) (Fig. 2) (Witkowski 1996).

Of the 23 exotic species, the following are most frequent in the Polish rivers: German carp (*C. auratus gibelio*) - 52.3% rivers, carp (*C. carpio*) - 50.8%, brown bullhead (*I. nebulosus*) - 21.5%, rainbow trout (*O. mykiss*) - 20.0%, huchen (*Hucho hucho*) - 9.2%, bro-

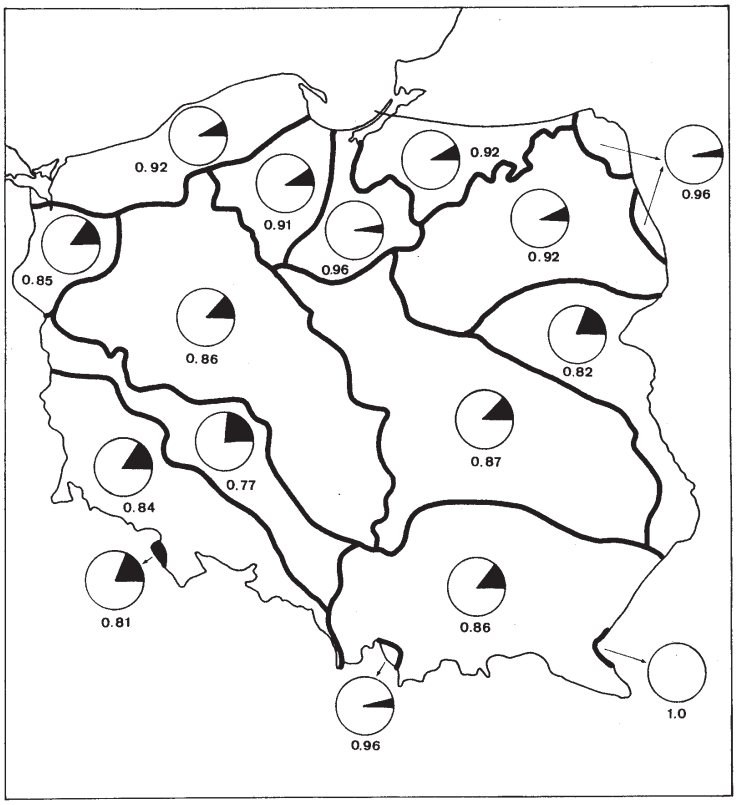

Fig. 1. Zoogeographic integrity coefficient *(ZIC)* for the Polish freshwater ichthyofauna in different river basins. Pie diagrams represent relative frequencies of native (open sectors) and exotic (solid sectors) fishes

ok trout (*S. fontinalis*) and grass carp (*C. idella*) - 6.1% each. The lakes were quickly invaded by the peled (*C. peled*), since according to recent data (Mamcarz 1992) it occurs already in c. 150 lakes, while stone moroco *(P. parva)* is found in most pond fish farms keeping native lowland fish species and carp.

4. PROS AND CONS OF INTRODUCTIONS

The introductions in Poland make one reflect on whether the gains compensate for the losses. Those that went out of control in most cases exerted an unfavourable effect on both the native ichthyofauna and on the aquatic environment.

