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An overview of nonindigenous fishes in inland waters of Russia

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Within historical time, native fish communities have undergone significant and adverse changes. These changes generally tend toward reduced distribution, lowered diversity, and increased numbers of species considered rare. At the same time, many species expand their ranges due to different reasons and by different means. Dispersal of nonindigenous species, including fish, is one of the most important issues in natural resource management and conservation biology today.

Humans have massively modified fish habitats through transformations of natural drainages and creation of new aquatic connections, construction of dams, reservoirs, domestic, agricultural, and industrial water withdrawing, flood protection, and pollution. Creation of new biotopes (e.g. reservoirs with lake conditions instead of river sections) and channels linking formerly isolated drainages is the main cause for "natural" dispersal of many species beyond their native ranges. In many cases, reasons of range expansion are not quite clear, but most probably are also caused by human activities in controlling or modifying the flow or degrading the quality of natural waters. Physical and chemical changes in fish habitats are not the only factors that impact fish communities. Throughout history, humans have transported and released fishes from one ecosystem to another for various purposes (food, sport, biological control, aquarium, esthetics). One of the first documented records in Russia is that of the introduction of *Acipenser ruthenus marsiglii,* Siberian sterlet, in the Neva River in 1763. In the USSR, transfers began on a large scale in the 1920s. In 1961-1971, there had been a dramatic increase in the numbers of fishes introduced due to the practice of acclimatizations: there had been up to 400 translocations into up to 370 water bodies each year (Karpevich, 1998). Although these introductions were often done with the best of intentions, they have subjected native fish species to new competitors, predators or other agents they were unable to withstand. In the former USSR and Russia, main attention has been devoted to document those aspects of the practice of acclimatization that provide economic and social benefits – possible or real – to humans. A large number of references can be found in summarizing publications by Karpevich (1998) and Kudersky (2001).

However, until now, the literature lacks a comprehensive review of all nonindigenous fishes in Russia that identifies introduced populations, assesses their status, and attempts to analyze their impacts.

This report provides a brief overview of non-indigenous freshwater fish species in inland waters of Russia in order to classify them with respect to their status and means of dispersal.

Fresh waters of Russia are inhabited by 365 species (379 in total, with still undescribed species and species of doubtful status) from 148 genera, 38 families, and 14 orders (Bogutskaya *et al*., 2001; URL: www.zin.ru/animalia/pisces). We have analyzed the ranges of all these species mainly based on records from wide literature (see Bogutskaya & Naseka, 2002 about the bibliographic database "Freshwater fishes of Russia") as well as on some personal field observations. To our data, the number of species recorded outside their historical ranges is at least 115.

Terminology and definitions reflect different aspects of the phenomenon: a species' geographic range, reproductive status, population size changes, dispersal rates, sources and ways of introductions. However there is no common agreement on most terms used in Russian. In general, terminology connected with fish ranges expansion is better developed in English (see, e. g., Fuller *et al.*, 1999), but Russian equivalents are absent for many terms. We try to find some consensus on the base of our understanding of the phenomenon. The definitions are given below.

Species in nonnative range, or "nonindigenous" ("*неаборигенный*" in Russian): an individual, group or population of species that is found in an area or ecosystem outside its historic, or native, geographic range because of known direct or indirect human actions or because of unknown reason supposedly caused by human activities. This is the most general term. In this report, the term is used synonymously with "alien" and "nonnative" ("*чужеродный*"). Nonindigenous species are grouped:

1) with respect to the donor-area into:

"foreign" (For): an organism moved from a foreign country; a species native to an area outside of the national geographic area under discussion (syn. "exotic"); this group in Russia includes at least 26 species, which are mostly objects of aquaculture (species from the genera *Aristichthys*, *Ictiobus*, *Clarias*, *Ictalurus*, *Tilapia*, *Oreochromis*, and others);

"transplant" (T): an organism moved outside its native geographic range but within a country where it occurs naturally; this group includes at least 91 species (over 100 units if infraspecific taxa and ecological morphs are taken into account);

2) with respect to the means of a species' dispersal into an area outside its native range:

"introduced" ("*интродуцент*", "*акклиматизант*"): an individual or population of organisms that occur in a particular locality because of direct human actions; a species moved by humans, either deliberately or accidentally, from an area where it is native, to another area outside its native distribution;

"invasive" ("*инвазионный вид*", "*вселенец*"): an individual, population or species expanding their distribution in a nonnative area due to different reasons often, but not exclusively, caused by indirect human activities; an invasive species may be first an introduced one or a source of invasion may be mixed including both a native range and an area of introduction.

The term "range expansion" is applicable to the following categories of events: 1) "introduction" ("*интродукция*"), and 2) "invasion" ("*инвазия*") which can be divided into "natural dispersal" and "rapid range expansion".

