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Fish Introductions in Europe with Particular Reference to its Central and Eastern Part[1]

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At least 134 exotic and/or translocated fish species belonging to 34 families which were introduced to 29 of 33 European countries are documented. These include 35 species of Cyprinidae (introduced to 28 countries), 17 Salmonidae (28), 11 Coregonidae (12), 10 Cichlidae (8), six Centrarchidae (23), five Acipenseridae (8), four Ictaluridae (18), four Poeciliidae (11), four Percidae(9), four Mugilidae (1), three Catostomidae(6), three Castero-steidae (5), two Anguillidae (3), two Atherinidae (2), two Clariidae (4), two Gobiidae (2), two Umbridae (6), two Pleuronectidae (1), two Thymallidae (3) and one species each of Anabantidae (1), Channidae (2), Clupeidae (1), Cobitidae 91), Eleotridae (1), Engraulidae (1), Esocidae (3), Mullidae (1), Osmeridae (1), Percichthyidae (1), Petromyzontidae (1), Polyodontidae (2), Siluridae (5), and Syngnathidae (1). True exotic species amount to 74 species/forms belonging to 21 families, of which 11 families are exotic for Europe. The remaining 60 species (21 families), are native in Europe and were translocated among various watersheds and/or countries. Most species were intentionally released since 1945 to enhance sport, commercial and subsistence fisheries, for fish farming and aquaculture, and for purposes such as mosquito, macrophytes and algal bloom control. Poor success was registered in most cases, along with adverse or unexpected effects on native fishes and their habitat.

Le présent article documente I'introduction dans 29 pays européens sur 33 d'au moins 134 espéces de poissons exotiques ou transplantées appartenant à 34 families différentes, soit 35 espéces de Cyprinidae (introduites dans 28 pays), 17 Salmonidae (28), 11 Coregonidae (12), 10 Cichlidae (8), 6 Centrarchidae (23), 5 Acipenseridae (8), 4 Ictaluridae (18), 4 Poeciliidae (11), 4 Percidae (9), 4 Mugilidae (1), 3 Catostomidae (6), 3 Gasterosteidae (5), 2 Anguillidae (3), 2 Atherinidae (2), 2 Clariidae (4), 2 Gobiidae (2), 2 Umbridae (6), 2 Pleuronectidae (1) 2 Thymallidae (3) et une espece de chacune des families suivantes : Anabantidae (1), Channidae (2), Clupeidae (1), Cobitidae (1), Eleotridae (1), Engraulidae (1), Esocidae (3), Mullidae (1), Osmeridae (1), Percichthyidae (1), Petromyzontidae (1), Polyodontidae (2), Siluridae (5), et Syngnathidae (1). On compte 74 espéces ou formes vraiment exotiques appartenant à 21 families, parmi lesquelles 11 sont exotiques (pour I'Europe). Les 60 autres especes (21 families) sont indigénes et ont été transplantées dans des bassins hydrographiques ou des pays dif-férents. Depuis 1945, la plupart des espéces ont été libérées intentionnel lenient dans le but d'améliorer les pêches sportive, commerciale et de subsistance, pour les besoins de la pisciculture et de l'Aquiculture et pour d'autres raisons, comme la lutte contre les moustiques, les macrophytes et les proliférations d'algues. Outre le peu de succés obtenu dans la plupart des cas, on a observé des effets néfastes ou imprévus sur les poissons indigénes et leur habitat.

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Introductions and/or translocation of fish in Europe may be traced back to the beginning of first century A.D., when some species of fish, mostly marine, but also freshwater, were held in *piscinae* by the Romans (Balon 1969). The common carp, *Cyprinus carpio,* seems to have been the first freshwater species transferred from its native range, first to Rome and then to other countries in Europe (Balon 1974). With expanding Christianity, the construction of ponds became a necessity and nearly all the more important monasteries or parishes kept fish transferred from neighbouring streams. Later, the nobility also followed this custom and during the Renaissance fish farming became a widespread fashion throughout Europe. The idea of transferring fish from other continents probably also arose during Renaissance times. However, large-scale introductions of fish species into areas outside of their native range is a comparatively recent phenomenon and the majority of fish translocations date from the second half of the last century.

Recently, Welcomme (1981, 1988) compiled lists of international transfers of inland fish species and provided an analysis of trends, motives, risks and evaluation of introductions, globally. In this review, I wish to describe the situation in Europe, especially in Central and Eastern Europe, which was not so thoroughly covered by Welcomme. Because of limited space, I wish to give only a general account of this subject and the more detailed analysis will be published later.

Definitions

Definitions used in this paper follow those by Karpevich (1975), and Shafland and Lewis (1984). *Introduced* species include any species intentionally or accidentally transported and released by man into an environment outside its original area. *Exotic* is a species not native to a given watershed, but, in this review, I am distinguishing the *true exotic* and the *translocated* species. The latter term has an exclusively political aspect to designate a species which is exotic for a given country or for some watershed inside it, but not in Europe, while the term exotic *sensu stricto,* is used here only for species not native within the mainland and insular Europe. *Acclimatization* is a process of adaptation of an introduced species and their offspring in the new environment. The final phase of acclimatization is *naturalization,* when the introduced species finds a "vacant niche" in a community, which means that it adapts to food, space, spawning grounds, etc., which are not fully exploited by native species in a given water body (Nilsson 1984).

In this paper, the subcontinent of Europe is considered by its generally accepted boundaries: it is separated from Asia by the Ural Mountains, Ural River, and Caspian Sea on the east, and by the depression of the Manych River, Caucasus Mountains, Sea of Azov, the Strait of Kerch, Black Sea, Bosporus, Sea of Marmara, Dardanelles, and the Aegean Sea on the south east. The Caucasus Mountains are excluded from Europe in this definition although included by all Soviet geographers. The island of Cyprus is considered to be a European country in this paper. Turkey is not mentioned as no data exist on its fish introductions and Germany is considered as one country within its present boundaries.

Because of limited space on the one hand and the enormous literature on the other, only a selected list of the most important items is introduced in the list of references. This list is predominantly restricted to the recent monographs dealing with fishes in particular European countries, special reports, compendia and also synthetic papers dealing with fish introductions in Europe. English translations of their titles are added in those cases where the paper under consideration was published in a language other than English, French, German, Spanish or Italian.

The following symbols and/or evaluation of the introduced species are used in Tables 1 and 2:

A = species used in aquaculture with artificial reproduction only. If another symbol is used in conjunction with A it means that species is used and reproduced predominantly in aquaculture;

D = species disappeared;

E = species established in nature in more than 50% of countries;

R = species rare, occurring in nature in less than 50% of countries;

* denotes family exotic for Europe.

Countries are arranged alphabetically and those which introduced particular species first in Europe are printed in italics. The year of first introduction to Europe of a species is also indicated along with the country to which it was first introduced.

Number of Species and Receiving Countries

All species of fish and lampreys known to be the subject of acclimatization experiments in Europe have been summarized (Tables 1 and 2). A total of 134 species were recorded belonging to 34 families, of which 11 are exotic for Europe (Table 3). There are 74 true exotic species belonging to 21 families, while there are 60 translocated species belonging to 21 families.

The most frequent introductions involved cyprinids followed by salmonids and coregonids. These three families include 63 species (30 exotic and 33 native) and share slightly more than 47% of the total number of both exotic and translocated species.

As may be expected, the first introductions were transloca-tions of some native European species among various watersheds and/or countries. As already mentioned, it was the common carp that was introduced step by step southward, westward and also northward from its native river basin, the Danube. This process began very early, most probably between first and fourth century A.D. (Balon 1974) and proceeded very rapidly, as the medieval annals indicate that between the seventh and twelfth centuries mass culturing of this species existed almost throughout Europe (Brylinska et al. 1986). Together with carp, other species certainly were also transferred, among them the crucian carp *{Carassius carassius)* and another cyprinid, *Leucaspius delineatus,* the natural distribution of which was probably limited by the Rhine (Berg 1949). Attempted intentional introductions of other species probably dated back as for as those of carp, however, there are no data on these, possibly because the lower hardiness of these species caused their introductions to fail. Among the few exceptions to this is the medieval introductions of the northern pike *(Esox lucius)* to Ireland (Fitzmaurice 1984) in the thirteenth to fourteenth century as indicated by Welcomme (1988) and also several attempts to introduce the sterlet *(Acipenser ruthenus)* into the Baltic Sea, White Sea, and even the Barents Sea watersheds during the middle of the eighteenth century (Linnaeus 1758; Mohr 1952; Burmakin 1963; Witkowski 1989).