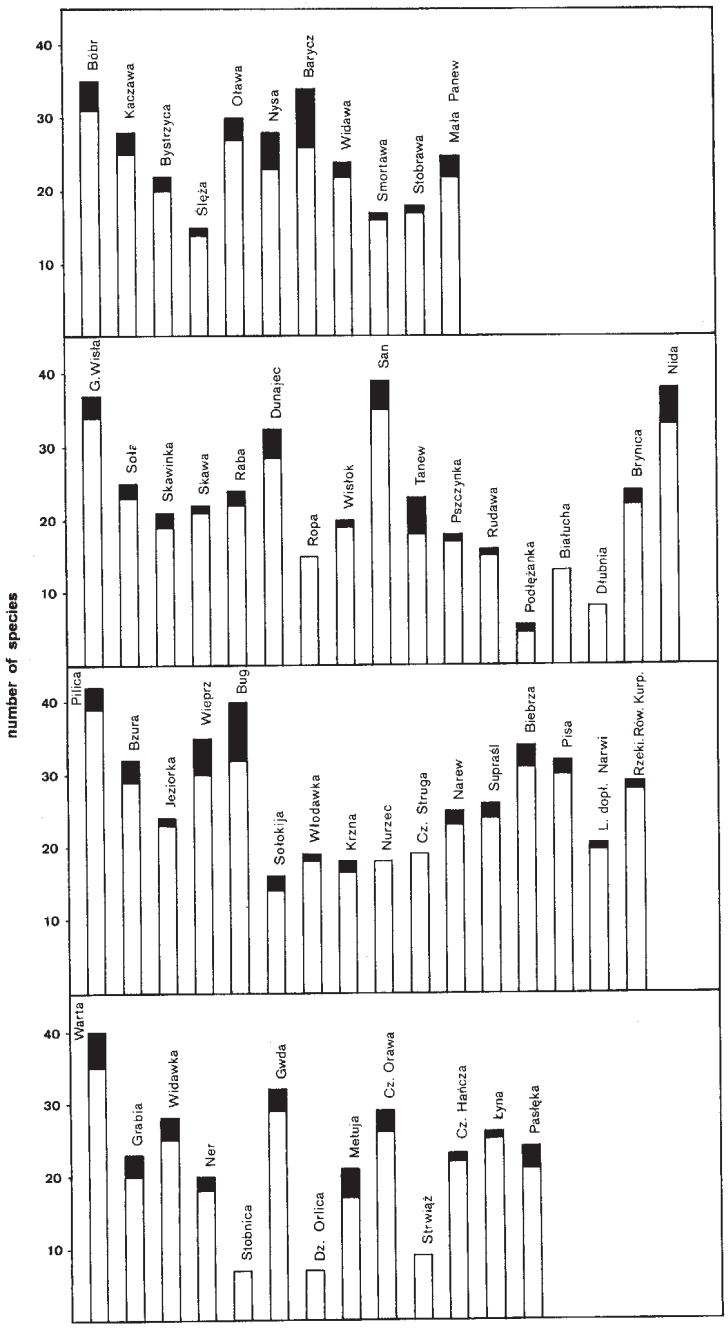

Fig. 2. Number of native (white bars) and exotic (black bars) species in larger Polish rivers

The brook trout (*S. fontinalis*) introduced in the Tatra Mt. lakes (the most valuable Polish national park!) has out competed the native brown trout (*Salmo trutta m. fario*). In addition, it caused an array of deleterius changes in the native fauna of planktonic crustaceans (Dawidowicz and Gliwicz 1983) and caused the disappearance of a relict phyllopod (*Branchinecta paludosa*) (Smagowicz and Dyduch 1980). In many mountain rivers, the brook trout cross-bred with the brown trout (*S. trutta*) resulting in infertile hybrids, and thus eventually decreased in abundance.

The large scale farming of the rainbow trout (*O. mykiss*), both in fish farms and lake cages, resulted in a rapid degradation of the aquatic habitats. It was noted that on considerable river sections many fish species receded as a result of increased pollution load (metabolites and remnants of food) and decreased oxygen concentration in water. In lakes eutrophication took place. In lakes and rivers a rapid receding of native steoecious species was observed (Backiel 1978, Korzeniowski and Sałata 1982, Korzeniowski et al. 1982).

The introduction of the peled (*C. peled*) in lakes where native coregonids occurred resulted in their mass hybridization. Mamcarz (1986, 1992) reports that in as many as 70% Polish lakes it is difficult to find genetically pure forms of native coregonids.

