

# Present Status of Aquatic Organisms Introduced into Japan

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Introductions of aquatic organisms into Japan are controlled only on the basis of the Convention on International Trade in Endangered Species (CITES) of Wild Fauna and Flora and the quarantine acts. Up to 1986 more than 120 exotic species have been introduced, of which only 36 were made prior to 1945.

Introductions are classified into four basic categories. In this paper of those in two categories, (i) species which have spread widely over Japan and are self reproducing, and (ii) those which have been maintained for generations through artificial propagation or in confined natural waters are dealt with.

Since the late 19th century, a great number of exotic species of aquatic organisms have been introduced into Japan primarily with a view to enrich the fish resources of the country. While the introduction of some of these species have caused serious ecological problems in natural waters, some others have been confined and cultured in aquaculture farms as market fish or well established in natural waters yielding new commodities of food or sports fishing without serious impact on the ecosystem. The evaluation of the transplantation of non-indigenous species can vary among people; an exotic fish species in a river or lake may be a acceptable game fish for anglers while it may be an enemy for fishermen who catch other species that are outrivalled by the newcomer. Moreover, we have to admit that the 'ecological sense' of the people vary in accordance with the cultural and socio-economic backgrounds of the country, even though conservation is the unanimous consensus of all nations. In any event, accumulation of accurate

information on the status of fauna and flora is essential to lay down effective schemes for controlling introduction of the species.

The purpose of this paper is to give a brief historical review of the introduction of exotic species of aquatic animals in Japan and a brief description of the present status of these species. Species introduced as ornamental aquarium fish are excluded from this report.

### Review of Aquatic Species Introduced into Japan

It is virtually impossible to trace all of the numerous aquatic organisms introduced into Japan over the last 100 years. However, efforts have been expended to collect distributional and ecological data on introduced exotic species by various institutions including the Fisheries Agency, prefectural fisheries stations and universities. The Environment Agency's on-going nation-wide survey of the distribution of freshwater fishes, which is carried out every 5 years, has also provided distributional information on the exotic species which have been naturalized in inland waters (Environmental Agency 1976, 1980, 1988).

There has been no regulation to control the introduction of aquatic animals from an ecological standpoint. Animals brought in from abroad are checked only on the basis of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), the municipal laws established in relation to the CITES, and the Quarantine Acts. Recently, FAO's program of the prevention of international epidemics was put into operation at the Fish Disease Center in Tokyo.

According to Maruyama et al. (1987), more than 120 exotic species of aquatic animals have been brought to Japan up to 1986. Of these, only 36 species were introduced to Japan before 1945. Entering the postwar period, the number increased drastically, due largely to the increasing demand for new commodities among commercial fishermen, aquaculturists and sports fishermen and the development of transportation.

Many of these species were introduced intentionally for stocking in the natural environment, commercial culture and/or sport fishing. Some species, such as the silver carp, *Hypophthalmichthys molitrix* and the bitterling, *Rhodeus ocellatus ocellatus* came to Japan accidentally; these two species arrived in Japan mixed with fry of the grass carp, *Ctenopharyngodon idella* (Nakamura 1955).

Of the 120 species brought into Japan, about 9 species accounting for 7.5% of the total number have acclimatized themselves to the natural environment as self-reproducing populations; about 32 or 26.7% have been successfully bred; about 26 or 24.6% have disappeared; the status of about 53 or 41.2% remains obscure. In Table 1 they are classified into four categories; (1) species which have spread widely over Japan and are self-reproducing, (2) species which have been maintained for generations in captivity through spontaneous or artificial reproduction and/or established as self-reproducing populations in limited areas of natural waters, (3) species which are already extinct in Japan, and (4) species of which the present status cannot be elucidated. The following description by taxonomic group deals with only species which belong to categories 1 and 2 above and which are considered to have an economic or ecological importance.

### *Salmonidae*

Examples of successful introduction of species for aquaculture are evident amongst salmonids, particularly the rainbow trout, *Salmo gairdneri*. Since its first introduction in 1877, many strains of rainbow trout have been imported from various localities of North America. This species is now the commonest species in cold-water aquaculture ponds in Japan and its annual production is maintained at 15,000-20,000 t. Programs of stocking of rainbow trout fingerlings in rivers have also been in operation in many areas since 1955. However, reproduction of the fish in natural waters has been confirmed only in Hokkaido (Kawanabe 1980).

Other exotic salmonid species that are known to reproduce in natural waters are the brown trout, *Salmo trutta* and the brook trout, *Salvelinus fontinalis*.