The first attempts to introduce true exotic fish species are not exactly known, but they are certainly older than those performed in the second half of the nineteenth century, when the modern era of introductions began. These introductions all involved North American species, the salmonids, followed by catfishes and centrarchids and also one coregonid species. The first was the brook trout *(Salvelinus fontinalis)* introduced to the United Kingdom in 1869, followed by the chinook salmon *(Oncorhynchus tschawytscha),* the rainbow trout *(Oncorhyn-chus mykiss,* syn. *Salmo gairdneri)* and the lake trout *(Saveli-nus namaycush)* subsequently imported by France and the Netherlands, Germany (Poland), and by Germany and Switzerland, respectively. Two easily confused American catfishes, the black bullhead *(Ictalurus melas)* and the brown bullhead (*I. nebulosus)* and six centrarchids (*Ambloplites rupestris, Lepomis cyanella, L. gibbosa, L. aurita, Micropterus dolom-ieui, M. salmoides)* were also introduced, mostly to Western Europe, up until the end of the nineteenth century.

Since the beginning of the twentieth century, the rate of introductions has increased rapidly. There is, however, some difference between the relative rate of introductions of the native and the true exotic species. By the end of the second World War, the percentage of the native fish introductions was 66.7%, which has since decreased by half to 33.3%. In the case of the introductions of the true exotic species the trend is exactly the opposite, in that the number of species introduced since 1945 has doubled and the initial (pre 1945) rate of 31.0% has increased to 69.0%.

There are records on introductions for 29 of the 33 European countries. Only Andorra, Monaco, San Marino and Vatican are not listed among countries receiving fish species from outside. This does not mean that they did not introduce fish species in the past, but rather that there are no available records for them. It may be that data for these little countries are included in references dealing with their larger neighbours, Spain, France and Italy, respectively. The frequency of introductions of particular species varies considerably. Although the most popular candidates for introductions come from families Salmonidae, Cyprinidae, Centrarchidae, Ictaluridae and Coregonidae, which were imported to and/or translocated in 28, 28, 23, 18, and 12 countries, respectively, the majority of species have only been introduced to a few countries. While there seems to be some correlation between the size of the country and the number of species introduced (Table 4), there are also exceptions showing for instance, that Hungary which is far smaller than Norway (93 032 km^2 versus 323 920 km^2) introduced four times as many fish species (28 versus 7). As expected, the Soviet Union also plays the role of the super power in this respect, as it introduced to, and transferred on its European territory 70 species including 40 exotic and 30 native, i.e. slightly more than half of the total number of fish species received by all other European countries.

TABLE 1. A list of exotic fishes introduced in Europe (including diffusion between countries). For explanation see text.

Species	Year of first introduction	Status	Country
ACIPENSERIDAE			
Acipenser baeri Brandt, 1869	1956	A	France, Hungary, *USSR*
Acipenser fulvescens Rafinesque, 1817	1969	A	USSR
Acipenser transmontenus Richardson, 1836	1987	A	Italy
*POLYODONTIDAE			
Polyodon spathula (Walbaum, 1792)	1974	A	Hungary, *USSR*
ANGUILLIDAE			
Anguilla australis schmidti Phillips, 1925	1975	D	Italy
Anguilla japonica Temminck et Schlegel, 1842	?	A	France, Germany, Italy
CYPRINIDAE			
Aristichthys nobilis Richardson, 1836	1954	A, R	Albania, Austria, Bulgaria, Czecho-Slovakia, France, Germany, Hungary, Italy, Netherlands, Poland, Romania, *USSR*, Yugoslavia
Barbus schwanenfeldi Bleeker, 1853	?	D	Italy
Capoeta capoeta sevangi Filippi, 1865	1950s	D	USSR
Catla catla (Hamilton-Buchanan, 1822)	1966	A	USSR
Cirrhinus mrigala (Hamilton-Buchanan, 1822)	1966	A	USSR
Ctenopharyngodon idella (Cuvier et Valenciennes, 1844)	1949	A, R	Albania, Austria, Belgium, Bulgaria, Cyprus, Czecho-Slovakia, Denmark, France, Germany, Greece, Hungary, Italy, Netherlands, Poland, Romania, Sweden, UK, *USSR*, Yugoslavia
Cyprinus carpio haematopterus Temminck et Schlegel, 1842	1947	A, R	Czecho-Slovakia, *USSR*
Hypophthalmichthys molitrix (Valenciennes, 1844)	1953	A, R	Albania, Austria, Belgium, Bulgaria, Cyprus, Czecho-Slovakia, Denmark, France, Germany, Greece, Hungary, Italy, Netherlands, Poland, Romania, Sweden, UK, *USSR*, Yugoslavia
Labeo rohita (Hamilton-Buchanan, 1822)	1966	A	USSR
Megalobrama terminalis (Richardson, 1845)	1963	D	Albania, *Hungary*, Yugoslavia
Mylopharyngodon piceus (Richardson, 1845)	1963	A	Albania, Czecho-Slovakia, Germany, *Hungary*, Romania, USSR
Parabramis pekinensis (Basilewski, 1855)	1963	D	Hungary
Pimephales promelas Rafinesque, 1820	1983	E	*Belgium*, France, Germany
Pseudorasbora parva (Schlegel, 1842)	1960	E	Albania, Austria, Bulgaria, Czecho-Slovakia, Germany, Hungary, *Romania*, USSR, Yugoslavia
*CATOSTOMIDAE			
Ictiobus bubalus (Rafinesque, 1812)	1971	A	Romania, *USSR*
Ictiobus cyprinella (Cuvier et Valenciennes, 1844)	1971	A	Czecho-Slovakia, Bulgaria, Hungary, Romania, *USSR*
Ictiobus niger (Rafinesque, 1819)	1971	A	Bulgaria, Czecho-Slovakia, Hungary, Poland, Romania, *USSR*
*ICTALURIDAE			
Ictalurus melas (Rafinesque, 1820)	1871	E	Belgium, *France*, Hungary, Ireland (?), Italy, Netherlands, Norway, Switzerland, Spain, UK
Ictalurus natalis (LeSueur, 1819)	1906	E	Italy
Ictalurus nebulosus (LeSueur, 1819)	1885	E	Austria, Czecho-Slovakia, Finland, France, *Germany*, Hungary, Ireland (?), Italy, Netherlands, Poland, Romania, Spain, UK, USSR, Yugoslavia
Ictalurus punctatus (Rafinesque, 1818)	1968	A, R	Belgium, Cyprus, Czecho-Slovakia, France, Hungary, Italy, *UK*, USSR, Yugoslavia
*CLARIIDAE			
Clarias batrachus (Linnaeus, 1758)	?	R	UK
Clarias lazera (Valenciennes, 1840) (syn. *Clarias gariepinus* (Burchell, 1842))	1974	A	*Cyprus*, Czecho-Slovakia, Netherlands
UMBRIDAE			
Umbra pygmaea DeKay, 1842	1913	R	Belgium, *France*, Germany, Netherlands
COREGONIDAE			
Coregonus autumnalis migratorius (Georgi, 1775)	1949	D	USSR
Coregonus clupeaformis (Mitchill, 1818)	1881	D	*France*, *Germany*, Italy (?), Netherlands, Switzerland, UK
Coregonus lavaretus baunti Mukhomedyarov, 1948	1953	D	USSR

TABLE 1. (*Continued*)