"Introduction": an event when an organism is moved by humans (or by direct human actions), intentionally or unintentionally, to an ecosystem or region where it was not found historically. Types of intentional introductions (means of introduction) include aquaculture and aquarium release.

"Aquaculture", or intentional stocking. First, a type of stocking involving a fish kept in captive conditions (CC) such as a research facility, hatchery, fish farm, ornamental farm, zoological park (stocking at fish farms in ponds and fishing-cribs is called "pond and industrial pisciculture" in Russia); captive conditions (in contrast to open water) mean the existence of boundaries or control preventing any permanent, temporary or intermittent water connection with other aquatic systems; controlled conditions obviously do not mean "escape-proof". Second, a type of introduction involving a fish intentionally released by humans into open water (OW), usually performed for such purposes as sport, commercial harvest, forage provision or biological control (stocking at fish farms with further releases into open waters for a purpose of commercial harvest is called "pasturing pisciculture" in Russia); open water includes all natural or artificial water bodies considered to have water connection to other aquatic systems.

"Aquarium release" (AR): a type of intentional introduction whereby a captive or pet fish is released into open waters by an aquarium-fish hobbyist.

Types of unintentional introductions:

"escape" (Esc): a type of unintentional introduction whereby a fish escapes into open waters from captive conditions;

"unintentional release" (UR): a type of unintentional introduction whereby an unwanted fish (a contaminant) is incidentally released into open waters together with organisms intentionally introduced.

"Invasion": an event when an organism is dispersed to an ecosystem or region where it was not found historically by natural means rather than by

direct human actions. With respect to intensity and extensity, invasion can be classified as "dispersal" (D), a type of relatively slow range expansion commonly caused by transformations of hydrographic pattern, and "rapid expansion" (RExp), a type of a fast invasion within large drainages of species able to compete with native fishes for common food resources and to expand their ranges into new habitats.

Both "introduction" and "invasion" are roughly divided into "local" and "large-scaled" ones. Sometimes, commonly in case of rare or a few records of probably non-indigenous species, it is not known with certainty what are the means of introduction, pathways or results of invasion ("?" in the Table 1).

A nonindigenous species in a new area can be characterized with respect to biological results of introduction and/or invasion as:

"failed" (F) (unsuccessfully introduced, "*не натурализовавшийся*"): a nonindigenous species that has failed to established a self-sustaining or reproducing population;

"temporarily established" (TEst): a nonindigenous species which had had one or more reproducing populations (self-sustaining populations) in open waters during a more or less long period but then extirpated in its non-native distribution;

"established" ("*натурализовавшийся*"): a nonindigenous species that has one or more reproducing populations ("locally established", LEst, and "widely established", WEst).

Characteristics of the nonindigenous freshwater fishes of Russia are summarized in Table.

Source, means and results of introductions and invasions of the nonindigenous freshwater fishes of Russia (abbreviations are given above in the text)

Taxon	source	means	results
Petromyzontidae			
Caspiomyzon wagneri (Kessler, 1870)	T	OW	F
**Eudontomyzon mariae* (Berg, 1931)	?T	?D	?LEst
Acipenseridae			
Acipenser baerii Brandt, 1869	T	CC, OW	F
A. gueldenstaedtii Brandt et Ratzeburg, 1833	T	CC, OW	F
A. mikadoi (Hilgendorf, 1892)	T	OW	F
A. ruthenus Linnaeus, 1758	T	CC, OW	LEst
A. stellatus Pallas, 1771	T	CC	F
Huso huso (Linnaeus, 1758)	T	CC, OW	F
Polyodontidae			
Polyodon spathula (Walbaum, 1792)	For	CC, OW	F