A number of species of the salmonid genus *Coregonus* have been introduced from East European countries for pond culture; still in experimental stages at research institutions and private farms. *Coregonus* species *C. lavaretus maraena* and *C. peled* among others are regarded as promising candidates for cold-water pond culture in Japan.

### *Cyprinidae*

Four species of Chinese carps *Ctenopharyngodon idella*, *Hypophthalmichthys molitrix*, *Aristichthys nobilis* and *Mylopharyngodon piceus* are reported to reproduce in the Tone, one of the largest rivers in Japan (Inaba 1955). Though they are of no high commercial value, the former two species are of some importance in the commercial fisheries in the area. Because of their low trophic levels, there have been no reports indicating disturbances of river fauna because of these species.

The bitterling *Rhodeus ocellatus ocellatus* is a small cyprinid occurring in continental East Asia accidentally introduced into Japan mixed with grass carp fry from China, and was first found in Japanese freshwaters in the mid-1940s (Nakamura 1955). Since then it has been expanding its distribution, most remarkably in the last decade, expelling the Japanese subspecies *R. ocellatus smithi* by ecological pressures and hybridization. *R. ocellatus smithi* is now on the brink of extinction as a distinct subspecies (Nagata and Nishiyama 1976).

### *Atherinidae*

The atherinid *Odonthestes bonariensis*, known as pejerrey in South America, was introduced into Japan from Argentina in 1966 as a species suitable for pond culture and stocking in lakes. It has turned out that the species can readily reproduce in captivity and the fish is now cultured at several fisheries stations and private farms. Seed has been stocked repeatedly in Lake Ashinoko and Lake Tsukui to create a new commodity of sport fishing, but it is not evident that the fish has adjusted itself in these lakes (Watase 1986).

### *Centrarchidae*

The North American bluegill, *Lepomis macrochirus* and largemouth bass *Micropterus salmoides* have readily established themselves in rivers and lakes and are spreading rapidly over

Table 1. List of exotic aquatic species (Status 1 - Established as self reproducing populations; Status 2 - being reproduced in certain experimental or natural ponds; Status 3 - extinct at present; Status 4 - accurate information not available; UI, unintentional).

Taxonomic Status	Status	From	Introduced Year	Remarks
<b>Pisces</b>				
<b>Acipenseridae</b>				
<i>Acipenser guldenstadti</i>	3	USSR	1963-	
<i>A. baeri</i>	3	USSR	1964	
<i>Huso huso</i> x	?	USSR	1974-	
<i>Acipenser ruthenus</i>				
<b>Clupeidae</b>				
<i>Alosa sapidissima</i>	3	USA	1928/29	
<b>Anguillidae</b>				
<b><i>Anguilla japonica</i></b>				
	?	Korea	1964-	Elver for commercial culture
	?	China	1964-	
	?	Taiwan	1964	
	?	France	1969	
<i>A. anguilla</i>	?	Italy		
	?	England		
<i>A. rostrata</i>	?	Canada	1971/72	
<i>A. dieffenbachi</i> and <i>A. australis</i>	3	New Zealand	1970/73	Elver for commercial culture
<i>A. bicolor pacifica</i>	3	Philippines	1972	
<b>Salmonidae</b>				
<i>Salmo gairdneri</i>	2	USA	1877	
<i>S. trutta</i>	2	USA	? - 1926	
<i>S. salar</i>	?	USSR	1980/83	
<i>Oncorhynchus tshawytscha</i>	?	USA	1881-	
<i>O. nerka</i>	?	Canada	1957	
	?	USA	1968	
<i>O. kisutch</i>	2	USA	1965	
<i>Salvelinus namaycush</i>	2	Canada	1966/69	
<i>S. fontinalis</i>	2	USA	1901/26	
<i>Coregonus lavaretus maraena</i>	2	Czecho	1977/78	
<i>C. l. ludoga</i>	?	USSR	1981	
<i>C. autumnalis migratorius</i>	?	USSR	1969-	
<i>C. muksun</i>	?	USSR	1981/83	
<i>C. peled</i>	2	Czecho	1972-	
		USSR	1978-	
<i>C. clupeaformis</i>	3	USA	1926/29	
<i>C. olbus</i>	3	USA	1926/29	
<i>C. lavaretus baeri</i>	3	USSR	1929/30	
<i>C. lavaretus maraena</i>	3	USSR	1929/30	
<b>Cyprinidae</b>				
<b><i>Aristichthys nobilis</i></b>				
	2	China	1878- 1940	Tone River S. UI (mixed in grass carp fry)
<i>Ctenopharyngodon idellus</i>	2	China	1878- 1955	
<i>Hypophthalmichthys molitrix</i>	2	China	1878- 1940	Tone River. S.
<i>Mylopharyngodon piceus</i>	2	China	1878- 1940	Tone River. S. UI (mixed in grass carp fry)
<i>Rhodeus ocellatus ocellatus</i>	1	China	1942-	