Species	Year of first introduction	Status	Country
Stenodus leucichthys nelma (Pallas, 1773)	1953	D	USSR
THYMALLIDAE			
Thymallus baicalensis Dybowski, 1874	1959	D	*Czecho-Slovakia*, Poland
SALMONIDAE			
Oncorhynchus clarki (Richardson, 1836) (syn. *Salmo clarki*)	1960s	A,R	Cyprus, Denmark, Sweden
Oncorhynchus gorbuscha (Walbaum, 1792)	1939	D,R	Finland, Ireland, Norway, Poland, UK, *USSR*
Oncorhynchus keta (Walbaum, 1792)	1932	D	Finland, *USSR*
Oncorhynchus kisutch (Walbaum, 1792)	1971	D	Cyprus, *France*, Germany, Greece, Italy, Netherlands, Spain, Yugoslavia
Oncorhynchus mykiss (Walbaum, 1792) (syn. *Salmo gairdneri* (Richardson, 1836)	1882	A, R	Albania, Austria, Belgium, Bulgaria, Cyprus, Czecho-Slovakia, Denmark, Finland, *France, Germany*, Greece, Hungary, Iceland, Ireland, Italy, Liechtenstein, Luxemburg, Netherlands, Norway, Poland, Portugal, Romania, Spain, Sweden,Switzerland, UK, USSR, Yugoslavia
Oncorhynchus nerka (Walbaum, 1792)	1959	D	Denmark, Finland, *Sweden*
Oncorhynchus rhodurus (Jordan et McGregor, 1925)	1976	D	Germany
Oncorhynchus tschawytscha (Walbaum, 1792)	1877	D	Denmark, Finland, *France*, Germany, Ireland, Italy, *Netherlands*, UK
Salmo ischchan Kessler, 1877	1949	D	USSR
Salvelinus fontinalis Mitchill, 1815	1869	R, A	Austria, Belgium, Bulgaria, Cyprus, Czecho-Slovakia, Denmark, Finland, France, Germany, Greece, Hungary, Italy, Netherlands, Norway, Poland, Romania, Spain, Sweden, Switzerland, *UK*, USSR, Yugoslavia
Salvelinus leucomaenis pluvius (Hilgendorf, 1876)	1977	A, (D?)	Germany
Salvelinus namaycush (Walbaum, 1792)	1888	R	Czecho-Slovakia, Denmark, Finland, France, Italy, *Germany*, Spain, Sweden, *Switzerland*, UK
*POECILIIDAE			
Gambusia affinis (Baird et Girard, 1853)	1921	E	France, Greece, Hungary, Italy, *Portugal*, Romania, *Spain*, USSR, Yugoslavia
Poecilia reticulata (Peters, 1859)	1963	R	Czecho-Slovakia, Hungary, Italy, Netherlands, UK
Poecilia sphenops Valenciennes, 1846	?	R	Czecho-Slovakia, Hungary
Xiphophorus helleri Heckel, 1848	?	R	Czecho-Slovakia, Hungary
ATHERINIDAE			
Odontesthes bonariensis (Valenciennes, 1853)	1970	R	Italy
*PERCICHTHYIDAE			
Morone saxatilis (Walbaum, 1792)	1965	D	USSR
*CENTRARCHIDAE			
Ambloplites rupestris (Rafinesque, 1817)	1930	E	France, *UK*
Lepomis aurita (Linnaeus, 1758)	1895	E	*Germany*, Italy
Lepomis cyanella Rafinesque, 1819	?	R	Germany
Lepomis gibbosa (Linnaeus, 1758)	1885	E	Austria, Belgium, Bulgaria, Czecho-Slovakia, *France*, Germany, Greece, Hungary, Italy, Netherlands, Poland, Portugal, Romania, Spain, Switzerland, USSR, Yugoslavia
Micropterus dolomieui Lacépède, 1802	1873	R	Austria, Belgium, Czecho-Slovakia, Denmark, *Finland*, France, Germany, Norway, Sweden, UK
Micropterus salmoides (Lacépède, 1802)	1877	R, A	Belgium, Cyprus, Czecho-Slovakia, Denmark, Finland, *France*, Germany, Hungary, Italy, Netherlands, Poland, Portugal, Spain, UK, USSR, Yugoslavia
PERCIDAE			
Stizostedion vitreum (Mitchill, 1818)	1925	D	UK
*CICHLIDAE			
Astronotus ocellatus (Cuvier, 1829)	?	D	Italy
Cichlasoma facetum (Jenyns, 1842)	1940s	R	Portugal
Oreochromis aureus (Steindachner, 1864)	1976	A	*Cyprus*, Czecho-Slovakia, USSR
Oreochromis mossambicus (Peters, 1852)	1962	A, R	Czecho-Slovakia, Malta, UK, *USSR*
Oreochromis niloticus (Linnaeus, 1758)	1957	A	Belgium, Cyprus, Czecho-Slovakia, *Germany*
Oreochromis urolepis hornorum (Trewavas, 1966)	?	A	Czecho-Slovakia, *USSR*

TABLE 1. (*Concluded*)

Species	Year of first introduction	Status	Country
Sarotherodon melanotheron Rüppell, 1852	?	A	USSR
Tilapia guineensis (Bleeker, 1863)	?	A	USSR
Tilapia mariae (Boulenger, 1899)	?	A	USSR
Tilapia zillii (Gervais, 1853)	1925	A, R	*UK*, USSR
MUGILIDAE			
Mugil soiuy Basilewski, 1855	1972	R	USSR
*ELEOTRIDAE			
Perccottus glehni Dybowski, 1877	1950s	E	USSR
*ANABANTIDAE			
Osphronemus goramy Lacépède, 1802	?	D (?)	Italy
*CHANNIDAE			
Channa argus warpachowskii Berg, 1909	1949	R	Czecho-Slovakia, *USSR*

Motives for Introduction

There are significant differences concerning the motives for the introductions between the true exotic and the native European species. In the first case, the rank of motives is as follows: aquaculture, including experimental (30.6%), accident (21.0), unknown reasons (15.5), improvement of the wild stock[3] (14.7), sport (9.1), biomanipulation[4] (7.1) and ornament (2.0). In the second group, translocated species, the primary motive for introduction was the improvement of the wild stock (37.6%), followed by unknown reasons (20.8), accident (18.4), sport (12.0), aquaculture (7.2) and ornament (4.0). The motives for introductions vary from country to country. In the USSR, for instance, most species, both exotic and native, were introduced or translocated to improve the wild stock and aquaculture is secondary, while in other countries aquaculture predominates followed then by sport. There are also considerable differences in the approach of some countries to the same species. The brown bullhead, for instance, was introduced for aquaculture by Yugoslavia, Poland and Germany, but for the improvement of the wild stock by Finland and the USSR.

Evaluation of Introductions

Almost all introductions into natural ecosystems made prior to the second World War may be considered to a certain degree as a gamble. The situation improved after the war, as greater awareness of ecology developed and introduction experiments started to be planned on a scientific basis. Here the leading role has been played by the Soviet Union, where the theory and practice of introductions and acclimatization of fish is based on ecological principles (Zenkevich 1940; Dryagin 1954; Bur-makin 1961,1963; Karpevich 1965a, b, 1975; Rass 1965). At the present time, almost all intentional introductions are more or less carefully planned. According to Burmakin (1963) up until 1957, 1 398 water bodies in the USSR (of which 87% were lakes, 7% reservoirs and 6% rivers) were planted with 51 species of freshwater fish belonging to 12 families. However, naturalization of both exotic and translocated species was only attained in 12% of these water bodies. Furthermore, catches of acclimated fish lagged considerably behind the effort exerted for their introductions. From the data presented by Karpevich et al. (1975) and Burmakin and Shimanovskaya (1975), one can calculate that between the periods 1957/1963 and 1964/ 1971 the mean annual number of plantings of exotic fishes rose by 123%, the number of water bodies stocked by 164% and the quantity of fishes (including the eggs, juveniles and adults) introduced by 229%. However, the catch of introduced fishes in the same period increased only by 56% and its percentage share to the total inland fish catch (the most part of which is probably shared by fish from aquaculture) only by 61%. According to the last evaluation of Lifshits and Belousov (1979) only 3% of all introductions released in the USSR up until 1978 gave a commercial benefit.

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[3]*This term is rather vague and in some European countries, like in Czecho-Slovakia, for instance, the term "enrichment of the native fish fauna" is used. According to Welcomme (1988) this term includes establishing new food fisheries, filling a "vacant niche," stocking natural waters, providing forage for predators, restoration of fisheries, establishing a wild stock and the control of stunted species.*

[4]*Including mosquito, macrophytes, algal blooms and forage fish species control.*

TABLE 2. A list of translocated fishes within the Europe (including diffusion between countries).