Table. Continued

Taxon	source	means	results
Anguillidae			
Anguilla anguilla (Linnaeus, 1758)	T	OW, D	F
Clupeidae			
Alosa caspia (Eichwald, 1838)	T	D	LEst
A. sapidissima (Wilson, 1811)	For	OW	F
Clupeonella cultriventris (Nordmann, 1840)	T	RExp	WEst
Cyprinidae			
Abbottina rivularis (Basilewsky, 1855)	T	?UR	LEst
Abramis brama (Linnaeus, 1758)	T	OW, RExp	WEst
A. sapa (Pallas, 1814)	T	D	LEst
Acanthorhodeus asmussii (Dybowski, 1872)	T	?UR	LEst
A. chankaensis (Dybowski, 1872)	T	?UR	LEst
Alburnus chalcoides (Guldenstadt, 1772)	T	OW, D	LEst
Aristichthys nobilis (Richardson, 1845)	For	CC, OW	F
Aspius aspius (Linnaeus, 1758)	T	D	LEst
Barbus brachycephalus Kessler, 1872	T	OW	F
B. ciscaucasicus Kessler, 1877	T	D	LEst
Carassius auratus (Linnaeus, 1758)	?For	CC, ?OW	?
C. carassius (Linnaeus, 1758)	T	OW	LEst
C. gibelio (Bloch, 1782)	T	CC, OW, RExp	WEst
Ctenopharyngodon idella (Valenciennes, 1844)	T	CC, OW	F
Culter alburnus Basilewsky, 1855	T	?OW	LEst
Cyprinus carpio Linnaeus, 1758	T	CC,OW,Esc	WEst
Hemibarbus maculatus Bleeker, 1871	T	?UR	LEst
Hypophthalmichthys molitrix (Valenciennes, 1844)	T	CC, OW	F
Leuciscus idus (Linnaeus, 1758)	T	CC, OW	TEst
L. waleckii (Dybowski, 1869)	T	?	LEst
Mylopharyngodon piceus (Richardson, 1846)	T	CC, OW	F
Ochetobius elongatus (Kner, 1867)	For	OW	F
Opsariichthys uncirostris (Temminck et Schlegel, 1846)	T	?	LEst
Parabramis pekinensis (Basilewsky, 1855)	T	CC	F
Pelecus cultratus (Linnaeus, 1758)	T	D	LEst
Phoxinus perenurus (Pallas, 1814)	T	UR, D	LEst
Pseudorasbora parva (Temminck et Schlegel, 1846)	T	UR, RExp	WEst
Rhodeus amarus (Bloch, 1782)	T	RExp	WEst
Romanogobio pentatrichus Naseka et Bogutskaya, 1998	T	D	LEst

Table. Continued

Taxon	source	means	results
Rutilus frisii (Nordmann, 1840)	T	OW	LEst
R. rutilus (Linnaeus, 1758)	T	OW, D	LEst
Scardinius erythrophthalmus (Linnaeus, 1758)	T	D	LEst
Varicorhinus capoeta (Guldenstadt, 1773)	For	OW	F
Vimba vimba (Linnaeus, 1758)	T	OW, D	LEst
Catostomidae			
Catostomus catostomus (Forster, 1773)	T	CC, Esc	F
Ictiobus bubalus (Rafinesque, 1818)	For	CC, OW	F
I. cyprinellus (Valenciennes, 1844)	For	CC, OW	F
I. niger (Rafinesque, 1820)	For	CC, OW	F
Balitoridae			
Lefua costata (Kessler, 1876)	T	UR	LEst
Siluridae			
Parasilurus asotus (Linnaeus, 1758)	T	OW, RExp	WEst
Silurus glanis Linnaeus, 1758	T	OW	LEst
S. soldatovi Nikolsky et Soin, 1948	T	OW	LEst
Pelteobagrus fulvidraco (Richardson, 1846)	T	?UR	LEst
Ictaluridae			
Ictalurus punctatus (Rafinesque, 1818)	For	CC, Esc	LEst
***Ameiurus nebulosus* (Lesueur, 1819)	For	?	?
Clariidae			
Clarias gariepinus (Burchell, 1822)	For	CC	F
Esocidae			
Esox lucius Linnaeus, 1758	T	OW	WEst
E. reichertii Dybowski, 1869	T	OW	LEst
Osmeridae			
Osmerus eperlanus (Linnaeus, 1758)	T	RExp	WEst
Plecoglossidae			
Plecoglossus altivelis Temminck et Schlegel, 1846	For	OW	F
Coregonidae			
Coregonus albula (Linnaeus, 1758)	T	OW, RExp	WEst
C. 'baerii' Kessler, 1864	T	OW	F
C. 'baunti' Muchomedijarov, 1948	T	OW	F
C. 'ludoga' Berg, 1916	T	OW	TEst
C. 'maraenoides' Berg, 1916	T	OW	WEst
C. pidschian (Gmelin, 1789)	T	OW	F
C. migratorius (Georgi, 1775)	T	OW	LEst