Continued

Table 1. Continued

Taxonomic Status	Status	Introduced		Remarks
		From	Year	
<i>Cyprinus carpio ruscus</i>	2	China	1971	Cross bred
<i>Cyprinus carpio</i>	2	Germany	1905-	
	2	Austria	1970	
	2	Indonesia	1980	
<i>Cirrhina molitorella</i>	?	China	1965/66	
<i>Megalobrama amblycephala</i>	2	China	1978	
<i>Tinca tinca</i>	2	Netherlands	1961	
<i>Carassius auratus gibelio</i>	3	USSR	1930/64	
<i>Catla catla</i>	3	India	1960	
		Pakistan	1970	
<i>Barbus tor</i>	3	India	1960	
<i>Labeo rohita</i>	3	India	1960	
<i>Cirrhina mrigala</i>	3	India	1960	
Ictaluridae				
<i>Ictalurus punctatus</i>	2	USA	1971	
Poeciliidae				
<i>Gambusia affinis</i>	1	Taiwan	1916	
Atherinidae				
<i>Odontesthes bonariensis</i>	2	Argentina	1966	
Percidae				
<i>Perca flavescens</i>	3	USA	1960	
Centrarchidae				
<i>Lepomis macrochirus</i>	1	USA	1960	Predation on native species
<i>Micropterus salmoides</i>	1	USA	1925	
<i>Morone interrupta</i>	3	USA	1960	
<i>Pomoxis nigromaculatus</i>	3	USA	1927/36	
<i>Roccus saxatilis</i>	3	USA	1927/28	
			1972/73	
Chichlidae				
<i>Oreochromis aureus</i>	2	Taiwan	1980	Colonized polluted brackish waters around Okinawa Island.
		USA	1983	
		Syria	1984	
<i>O. macrochir</i>	3	USA	1964	
<i>O. mossambicus</i>	2	Thailand	1954-	
<i>O. urolepis hornorum</i> (reported as <i>Tilapia macrocephala</i> )	2	Israel	1981	
<i>O. niloticus</i>	2	Egypt	1962	
<i>Sarotherodon melanotheron</i>	3	USA	1960	
<i>S. galilaeus</i>	3	USA	1964	
<i>Tilapia sparrmanii</i>	2	USA	1959	
<i>T. zillii</i>	2	Egypt	1962	
Belontiidae				
<i>Macropodus chinensis</i>	1	Korea	1914	
Osphronemidae				
<i>Osphronemus goramy</i>	?	Thailand	1956	
Sciencidae				
<i>Aplodinotus grunniens</i>	3	USA	1960	

Continue

Table 1. Continued

Taxonomic Status	Status	From	Introduced	Year	Remarks
Channidae					
<i>Channa argus</i>	2	Korea		1923/24	Predation on native species
<i>C. maculata</i>	1	Taiwan		1906/19	parasites Parasites
Crustacea					
Astacidae					
<i>Pacifastacus leniusculus</i>	2	USA		1909/29	Pond Tankai in Shiga Pref.
<i>P. trowbridgii</i>	2	USA		1928/30	Lake Mashu in Hokkaido
<i>Procambarus clarkii</i>	1	USA		1930	
Parastacidae					
<i>Cherax tenuimanus</i>	3	Australia		1981-	
Nephropsidae					
<i>Homarus Americanus</i>	?	USA		1914 1975/78	
Penaeidae					
<i>Penaeus chinensis</i>	?	Yellow Sea		1965-	
Palaemonidae					
<i>Macrobrachium rosenbergii</i>	2	Malaysia Thailand USA (Hawaii)		1967-	
Mollusca					
Unionidae					
<i>Lamprotula (Quadrula) bazini</i>	3	China		1917	
<i>Lampsilis luteola</i>	3	USA		1926	
<i>Anodonta woodiana</i>	3	Taiwan		1962	
Mytilidae					
<i>Mytilus edulis galloprovincialis</i>	1	?		ca.1926	UI
Ostreidae					
<i>Ostrea lurida</i>	2	USA		1948	
<i>O. edulis</i>	2	France		1952	
<i>Crassostrea angulata</i>	?	France		1952	
<i>C. virginica</i>	?	USA		1968	
Haliotidae					
<i>Haliotis rufescens</i>	2	USA		1966	
Ampullaridae					
<i>Pila leporavillensis</i> <i>x Ampullarium insclarum</i>	1	Taiwan		1981	Hybrid; it is unknown whether pure strains have been introduced or not