Species	Year of first introduction	Status	Country
PETROMYZONTIDAE			
Caspiomyzon wagneri (Kessler, 1870)	1968	D	USSR
ACIPENSERIDAE			
Acipenser gueldenstaedti Brandt, 1833	1962	D	Finland, Sweden, *USSR*
Acipenser ruthenus Linnaeus, 1758	1763	R	Finland, France, Germany, Poland, Sweden, *USSR*
CLUPEIDAE			
Clupeonella cultriventris (Nordmann, 1840)	?	E	USSR
ENGRAULIDAE			
Engraulis encrasicholus (Linnaeus, 1758)	1931	D	USSR
CYPRINIDAE			
Abramis ballerus (Linnaeus, 1758)	1957	E	USSR
Abramis bjoerkna (Linnaeus, 1758)	?	R	Cyprus, Italy
Abramis brama (Linnaeus, 1758)	1932	R	Italy, Spain, *USSR*
Alburnus alburnus (Linnaeus, 1758)	?	E	Cyprus, Spain
Aspius aspius (Linnaeus, 1758)	1984	D	Netherlands
Barbus barbus (Linnaeus, 1758)	1956	E	UK
Carassius auratus (Linnaeus, 1758)	?	E	Albania, Austria, Bulgaria, Cyprus, Czecho-Slovakia, Germany, Hungary, Italy, Poland, Portugal, Spain, UK, USSR, Yugoslavia
Carassius carassius (Linnaeus, 1758)	?	E	Belgium, Cyprus, France
Cyprinus carpio Linnaeus, 1758	?	E, A	Albania, Belgium, Cyprus, Czecho- Slovakia, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Liechtenstein, Luxemburg, Malta, Netherlands, Norway, Poland, Portugal, Spain, Sweden, Switzerland, UK, USSR
Gobio gobio (Linnaeus, 1758)	1899	E	*Portugal*, Spain
Leucaspius delineatus (Heckel, 1834)	?	E	Belgium
Leuciscus idus (Linnaeus, 1758)	1874	R	Netherlands, Spain, *UK*
Leuciscus leuciscus (Linnaeus, 1758)	1889	E	Ireland
Leuciscus souffia Risso, 1826	?	D	Spain
Pelecus cultratus (Linnaeus, 1758)	1957	E	USSR
Rhodeus sericeus (Pallas, 1776)	1920s	R	UK
Rutilus frisii kutum (Kamenskii, 1891)	1933	D	USSR
Rutilus rutilus (Linnaeus, 1758)	1889	E	Cyprus, *Ireland*
Scardinius erythrophthalmus (Linnaeus, 1758)	?	R	Spain
Tinca tinca (Linnaeus, 1758)	1600s	E	Finland, *Ireland*, Norway
Vimba vimba (Linnaeus, 1758)	1957	D	USSR
COBITIDAE			
Misgurnus fossilis (Linnaeus, 1758)	?	E	Spain
SILURIDAE			
Silurus glanis (Linnaeus, 1758)	1881	R	Belgium, Cyprus, *Denmark*, Italy, Spain
ESOCIDAE			
Esox lucius (Linnaeus, 1758)	1200s	E	*Ireland*, Portugal, Spain
UMBRIDAE			
Umbra krameri Walbaum, 1792	1925	R	Poland, *UK*
OSMERIDAE			
Osmerus eperlanus (Linnaeus, 1758)	1932	E	USSR
COREGONIDAE			
Coregonus albula (Linnaeus, 1758)	1872	R (D)	Czecho-Slovakia, Hungary, Romania, *USSR*
Coregonus autumnalis autumnalis (Pallas, 1776)	1960	D	Czecho-Slovakia
Coregonus lavaretus (Linnaeus, 1758) *s. lato*	1861	R, A	Belgium, Czecho-Slovakia, Germany, Greece, Hungary, *Italy*, Netherlands, Romania, USSR, Yugoslavia
Coregonus muksun (Pallas, 1814)	1984	D	Poland
Coregonus nasus (Pallas, 1776)	?	R	Belgium, USSR
Coregonus peled Gmelin, 1789	1954	E, A	Czecho-Slovakia, Finland, Germany, Hungary, Poland, *USSR*, Yugoslavia
Stenodus leucichthys leucichthys (Guldenstadt, 1772)	1925	D	USSR
THYMALLIDAE			
Thymallus thymallus (Linnaeus, 1758)	?	R	Italy

TABLE 2. (*Concluded*)

Species	Year of first introduction	Status	Country
SALMONIDAE			
Hucho hucho hucho (Linnaeus, 1758)	1888	R, (D)	Belgium, *Czecho-Slovakia*, France, Poland, Spain, Sweden, Switzerland, UK
Salmo salar Linnaeus, 1758	1866	D	Cyprus, Greece, *Italy*, USSR
Salmo trutta Linnaeus, 1758	1970	R	Cyprus
Salvelinus alpinus (Linnaeus, 1758)	1955	R, (D, A)	Cyprus, *Denmark*, France, Ireland, Italy, Netherlands, Spain, Yugoslavia
Salvelinus salvelinus (Linnaeus, 1758)	1851	R	*Czecho-Slovakia*, France, Yugoslavia
ATHERINIDAE			
Atherina mochon pontica Eichwald, 1831	?	E	USSR
GASTEROSTEIDAE			
Gasterosteus aculeatus Linnaeus, 1758	?	E	Austria, Czecho-Slovakia, Hungary, Italy
Pungitius platygaster (Kessler, 1859)	1981	R	USSR
Pungitius pungitius (Linnaeus, 1758)	?	R	Austria
SYNGNATHIDAE			
Syngnathus nigrolineatus Eichwald, 1831	?	E	USSR
PERCIDAE			
Gymnocephalus cernuus (Linnaeus, 1758)	1982	E	UK
Perca fluviatilis Linnaeus, 1758	1971	E	Cyprus
Stizostedion lucioperca (Linnaeus, 1758)	?	E	Czecho-Slovakia, Denmark, France, Germany, Italy, Netherlands, UK, USSR
MULLIDAE			
Mullus barbatus ponticus Essipov, 1927	1931	D	USSR
MUGILIDAE			
Liza aurata (Risso, 1810)	1930	E	USSR
Liza saliens (Riso, 1810)	1930	E	USSR
Mugil cephalus Linnaeus, 1758	1930	E	USSR
GOBIIDAE			
Neogobius fluviatilis (Pallas, 1811)	1970	E	Hungary
Neogobius melanostomus (Pallas, 1811)	?	E	USSR
PLEURONECTIDAE			
Platichthys flesus luscus (Pallas, 1811)	1902	D	USSR
Scophthalmus maeoticus (Pallas, 1811)	1930	D	USSR

The discrepancy between the effort and result of introduction is explained mainly by the lack of biological justification, insufficient analysis and generalization of experience obtained, by the slow development of the theory of acclimatization and by shortcomings in the actual practice and organization of the introductions (Karpevich et al. 1975; Lifshits and Belousov 1979).

There are, however, some examples of successful introductions. Three species of mullets (Mugilidae), viz. *Liza aurata, L. saliens* and *Mugil cephalus,* which were transferred from the Black Sea to the Caspian Sea in 1930, fully acclimated and naturalized there and now constitute commercially important species, not only in the USSR, but also in Iran. Attempts to introduce the peled whitefish *(Coregonus peled)* were also successful in lakes, impoundments and for aquaculture in the European part of the USSR, and in Czecho-Slovakia, Poland and Germany. These are, however, rather the exceptions and most attempts to establish some exotic species in nature have failed. Thus, the naturalization of the grass carp (*Ctenopharyngodon idella)* and the silver carp *(Hypophthalmichthys molitrix)* was successful only in two rivers in the European USSR, the Kuban' and the Volga (Motenkov 1966; Kazancheev 1981), in the Terek River flowing from Caucasus Mountains (Abdusamadov 1986), and, probably also in the Tisza River in Hungary (Toth and Biro 1984), although many attempts were made to acclimatize them, especially in the USSR. The release of coregonids into reservoirs of the USSR has not been successful (Berka 1990) and the members of this family naturalized only as rare exceptions. Moreover, several introductions of the Pacific salmons such as *Oncorhynchus keta* and *O. gorbuscha* in the Barents Sea and even in the Caspian Sea made by the USSR since early 30's, almost completely failed, as well as did earlier experiments with *O. kisutch, O. nerka* and *O. tschawytscha* conducted by Western European countries including the United Kingdom, France, Denmark, Italy, Sweden, Germany and Yugoslavia.

Of three species of sturgeons, *Acipenser ruthenus, A. baeri,* and *A. gueldenstaedti,* introduced mainly by the USSR into the Baltic Sea watershed, none became established and only the introduction of the sterlet into the Pechora (Barents Sea) and Western Dvina (White Sea) proved successful. Most attempts to introduce the rainbow trout and the brook trout into natural water bodies failed and these species established only rarely in nature. Some species are therefore maintained only, or predominantly in aquaculture facilities. This is the case for the rainbow trout, as well

as all the three major Chinese herbivorous carps. These species are widely used throughout the Central and Eastern Europe in fishery farms and form some contribution to the aquaculture output of the Soviet Union, Romania, Germany, Hungary, Poland and Czecho-Slovakia. Even several tilapine cichlids have become aquaculture subjects during recent years in the Soviet Union, Czecho-Slovakia and even Belgium, where they are reared mainly in the heated power station cooling waters and sold occasionally in markets.