Table. Continued

Taxon	source	means	results
C. muksun (Pallas, 1814)	T	CC, OW	F
C. nasus (Pallas, 1776)	T	CC, OW	F
C. peled (Gmelin, 1789)	T	CC, OW	LEst
C. sardinella Valenciennes, 1848	T	OW	F
Stenodus leucichthys (Guldenstadt, 1772)	T	CC, OW	F
Salmonidae			
Hucho taimen (Pallas, 1773)	T	CC	F
Oncorhynchus gorbuscha (Walbaum, 1792)	T	OW, RExp	?WEst
O. keta (Walbaum, 1792)	T	OW	F
O. kisutch (Walbaum, 1792)	T	CC, OW	F
O. nerka (Walbaum, 1792)	T	OW	F
O. tschawytscha (Walbaum, 1792)	T	OW	F
Parasalmo mykiss (Walbaum, 1792)	T	CC, OW, Esc	LEst
Salmo salar Linnaeus, 1758	T	OW	F
S. trutta Linnaeus, 1758	T	CC, OW	F
S. ezenami Berg, 1948	T	OW	LEst
S. ischchan Kessler, 1877	For	OW	F
Salvelinus fontinalis (Mitchill, 1814)	For	CC, Esc	LEst
S. lepechini (Gmelin, 1789)	T	OW	F
Thymallidae			
Thymallus baicalensis Dybowski, 1874	T	OW	?
Th. brevipinnis Svetovidov, 1931	T	OW	?
Oryziidae			
Oryzias sinensis Chen, Uwa et Chu, 1989	For	OW, RExp	WEst
Poeciliidae			
Gambusia holbrooki Girard, 1859	For	OW, RExp	WEst
Poecilia reticulata Peters, 1859	For	AR	LEst
Gasterosteidae			
Pungitius platygaster (Kessler, 1859)	T	RExp	WEst
P. pungitius (Linnaeus, 1758)	T	RExp	WEst
Syngnathidae			
Syngnathus abaster Risso, 1826	T	RExp	WEst
Centrarchidae			
***Lepomis gibbosus* (Linnaeus, 1758)	For	?	?
Micropterus salmoides (Lacepede, 1802)	For	OW	TEst
Moronidae			
Morone saxatilis (Walbaum, 1792)	For	OW	LEst

Table. Continued

Taxon	source	means	results
Percidae			
Perca fluviatilis Linnaeus, 1758	T	OW, RExp	WEst
Sander lucioperca (Linnaeus, 1758)	T	OW, RExp	WEst
S. volgensis (Gmelin, 1789)	T	RExp	WEst
Cichlidae			
Oreochromis aureus (Steingachner, 1864)	For	CC, Esc	?F
O. mossambicus (Peters, 1852)	For	CC, Esc	?F
O. niloticus (Linnaeus, 1758)	For	CC, Esc	F
O. urolepis (Norman, 1922)	For	CC, Esc	?F
Tilapia zillii (Gervais, 1848)	For	CC	F
Odontobutidae			
Perccottus glenii Dybowski, 1877	T	AR, UR, RExp	WEst
Gobiidae			
Benthophilus stellatus (Sauvage, 1874)	T	D	LEst
B. leobergi Berg, 1949	T	UR, RExp	WEst
Knipowitschia caucasica (Berg, 1916)	T	D	LEst
K. longecaudata (Kessler, 1877)	T	D	LEst
Neogobius gorlap Iljin, 1949	T	D	LEst
N. gymnotrachelus (Kessler, 1857)	T	D	LEst
N. melanostomus (Pallas, 1814)	T	RExp	WEst
Proterorhinus marmoratus (Pallas, 1814)	T	RExp	WEst
Belontiidae			
**Macropodus chinensis* (Bloch, 1790)	?For	?	?
Channidae			
Channa argus (Cantor, 1842)	T	OW	F
Pleuronectidae			
Platichthys flesus (Linnaeus, 1758)	T	OW	F

Note: * – native range is not known with certainty; ** – occurrence of the species in Russia is probable but not reliably confirmed.

Many introductions have been viewed as providing economic and /or social benefits to humans. However, from the beginning of the 1970s, the ideology began gradually to change to considering any introduction or invasion as harmful to natural biological diversity (Vilwock, 1971; Vooren, 1972). Now, the ability of nonindigenous species to alter population and community structure and function is well documented. Ecosystem-level consequences of some invasive species have major ecological and eco-

nomic implications. Sometimes, invasive species are able to spread to and proliferate in new habitats because of their tolerance for a wide range of environmental conditions, much wider than that in their native distribution. They usually also demonstrate diverse diet, aggressive behavior, long spawning period, ability to spawn repeatedly or to markedly increase absolute and relative fecundity, larger body size compared with species of a similar lifestyle. The group of the most harmful species includes *Perccottus glenii, Pseudorasbora parva, Neogobius melanostomus*, *Clupeonella cultriventris, Sander lucioperca,* and *Perca fluviatilis.* Interactions within recipient aquatic communities must be monitored and analyzed before crisis situations arise or to stop the invasion. The most impacted systems are the Kuban and Volga rivers. To our data, the total number of species distributed in or recorded from the Kuban drainage is 85, among them 21 are introduced from outside the drainage. Nine nonnative species are widely spread and established, three are abundant only due to the stocking. Among 64 native Kuban species, 13 are locally spread, markedly declined or extirpated while only three expanded their ranges. In the Volga basin, the total number of species is 102, among them 29 are introduced. 22 non-native species are locally spread, failed or objects of limited intentional stocking. Only 5 species introduced from outside the drainage are more or less widely dispersed and established, and 2 are abundant only due to the stocking. Among 73 native Volga species, 16 are very locally spread, markedly declined or almost extirpated while 11 species expand their ranges.

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