the Japanese main islands. After its first introduction into Lake Ashinoko in 1925 for lure fishing (Akaboshi 1959) and an initial unsuccessful attempt of its transplantation into several other lakes, transplantation of *M. salmoides* from Lake Ashinoko to other waters was prohibited to prevent possible destruction of local fish fauna by this predaceous species. However, the attraction of this fish as a game for lure fishing has led some indiscreet anglers to secretly transplant it into many lakes. This resulted in its subsequent rapid dispersal over Japan and its predation on many native fish species. The impact of the largemouth bass on indigenous fish fauna appears to vary particularly in relation to the depth of water (Nomura and Furuta 1977). The predation on indigenous fish by largemouth bass has caused serious problems in shallow waters and efforts to eradicate this predator have not been successful (Kikukawa 1980). In deep waters such as Lake Ashinoko, largemouth bass coexist with native fish by habitat segregation.

### *Cichlidae*

Nine species of tilapia have been introduced into Japan for the purpose of pond culture utilizing heat from hot springs or cooling-water discharge from power plants or factories. Of these species, *Oreochromis niloticus* is enjoying a comparatively high reputation as a food fish, with its annual production reaching more than 5,000 t in 1985 (Maruyama 1986). *O. niloticus*, *O. mossambicus*, *Tilapia sparmanii* and *T. zillii* have colonized estuarine waters in the Okinawa Islands (Imai 1980).

## Changes in the Japanese Freshwater Fish Fauna

The freshwater fish fauna of Japan has been changing rather conspicuously in recent years. The freshwater fauna is originally rich in southwestern Japan and comparatively poor in northeastern Japan. The recent changes in freshwater fish fauna are characterized primarily by the dispersal of many species endemic or indigenous to southwestern and northeastern Japan. This northeastward dispersal is considered to be attributable largely to the transplantation of a species called "ayu" from Lake Biwa in central Honshu. Though this has little to do with the introduction of exotic species, we believe it worthwhile to briefly mention of what is going on in the Japanese freshwater fish fauna.

Ayu, *Plecoglossus altivelis*, a small, annual fish closely related to salmonids is one of the favourite game fish and an inland water delicacy among the Japanese. Young and sub-adult ayu inhabit the middle to upper reaches of clear water rivers and reach maturity as they descend to the lower reaches where they spawn. Larvae migrate to the sea and juvenile ayu ascend rivers after spending the whole winter in the sea. Due to obstructions on the migration route by dams and other structures, fry of ayu are being released into upstream areas all over Japan in large numbers every year. The majority of the fry released are collected from Lake Biwa where a land-locked population of ayu abounds.

This stocking activity is certainly a boon to more than 10 million amateur anglers who enjoy ayu fishing. However, it has created a side-effect; colonization of the inland waters of northeastern Japan by species that had been found only in southeastern Japan. It is widely accepted that the dispersal of southwestern elements has caused by incidental transportation of fry of many species mixed in ayu seed collected from Lake Biwa. These immigrants include a few carnivorous cyprinids and the predaceous largemouth bass.

From this historical review, it can be seen that the introduction of aquatic species into Japan is closely related to the development of transportation. Before the World War II, shipping was the only mode of transportation live species from foreign countries to Japan. It was difficult for private enterprises to introduce live aquatic species from foreign countries because of shipping costs. Therefore, only the national and/or local governments were able to introduce the aquatic species from other countries for productive increase of animal protein. As the target species were selected by the government authority itself, rules governing introduction of aquatic species were not thought to be necessary.

Entering the postwar period, the development of transportation drastically increased the number of species introduced from other countries; they are not only used in pond culture, but also as ornamental pet fish in aquariums. Critical changes in fauna and flora caused by exotic species have never been observed as a result of unrestricted introduction of aquatic species. However, some changes, as mentioned above, have already been reported. Those are *Rhodeus ocellatus smithi* being replaced by *R. o. ocellatus*, colonization of northeastern Japan by native-born species found in southwestern Japan, and the predation of largemouth bass *Micropterus salmoides* on many native fish species in certain places. These situations should be considered as a warning alarm for unrestricted introduction of aquatic species and the need for deliberation and care for further introduction of aquatic species in Japan.

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