TABLE 3. List of families, number of species, and number of receiving countries. Asterisk denotes family exotic for Europe. Arrangement of families according to decreasing number of species.

Family	Number of species (exotic/translocated)	Number of countries	Family	Number of species (exotic/translocated)	Number of countries
Cyprinidae	35 (14/21)	28	Umbridae	2 (1/1)	6
Salmonidae	17 (12/5)	28	Pleuronectidae	2 (–/2)	1
Coregonidae	11 (4/7)	12	*Anabantidae	1 (1/–)	1
*Cichlidae	10 (10/–)	8	*Channidae	1 (1/–)	2
*Centrarchidae	6 (6/–)	23	Clupeidae	1 (–/1)	1
Acipenseridae	5 (3/2)	8	*Eleotridae	1 (1/–)	1
*Poeciliidae	4 (4/–)	11	Engraulidae	1 (–/1)	1
Percidae	4 (1/3)	9	Esocidae	1 (–/1)	3
Mugilidae	4 (1/3)	1	Mullidae	1 (–/1)	1
*Ictaluridae	4 (4/–)	18	Osmeridae	1 (–/1)	1
*Catostomidae	3 (3/–)	6	*Percichthyidae	1 (1/–)	1
Gasterosteidae	3 (–/3)	5	Petromyzontidae	1 (–/1)	1
Anguillidae	2 (2/–)	3	*Polyodontidae	1 (1/–)	2
Atherinidae	2 (1/1)	2	Siluridae	1 (–/1)	6
*Clariidae	2 (2/–)	4	Syngnathidae	1 (–/1)	1
Gobiidae	2 (–/2)	2			
Thymallidae	2 (1/1)	3			

TABLE 4. List of countries, their area (A, km^2) and the number of species (n) they received. Number of exotic (numerator) and translocated (denominator) species is also shown.

Country	A	n	Country	A	n
USSR	5 443 900	70 (40/30)	Denmark	43 075	13 (9/4)
Italy	301 262	38 (26/12)	Austria	83 853	12 (9/3)
Czecho-Slovakia	127 889	36 (24/12)	Greece	131 944	11 (7/4)
Germany	356 330	29 (23/6)	Ireland	70 282	11 (6/5)
France	543 965	28 (21/7)	Sweden	449 964	11 (7/4)
Hungary	93 032	28 (22/6)	Bulgaria	110 912	10 (9/1)
UK	244 737	26 (17/9)	Portugal	91 631	9 (5/4)
Cyprus	9 351	22 (12/10)	Albania	28 748	9 (7/2)
Netherlands	41 160	21 (14/7)	Switzerland	41 293	8 (6/2)
Spain	504 783	20 (8/12)	Norway	323 920	7 (5/2)
Belgium	30 521	19 (12/7)	Luxemburg	2 586	2 (1/1)
Poland	312 683	18 (11/7)	Liechtenstein	157	2 (1/1)
Yugoslavia	255 804	18 (13/5)	Malta	316	2 (1/1)
Romania	237 500	15 (13/2)	Iceland	102 829	1 (1/1)
Finland	337 032	13 (18/5)			

Risks of Introductions

In addition to the lack of apparent benefits, there are also cases of adverse or unexpected effects arising from introductions. For instance, it was observed that in both natural and man-made lakes, and in large channels stocked with grass carp the species composition of both macrophytes and phytoplank-ton changed dramatically, and the total catch of fish declined significantly (Vinogradov and Zolotova 1974; Kogan 1974; Radziej and Krzywosz 1979;Krzywosz et al. 1980). Long-term observations made in one Danubian locality in Slovakia also revealed changes in the physical and chemical properties of the water (Holčík et al. 1985). The combined effect of these phenomena, initiated by the introduction of the grass carp, caused the density and biomass of fishes to decrease, in particular, those species (pike, common carp) whose reproduction invariably needs aquatic plants (Holcik et al. 1985). The rapid increase of the German carp *(Carassius auratus)* population, which invaded the lower and middle

Danube in the late sixties and at the beginning of the seventies, is connected with the decrease of more valuable fish species, especially the common carp (Holčík 1980). Among the unexpected events, belongs the case of the exceptionally fast upstream invasion of the accidentally introduced Chinese cyprinid, *Pseudorasbora parva.* This species was discovered in one fish farm facility in Romania in 1960, but during next 24 years it was found in all the Danubian countries. Moreover, as a result of the stocking of other fish, especially the carp, it was also transferred to Germany, Albania and the USSR (Lithuania). It forms dense populations in some water bodies and it is blamed for strong food competition with other species and even for predation on their eggs and juveniles (Wohlgemuth and Sebela 1987). Pike *(Esox lucius)* and zander *(Stizostedion lucioperca)* introduced into Ireland and England are blamed for the eradication of salmonids and for the substantial decrease of some cyprinids (Fitzmaurice 1984; Linfield 1984). Nearly all North American centrarchids and ictalurids introduced to Europe are considered as pests and are blamed for predation on the eggs and young of native fish species. In some water bodies occupied by *Lepomis gibbosa* or by *Ictalurus nebulosus,* the native fish species were suppressed and their density decreased (Balon 1966; Adamczyk 1975; Danilkiewicz 1973). Introduction of the peled whitefish *(Cor-egonus peled)* led to hybridization with the native *Coregonus lavaretus* to such an extent that in 70% examined lakes in Poland, and in most fishery farms in Czecho-Slovakia, only the hybrids occur. It is suspected that because of this, some strains of *Coregonus lavaretus,* for example *C. lavaretus maraena,* probably do not occur more in their homeland (Holcik et al. 1989; Whitkowski 1989).

Introduction of diseases and parasites is also a problem intimately connected with introduction of fishes. Several new species of parasites have spread into Europe as a consequence of fish transfers. The parasite fauna of Central Europe has increased, especially after the introduction of East Asian herbivorous carps, which — apart from their specific parasites — also carried several parasites which have affected the native fishes. For instance, these include the tapeworms *Bothrioce-phalus acheilognathi* (syn. *B. gowkongensis)* and *Khavia sinensis* which have become widely distributed in the fish farms of Hungary, Poland, Czecho-Slovakia and the USSR and are now the most significant pathogens in carp stocks (Žitňan 1974; Bauer 1975; Molnár 1984).

Conclusions

In conclusions, it may be stated that introductions of exotic species to Europe have brought controversial results. While there is no doubt as to the positive influence of some introduced fishes in aquaculture, the situation is much more complicated in natural water bodies. Although there is a vast amount of literature, especially in the USSR, dealing with the introduction of exotics into natural waters, there is a lack of any serious, impartial and generally valid evaluation of introduction experiments based on thorough ecological analysis. Moreover, a vast amount of data and information concerning introductions are of variable value. For instance, one is unable to judge whether any increased catch of fish in some water bodies is due to introductions or due to changes in fishing effort (Holcfk 1984). In addition, there are indications that the success of acclimatization experiments is often exaggerated, in that the actual results do not correspond with those which are proclaimed (Holcfk 1984), and that there are also serious shortcomings and adverse effects (Markevich 1978; Myagkov 1990), which are usually not published. However, one fact remains certain: only few species are generally accepted as having been beneficial introductions. From native species there is a common carp, and in some countries also the zander, and one or two coregonids. From the exotic species it is the rainbow trout which received a good reputation everywhere, along with Chinese herbivorous carps.

As a result of the dangers and risks caused by introductions, many European countries have introduced measures to control them. However, it is essential that unified regulations are developed, as at present they differ among countries. It is recommended, therefore, to accept the Code of Practice adopted by the European Inland Fishery Advisory Commission in 1987 as the most useful tool for the regulation and international control of fish introductions.

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References[5]

ABDUSAMADOV, A. S. 1986. Biologiya belogo amura *Ctenopharyngodon idella* (Val.), belogo tolstolobika *Hypophthalmichthys molitrix* (Val.) i pëstrogo tolstolobika *Aristichthys nobilis* (Rich.) akklimatizirovanykh v Terskom raione Kaspiiskogo basseina [Biology of the grass carp, silver carp and bighead carp in the Terek region of the Caspian basin]. Vopr. Ikhtiol. 26: 425–433.