The introduction of herbivorous fishes, mainly grass carp (*C. idella*) in lake ecosystems caused a distinct decrease in catches of such native species as pikeperch (*Stizostedion lucioperca*), pike (*Esox lucius*), tench (*Tinca tinca*), bream (*Abramis brama*), roach (*Rutilus rutilus*), perch *(Perca fluviatilis*) (Mastyński et al. 1987, Wilkońska 1988). Grass carp consumes plants (submerged and emerged) and thus, destroys the spawning grounds, places for fry growth and feeding grounds of adult fishes. In addition, in lakes stocked with the grass carp (*C. idella*) a distinct impoverishment of bird community was noted, especially a decrease in abundance of such species as coot (*Fulica atra*) and swan (*Cygnus* sp.), that feed on submerged (soft) vegetation (Krzywosz et al. 1980, Radziej and Krzywosz 1979).

The German carp (*C. auratus gibelio*), reproducing in Poland only through gynogenesis, led to disturbances in the spawning of native phytophilous species and thus to a decrease in their abundance (Witkowski 1989).

The brown bullhead (*I. nebulosus*) introduced in lakes and small reservoirs soon became dominant species, since it ate both the eggs anf fry of the native species (Adamczyk 1975, Danilkiewicz 1973). In the Polish literature there are no exact data on the role of other introduced species (*Lepomis gibbosus*, *Pseudorasbora parva*, *Percottus glehni*, *Neogobius gymnotrachelus*, *Umbra pygmaea*, *U. krameri*). Probably, like in other

parts of Europe where they were introduced, they compete for food with many native fish species, both in open waters and in fish farms (Holčik 1991).

Parasites were introduced in the Polish waters along with their hosts - exotic species: *Bothriocephalus acheilognathi* (= *gowkongensis*), *Khavia sinensis* and *Basanistes huchonis*. The two tapeworm species proved to be especially dangerous to the native cyprinids and carp (Pańczyk and Żelezny 1974).

Introductions of only a few fish species (*O. mykiss*, *C. carpio*, *C. idella*, *H. molitrix*, *A. nobilis*), destinated mostly for aquaculture, can be regarded as fully successful. Only in those cases there was a significant increase in fish production. The production of rainbow trout in Poland has increased from 1 700 tons in 1980 to 3 100 tons in 1987, and finally to 4 750 tons in 1994 (Bontemps 1995). The carp production increases have been observed: in 1984 - 16 800 tons, in 1994 - 24 500 tons, which constitutes over 90% of fish production in ponds, while the production of herbivorous fishes at the beginning of the 1980s amounted to 450 tons per year (Szczerbowski 1985). The production of introduced coregonids is still low and amounts to 24-35 tons per year.

In conclusion, the majority of introductions of exotic species into Polish water bodies have resulted equivocally. Potential gains may not fully compensate the losses to the native ichthyofauna and the aquatic habitats. In terms of productivity of a few species in aquaculture a positive effect has been noted. The situation in natural water bodies, where introduced species escaped control, is more complicated. Here the losses, though possible to observe, are not always easy to estimate on the basis of a broad ecological analysis.

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STRESZCZENIE

INTRODUKOWANE RYBY W POLSKICH WODACH: ZA I PRZECIW

Od średniowiecza do chwili obecnej do śródlądowych wód Polski próbowano introdukować ponad 30 gatunków ryb. Aktualnie na terenie Polski występują stale lub okresowo aż 23 obce gatunki, co stanowi prawie 30 % naszej ichtiofauny (indeks naturalności polskiej ichtiofauny *(ZIC)* = 0.71). Największe nasilenie introdukcji (celowych i przypadkowych) nastąpiło w okresie ostatnich trzydziestu lat, podczas których wprowadzono aż 15 gatunków. W zdecydowanej większości przypadków odnotowano niekorzystne oddziaływanie introdukowanych ryb na rodzime zespoły ichtiofauny oraz środowisko wodne. Tylko introdukcje zaledwie kilku gatunków (pstrąg tęczowy, karp, ryby roślinożerne) można uznać za udane bowiem w ich przypadku i tylko w akwakulturze uzyskano znaczący przyrost produkcji ryb.

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