ADAMCZYK, L. H. 1975. Sumik karlowaty, *Ictalurus nebulosus* (LeSueur), 1819 w biocenozie jeziora [Brown bullhead in the ecosystem of a lake]. Przegl. Zool. 19: 71–73.

*ALLARDI, J. 1984. Introduction et acclimatation de poissons d'eau douce en France; historique et bilan. EIFAC Tech. Pap. 42 (Suppl. Vol. 2): 427–447.

*ALMAÇA, C. 1986. Fish and their environment in large European river ecosystems Tejo and Guadiana. Sci. de l'eau 7: 3–19.

*ANDRUSHAITIS, G. P. 1966. Acclimatization of fish in the inland water bodies of Latvia, p. 143–144. *In* A. I. Yanushevich [ed.] Acclimatization of animals in the U.S.S.R. Izd. Akademii Nauk Kazakhskoi SSR, Alma-Ata 1963. Israel Programme for scientific Translations, Jerusalem.

*ANONYMOUS. 1970. Fish introductions. Recent introductions. FAO Fish. Cult. Bull. 2 (2): 17.

*AZBELEV, V. V., AND S. S. SURKOV. 1966. An experiment in acclimatization of pink salmon and chum salmon in the Barents and White Seas, p. 142–143. *In* A. I. Yanushevich [ed.] Acclimatization of animals in the U.S.S.R. Izd. Akademii Nauk Kazakhskoi SSR, Alma-Ata 1963. Israel Programme for Scientific Translations, Jerusalem.

*BACALBASA-DOBROVICI, N. 1984. Introduction de nouvelles espèces de poissons dans les pêcheries d'eau douce de la Roumanie. EIFAC Tech. Pap. 42 (Suppl. Vol. 2): 458–465.

*BACALBASA-DOBROVICI, N., P. BĂNĂRESCU, J. HOLČÍK, R. JANISCH, D. JANKOVIĆ, C. KEIZ, AND E. WEBER. 1984. Das Vorkommen einzelner Fischarten im Donaustrom und Ueberschwemmungsgebiet im Jahre 1983 (Vorläufige Mitteilung). 24. Arbeitstagung der IAD, Szentendre (Ungarn) 1984: 149–156.

BALON, E. K. 1966. Ryby Slovenska [Fishes of Slovakia]. Obzor, Bratislava. 413 p.

1969. Studies on the wild carp *Cyprinus carpio carpio* Linnaeus, 1758. I. New opinions concerning the origin of the carp. Práce Laboratória rybárstva 2: 99–120.

1974. Domestication of the carp *Cyprinus carpio* L. Toronto, Royal Ontario Museum, Life Science Misc. Publ. 37 p.

*BALON, E. K., S. S. CRAWFORD, AND A. LELEK. 1986. Fish communities of the upper Danube River (Germany, Austria) prior to the new Rhein–Main–Donau connection. Environ. Biol. Fish. 15: 243–271.

*BĂNĂRESCU, P. 1964. Pisces-Osteichthyes. Fauna Republicii Populare Romine 13. Editura Acad. Republ. Pop. Romine, Bucuresti. 959 p.

*BAUCH, G. 1966. Die einheimischen Süsswasserfische. Neumann-Verlag, Radebeul. 200 p.

BAUER, O. N. 1975. Rasprostranenie zabolevanii i parazitov ryb pri akklimatizatsionnykh meropriyatiakh (Distribution of diseases and parasites of fishes during acclimatization measures). Izv. GosNIORKh 103: 71–78.

*BERDICHEVSKII, L. S., A. F. KARPEVICH, AND I. E. LOKSHINA. 1968. Itogi i effektivnost' akklimatizatsii ryb i bespozvonochnykh v vodoemakh SSSR za 15 let [Results and efficiency of fish and invertebrates acclimatization in the water bodies of the USSR during 15 years], p. 5–32. *In* A. F. Karpevich [ed.] Akklimatizatsia ryb i bespozvonochnykh v vodoemakh SSSR. Izd. Nauka, Moskva.

BERG, L. S. 1949. Ryby presnykh vod SSSR i sopredel'nykh stran [Freshwater fishes of the USSR and adjacent countries]. II. p. 469–925. Izd. Akademii Nauk SSSR, Moskva-Leningrad.

*BIANCO, P. G. 1976. I pesci d'acqua dolce d'Italia: considerazioni e criteri generale sulle semine in natura, p. 243–265. Proceedings of seminar "Reintroductions: technique and ethics." WWF, Roma, giugno 1976.

BRYLIŃSKA, M. [ED.]. 1986. Ryby słodkowodne Polski [Freshwater fishes of Poland]. Państwowe Wydawnictwo Naukowe, Warszawa. 429 p.

BURMAKIN, E. V. 1961. Nekotorye voprosy teorii akklimatizatsii ryb v SSSR [Some problems of the fish acclimatization theory in the USSR]. Zool. Zh. 40: 385–395.

1963. Akklimatizatsiya presnovodnykh ryb v SSSR [Acclimatization of the freshwater fishes in the USSR]. Izv. GosNIORKh 53: 317 p.

BURMAKIN, E. V., AND L. V SHIMANOVSKAYA. 1975. Rezul'taty akklimatizatsii ryb v presnovodnykh vodoyemakh SSSR [Results of the acclimatization of fish in the freshwater bodies in the USSR]. Izv. GosOSNIORKh 103: 116–119.

*BURTSEV, I. A., AND A. D. GERSHANOVICH. 1976. Ob akklimatizatsii veslonosa v SSSR [On the acclimatization of the paddle fish in the USSR]. Rybn. Khoz. 1976 (10): 13–16.

*CAVICCHIOLI, G., AND P. GUARNIERI. 1969. Revisionne sistematica, diffusione e speciazione dei pesci-gatto della Provinzia di Ferrara. Degli Annali del Museo Civico di Storia Naturale di Genova 77: 591–608.

*CHURCHWARD, A. S., P. HICKLEY, AND T. NORTH. 1984. Introduction, spread and influence of the barbel (*Barbus barbus*) in the river Severn, Great Britain. EIFAC Tech. Pap. 42, (Suppl. Vol. 2): 335–343.

DANILKIEWICZ, Y. 1973. Ichtiofauna dorzeczy Tysmienicy i Wołodawki [Fishfauna of the Tysmienica and Wołodawka basins]. Fragm. Faun. 19: 121–147.

*DE SOSTOA, A., F. J. DE SOSTOA, J. LOBON-CERVIA, B. ELVIRA, J. A. HERNANDO, AND M. AVILA. 1984. Atlas y distribución de los peces de agua dulce de España: el proyecto, metodos y resultados preliminares. Bol. Est. Centr. Biol. 13 (25): 75–81.

*DELMASTRO, G. B. 1986. Problemi relativi all'introduzione di specie esotiche di pesci nelle acque dolci italiane. Quaderni E.T.P.-Udine 14: 85–96.

*DRENSKI, P. 1948. S'stav i razprostranenie na ribite v B'lgariya [Synopsis and distribution of fishes in Bulgaria]. Annuaire de l'Université de Sofia 44 (3): 1–71.

DRYAGIN, P. A. 1954. Teoreticheskie osnovy i plan akklimatizatsii ryb vo vnutrennikh vodoemakh SSSR [Theoretical principles and plan of the acclimatization of fishes in the inland waters of the USSR]. Tr. Sovehch. Ikhtiol. Kom. AN SSSR 3: 9–20.

*ECONOMIDIS, P. S. 1972. Katalogos ton ichthyon tes Ellados [Catalogue of fishes of Greece]. Hell. Oc. Limnol. 11: 421–599.

*ECONOMIDIS, P. S., M. E. KATTOULAS, AND A. STEPHANIDIS. 1981. Fish fauna of the Aliakmon River and adjacent waters (Macedonia, Greece). Cybium, 30 série, 5: 89–95.

FITZMAURICE, P. 1984. The effects of freshwater fish introductions into Ireland. EIFAC Tech. Pap. 42 (Suppl. Vol. 2): 449–457.

HOLČÍK, J. 1980. *Carassius auratus* (Pisces) in the Danube River. Acta Sci. Nat. Brno 14 (11): 1–43.

1984. Some considerations on the role of introduced species of fish in the management on inland fisheries. EIFAC Tech. Pap. 42 (Suppl. Vol. 2): 488–495.

*[ed.]. 1986. The freshwater fishes of Europe 1/I. Petromyzontiformes. AULA-Verlag, Wiesbaden. 313 p.

*[ed.]. 1989. The freshwater fishes of Europe 1/II. AULA-Verlag, Wiesbaden. 469 p.

HOLČÍK, J., I. BASTL, M. ERTL, L. KOVÁČIK, S. NAGY, E. ŠTEFKOVÁ, J. TOMAJKA, AND M. VRANOVSKÝ. 1985. Hydrocenózy inundačných vôd Dunaja v oblasti výstavby vodných diel [Aquatic communities of the Danube River floodplain in the region affected by the water works construction]. Project VI-2-4/3. Final Report, Institute of Fishery Research and Hydrobiology, Bratislava (Mimeo.). 54 p.

*HOLČÍK, J., K. HENSEL, J NIESLANIK, AND L. SKÁCEL. 1988. The Eurasian huchen, *Hucho hucho*, largest salmon of the world. Perspectives in Vertebrate Sciences 5. Dr. W. Junk Publishers (Kluwer), Dordrecht, Boston, Lancaster. 239 p.

HOLČÍK, J., S. NAGY, AND I. BASTL. 1989. Sih veľký (maréna) — *Coregonus* lavaretus (Linnaeus, 1758) v Štrbskom plese (The whitefish (*Coregonus lavaretus* (Linnaeus, 1758) in the Štrbské pleso tarn), p. 79–83. *In* R. Berka [ed.] Chov lososovitych ryb. Proceedings from conference. ČSVTS pri VÚRH and SRŠ, Vodňany.

*INSTITUTO NACIONAL PARA LA CONSERVACION DE LA NATURALEZA, 1986: Lista roja de los vertebrados de Espana. Ministerio de Agricultura, Pesca y Alimentacion, Madrid. 400 p.

*IVANOVIĆ, B. M. 1973: Ichthyofauna of Skadar Lake. Biological Station, Titograd. 146 p.

*IVOILOV, A. A. 1986. Klassifikatsiya i nomenklatura triby Tilapiini (Chichlidae)-novykh ob'ektov rybovodstva na teplykh vodakh v SSSR [Classification and nomenclature of tilapias from the tribe Tilapiini (Cichlidae), a new subjects of warm water culture in the USSR]. Vopr. Ikhtiol. 26: 355–366.

KARPEVICH, A. F. 1965a. Itogi simpoziuma po teoreticheskim voprosam akklimatizatsii ryb i drugikh gidrobiontov (Results of the symposium on theoretical problems of the acclimatization of fish and other aquatic organisms). Vopr. Ikhtiol. 5: 219–223.

1965b. Teoreticheskie prodposylki k akklimatizatsii vodnykh organizmov [Theoretical assumptions for the freshwater organisms acclimatization]. Tr. VNIORKh 43: 9–30.

KARPEVICH, A. F. 1975. Teoriya i praktika akklimatizatsii vodnykh organizmov [Theory and practice of the aquatic organisms acclimatization]. Pishch. Promst', Moskva. 432 p.

KARPEVICH, A. F., L. S. BERDICHEVSKII, N. K. LUKONINA, AND V. S. MALYUTIN. 1975. Rezul'taty akklimatizatsii ryb i kormovykh organizmov v vodoyemakh SSSR [Results of the acclimatization of fishes and food organisms in the water bodies of the USSR]. Izv. GosNIORKh 103: 5–19.

KARPEVICH, A. F., V. K. GORELOV, V S. MALYUTIN, AND O. N. KOZHINA. 1989. Problemy akklimatizatsii vodnykh organizmov v SSSR [Problems

of the acclimatization of the aquatic organisms in the USSR]. Rybn. Khoz. 1989 (6): 32–35.

KAZANCHEEV, E. N. 1981. Ryby Kaspiiskogo morya [Fishes of the Caspian Sea]. Lëgkaya i Pishchevaya Promyshlennost', Moskva. 167 p.

KOGAN, SH. I. 1974. O zarastanii Karakumskogo kanala i nekotorykh posledstviyach vseleniya v vodoyemy belogo amura [On the macrophytes growth in the Karakum Canal and on some consequences of the grass carp introduction]. Gidrobiol. Zh. 10: 110–115.

KRZYWOSZ, T., W. KRZYWOSZ, AND J. RADZIEJ. 1980. The effect of grass carp, *Ctenopharyngodon idella* (Val.) on aquatic vegetation and ichthyofauna of lake Dgal Wielki. Ekol. Pol. 28: 433–450.

*KUDERSKII, L. A. 1975. O samorasselenii ryb vo vnutrennikh vodoyemakh (On the diffusion of fish in inland waters). Izv. GosNIORKh 103: 58–64.

LIFSHITS, S. M., AND A. M. BELOUSOV. 1979. Itogi i effektivnost' akklimatizatsionnykh rabot v SSSR [Results and efficiency of acclimatization works in the USSR]. Obzor Informatsii TsNIITERKh 1979 (3): 1–8.

LINFIELD, R. S. J. 1984. The impact of zander (*Stizostedion lucioperca* (L.)) in the United Kingdom and the future management of affected fisheries in the Anglian region. EIFAC Tech. Pap. 42 (Suppl. Vol. 2): 353–362.

LINNAEUS, C. 1758. Systema Naturae. Nantes Pisces. X. ed., Vol. 1. Holmiae. p. 230–338.

*LOBON-CERVIA, J., B. ELVIRA, AND P. A. RINCON. 1989. Historical changes in the fish fauna of the river Duero basin, p. 221–232. *In* G. E. Petts [ed.] Historical change of large alluvial rivers: Western Europe. J. Wiley and Sons, New York, NY.

*LUSK, S. 1988. Stav a výhledy introdukce ryb v Československu [The state and prospects of fish introductions in Czechoslovakia]. Zprávy ÚSEB 1988: 171–174.

1989. Gene pool of fishes in Czechoslovakia, present state and conservation efforts. Práce VÚRH Vodňany 18: 15–26.

MAITLAND, P. S. 1987. Fish introductions and translocations — their impact in the British Isles, p. 51–56. *In* P. S. Maitland and A. K. Turner [ed.] Angling and Wildlife in Freshwaters. ITE Symposium 19.

MAITLAND, P. S., AND K. EAST. 1989. An increase in numbers of ruffe, *Gymnocephalus cernua* (L.) in a Scottish loch from 1982 to 1987. Aquacult. Fish. Manage. 20: 227–228.

*MARINOV, B. 1978. Ikhtiofaunata na b'lgarskiya sektor na reka Dunav i nechnato stopansko znachenie [Fishes of the Bulgarian stretch of the Danube River and their economic importance], p. 201–228. *In* B. K. Rusev and V. T. Naidenov [ed.] Limnologiya na b'lgarskiya sektor na reka Dunav. Izd. na B'lgarskata Akademiya na naukite, Sofia.

MARKEVICH, N. 1978. Uchityvat' de tol'ko polozhitel'nye rezul'taty [To not consider only the positive results]. Rybovodstavo i Rybolovstvo 1978 (2): 8–9.

*MARTINO, K. V. 1975. Akklimatizatsiya rastitel'noyadnykh ryb v vodoyemakh nizhnei Volgi [Acclimatization of the herbivorous fishes in the Lower Volga waters]. Izv. GosNIOKh 103: 146–149.

*MELNIKOV, G. B., AND A. M. CHAPLINA. 1966. An experiment in acclimatization of fishes in reservoirs of Crimea, p. 182–193. *In* A. I. Yanushevich [ed.] Acclimatization of animals in the U.S.S.R. Izd. Akademii Nauk Kazakhskoi SSR, Alma-Ata, 1963. Israel Progr. for Sci. Transl. Jerusalem.

*MELOTTI, P., A. RONCARATTI, E. GARELLA, S. PEOLILLI, AND R. ROSSI. 1991. Prove di svezzemento larvale dello storione bianco. Lagune 1991 (2): 30–35.

*MICHA, J.-C., AND M. C. BORLEE. 1989. Recent historical changes on the Belgian Meuse, p. 269–295. *In* G. E. Petts [ed.] Historical change of large alluvial rivers: Western Europe. J. Wiley and Sons.

*MIKEL'SAAR, N. F. 1966. Acclimatization of fishes in Estonia, p. 184–185. *In* A. I. Yanushevich [ed.] Acclimatization of animals in the U.S.S.R. Izd. Akademii Nauk Kazakhskoi SSR, Alma-Ata, 1963. Israel Progr. Sci. Transl., Jerusalem.

MOHR, E. 1952. Der Stör. Die Neue Brehm Bücherei. Akademische Verlagsgeselschaft Geest und Porting K.-G., Leipzig.

MOLNÁR, K. 1984. Parasite range extension by introduction of fish to Hungary, EIFAC Tech. Pap. 42 (Suppl. Vol. 2): 534–540.

MOTENKOV, YU. 1966. Razmnozhenie tolstolobika v Kubani [Reproduction of the silver carp in the Kuban' River]. Rybovodstvo i Rybolovstvo 1966 (1): 16–17.

*MUSATOV, A. P., AND V. V. STEPANTSEV. 1968. Introduktsiya ryb v vodoemy Moskovskoi oblasti [Introduction of fishes in the Moscow region], p. 137–142. *In* A. F. Karpevich [ed.] Akklimatizatsiya ryb i bespozvonochnykh vo vodoemakh SSSR. Izd. Nauka, Moskva.

MYAGKOV, N. A. 1990. Dve storony medali [Two sides of the medal]. Rybn. Khoz. 1990 (1): 46–47.

NILSSON, N.-A. 1984. The niche concept and the introduction of exotics. EIFAC Tech. Pap. 42 (Suppl. Vol. 2): 496–505.

*PINTÉR, K. 1989. Magyarország halai [Fishes of Hungary]. Akadémiai Kiadó, Budapest. 202 p.

*POVŽ, M., AND B. SKET. 1990. Naše sladkovodne ribe [Our freshwater fishes]. Mladinska knjiga, Ljubljana. 370 p.

RADZIEJ, J., AND T. KRZYWOSZ. 1979. Wpływ amura bialego na biomase i sklad gatunkowy roslin oraz na ichtiofaune jeziora Dgal Wielki [Impact of the grass carp upon the biomass and diversity of macrophytes and on the fish fauna of the Dgal Wielki Lake]. Gospodarka Rybna 31: 6–8.

RASS, T. S. 1965. Rybnye resursy evropeiskikh morei SSSR i vozmozhnosti popolnenia akklimatizatsiei [Fish resources of European seas of the USSR and possibilities of their completing by acclimatization]. Izd. Nauka, Moskva. 107 p.

*RAUNICH, L., C. CALLEGARINI, AND G. CAVICCHIOLI. 1966. Polimorfismo emoglobinico e caratteri sistematici del genere *Ictalurus* dell'Italia settentrionale. Arch. Zool. Ital. 51 (oarte Ia): 497–509.

*SOKOLOV, L. I. [ED.] 1988. Ryby Podmoskov'ya (Fishes of the Moscow region). Nauka, Moskva. 143 p.

*SOKOLOV, L. I., E. A. TSEPKIN, V. I. LAPIN, AND A. E. MIKULIN. 1986. Ryby basseina Moskvy-reki [Fishes of the Moskva River basin]. Izdatel'stvo MGU, Moskva. 86 p.

*SPANOVSKAYA, V. D., K. A. SAVVAITOVA, AND T. L. POTAPOVA. 1964. Ob izmenchivosti rotana (*Perccottus glehni* Dyb., fam. Eleotridae) pri akklimatizatsii [On the variability of *Perccottus glehni* Dyb. during the period of acclimatization]. Vopr. Ikhtiol. 4: 632–643.

*SPILLMANN, CH. J. 1961. Poissons d'eau douce. Faune de France 65. Librairie de la Faculté des Sciences, Paris. 303 p.

*STARUSHENKO, L. I. 1977. Rezul'taty akklimatizatsii dal'nevostochnoi kefali pilengasa v Chernom more [Results of the haarder acclimatization in the Black Sea]. Rybn. Khoz. 1977 (1): 26–28.

*SURKOV, S. S., AND E. I. SURKOVA. 1968. Itogi i perspektivy akklimatizatsionnykh rabot v basseine Barentseva i Belogo morei [Results and prospects of the acclimatization measures in the Barents and White Seas basins], p. 40–45. *In* A. F. Karpevich [ed.] Akklimatizatsiya ryb i bespozvonochnykh v vodoemakh SSSR. Izd. Nauka, Moskva

TÓTH, J., AND P. BIRÓ. 1984. Exotic fish species acclimatized in Hungarian natural waters. EIFAC Tech. Pap. 42 (Suppl. Vol. 2): 550–554.

*VINOGRADOV, V. K., AND A. V. EROKHINA. 1975. Predstaviteli severoamerikanskoi ikhtiofauny kak ob'ekty vo vnutrennikh vodoyemakh SSSR [Representants of the North American fish fauna as the new objects in the inland waters of the USSR]. Izv. GosNIORKh 103: 220–225.

*VINOGRADOV, V. K., AND L. V. EROKHINA. 1976. Novye ob'ekty rybovodstva i akklimaatizatsii [New objects for fish breeding and acclimatization]. Rybn. Khoz. 1976 (10): 10–13.

VINOGRADOV, V. K., AND Z. K. ZOLOTOVA. 1974. Vliyanie belogo amura na ekosistemy vodoyemov [Impact of the grass carp upon the aquatic ecosystems]. Gidrobiol. Zh. 10: 90–98.

*VOVK, P. S. 1966. Results and prospects of acclimatization of valuable fish in the Ukraine, p. 153–155. *In* A. I. Yanushevich [ed.] Acclimatization of animals in the U.S.S.R. Izd. Akademii Nauk Kazakhskoi SSR, Alma-Ata, 1963. Israel Progr. Sci. Transl., Jerusalem

*VUKOVIĆ, T., AND B. IVANOVIĆ. 1971. Slatkovodne ribe Jugoslavije [Freshwater Fishes of Yugoslavia]. Zemaljski Muzej BiH, Sarajevo. 265 p.

WELCOMME, R. L. (COMP.). 1981. Register of international transfers of inland fish species. FAO Fish. Tech. Pap. 213: 120 p.

(COMP.). 1988. International introductions of inland aquatic species. FAO Fish. Tech. Pap. 294: 318 p.

*WESTMAN, K., AND P. TUUNAINEN. 1984. A review of fish and crayfish introductions made in Finland. EIFAC Tech. Pap. 42 (Suppl. Vol. 2): 436–448.

WITKOWSKI, A. 1989. Introdukowane ryby w polskich wodach i ich wplyw na srodowisko [Fishes introduced to Polish waters and their effect on environment]. Przegl. Zool. 33: 583–598.

WOHLGEMUTH, E., AND M. ŠEBELA. 1987. Strevlička východní, nový prvek evropské ichtyofauny [*Pseudorasbora parva*, a new element of the European fish fauna]. Živa 35: 27–28.

*YAROSHENKO, M. F., I. I. LEDYU, I. F. KUBRAK, AND A. M. ZELENIN. 1986. Itogi i perspektivy akklimatizatsii nekotorykh ryb i kormovykh bespozvonochnykh v vodoemakh Moldavii [Results and prospects of some fish and invertebrates introduction in the waters of Moldavia], p. 172–178. *In* A. F. Karpevich [ed.] Akklimatizatsiya ryb i bespozvonochnykh v vodoemakh SSSR. Izd. Nauka, Moskva.

ZENKEVICH, L. A. 1940. Ob akklimatizatsii v Kaspiiskom more novykh kormovykh bespozvonochnykh i teoreticheskie k nei presposylki [On the acclimatization of new species of the food invertebrates in the Caspian Sea and on the theoretical assumptions of the former]. Byulleten' MOIP 49: 1–30.

*ZHUKOV, P. I. 1965. Ryby Belorussii [Fishes of Belorussia]. Nauka i Tekhnika, Minsk. 413 p.

*ZYUGANOV, V. V. 1986. Ob izmenenii gnezdostroitel'nogo povedeniya devyatiigloi kolyushki *Pungitius pungitius* (L.) (Gasterosteidae) pri introduktsii v neobychnye ulsoviya sredy [On the change of the nest building behaviour of the ten spined stickleback introduced in unusual environmental conditions]. Vopr. Ikhtiol. 26: 1044–1046.

ŽITŇAN, R. 1974. Acclimatization of fish in the Carpathian Region of Czechoslovakia and the role of helminths in this process. Acta Biol. Jugosl. Ichthyol. 6: 143–155.