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Intentionally Introduced and Transferred Fishes in China's Inland Waters

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Abstract

Investigations showed that 72 exotic species and nearly 100 native species of fishes were intentionally introduced and cultured in the inland waters of China. The most influential species were Chinese carps and tilapias, which constitute most of the production in China's freshwaters. The main purposes of introduction involved aquaculture, sale, ornament, resources conservation and biological control. Impacts included ecological deterioration and economic loss. To solve these problems, cooperation of legislation, administration, education and technical assistance are the top priority.

Introduction

With the increasing of population and decreasing of fisheries resources, the Chinese people have been turning to the aquaculture of fishes introduced and transferred into their inland waters. It was generally believed that through the introduction and transfer of non-indigenous species, new protein resources and economic benefit would be achieved, and as such she has become one of the countries with a high number of introduced and transferred fish species in the world (Lou 2000). Although the Chinese people currently enjoy many benefits, still the "red flag" has emerged in their ecological and economic fields (Chen and Cui 1993; Li and Cai 1995). However, introduction and transfer are still continued for commercial benefit. To avoid repetition of North America's negative impacts on non-indigenous fish introductions (Lassuy 1995; Alan and Coscarelli 1999; Charles and Cooley 1999), it is emergent to pay more attention to the strict regislation of intentional introduction and transfer of fish species in China's inland waters.

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In the past year, some ordinary species and other good quality species were imported into China. According to Lou (2000) and investigations conducted by the authors, in the last century, at least 71 species of foreign fishes were cultured in China's inland waters (Table 1; not including mini species as pets). Most of them belonged to salmonids, cyprinids and tilapias. Their devotion to the inland fisheries was obvious and commonly appreciated (Lou 2000; Shi 2000).

SALMONIDS

Salmonids were the most widely cultured and stocked group of fishes in North America, and many of them were popular sport fishes (Crossman and

Table 1. Intentionally introduced exotic fishes in China's inland waters

Species name	Origin	Time	Main purpose
Abramis brama orientalis (European bream)	USSR	1949	food
Acipenser nudivenris (ship sturgeon)	USSR	1933	food and sale
Acipenser guldenstaedti (Russian sturgeon)	Russia	1993	food and sale
Acipenser stellatus (star sturgeon)	Russia	1996	food and sale
Anguilla anguilla (European eel)	France	1995	food
Arapaima gigas (arapaima)	South America	1990	ornament
*Astronotus ocellatus (*oscar*)*	Thailand	1990	ornament
Bidyanus bidyanus (silver perch)	Australia	1991	food
Carasius auratus caviers (white goldfish)	Japan	1976	food
Catla catla (catla)	Bangladesh	1983	food
Channa micropeltes (giant snakehead)	Thailand	1986	food
Channa striata (chevron snakehead)	Thailand	1986	food
Cichlasoma managuense (jaguar guapote)	Taiwan	1989	ornament
Cirrhina mrigala *(mrigal)*	India	1982	food
Clarias batrachus (waking catfish)	Thailand	1978	food
Clarias lazera (clara)	Egypt	1981	food
Clarias macrocephelus (spotted catfish)	Thailand	1982	food
Colossoma brachypomus (freshwater colossoma)	Taiwan	1985	food and sport
Coregonus actedii (Cisco)	Canada	1997	food
Coregonus lavaretus maroinoides (powan)	Japan	1985	food
Coregonus muksun (Muksun)	USSR	1983	food
Coregonus nasus (broad whitefish)	USSR	1987	food
Coregonus peled (northern whitefish)	Japan	1985	food
Cyprinus carpio (German mirror carp)	Japan	1982	food
Gambusia affinis (mosquitofish)	Philippines	1927	bio-control
Gnathonemus petersii (Ubangi mormyrid)	Africa	1990	ornament
Hypomesus nippnensis (wagasaki)	DPRK	1940's	food and sale
Hypostomus plecostomus (sucker mouth catfish)	South America	1990	ornament
Ictalurus furcatus (blue catfiah)	U.S.A.	1980's	food
Ictalurus nebulosus (brown bullhead)	U.S.A.	1984	food
Ictalurus punctatus (channel catfish)	U.S.A.	1984	food
Ictiobus cyprinellus (bigmouth bafflo)	U.S.A.	1993	ornament
Labeo calbusu (blue labeo)	Thailand	1990	food
Labeo rohita (South Asia labeo)	Thailand	1978	food
Lates calcarifer (giant perch)	Thailand	1983	food
Lepisosteus oculatus (spotted gar)	U.S.A.	1990	ornament

continued...

Table 1 continued...

Species name	Origin	Time	Main purpose
Leptobarbus hoeneni (fine barbel)	Thailand	1988	food
Lepomis auritus (redbreast sunfish)	Japan	1987	food
Lepomis cyanellus (green sunfish)	U.S.A.	1999	food
Lepomis macrochirus (bluegill)	Japan	1987	food
Lepomis megalotis (long-ear sunfish)	Japan	1987	food
Lepomis nigromaculatus (spotted sunfish)	U.S.A.	1989	food
Lucioperca lucioperca (pikeperch)	USSR	1960's	food
Lutjanus argentimaculatous (creek red bream)	Southeastern Asia	1992	sale
Macquaria ambiguus (golden perch)	Australia	1991	food
Micropterus salmonides (largemouth bass)	Hong Kong	1983	ornament
Morone saxatilis (striped bass)	U.S.A.	1990	food
Notopterus blanci (featherback)	Thailand	1990	ornament
Notopterus chitala (featherback)	Thailand	1990	food
Oncorhynchus kisutch (coho salmon)	U.S.A.	1982	food and sport
Oncorhynchus mykiss (rainbow trout)	DPRK	1959	food and sport
Oncorhynchus mykiss var. (golden trout)	Japan	1996	food
Oreochromis aureus (blue tilapia)	Taiwan	1981	food
Oreochromis anulerson (yellow-belly tilapia)	Africa	1987	food
Oreochromis mossambicus (Mozambique tilapia)	Viet Nam	1957	food
Oreochromis nilotics (Nile tilapia)	Sudan	1978	ornament
Osteoglossum bicirrostum (arawana)	South America	1990	ornament
Osteoglossum. ferreirai (black arowana)	South America	1990	ornament
Oxyelectris marmoratus (marbled sleeper)	Thailand	1988	food
Pangasianodon gigas (giant catfish)	Thailand	1986	food
Pangasius sutchi (sutchi catfish)	Thailand	1978	food and ornament
Polyodon spathula (puddlefish)	U.S.A.	1988	food and sale
Prochilodus scrofu (Brazil perch)	North America	1996	food
Puntius gonionotus (silver barb)	Thailand	1986	food
Salmo trutta fario (European brown trout)	Britain	1976	food and sport
Sarotherodon galilaeus (Galilee cichlid)	Sudan	1978	food
Scleropages formosus (Malayan bonytongue)	Thailand	1990	ornament
Scleropages leichardti (Australian bonytongue)	Australia	1990	food
Stizostedion virtreum (Walleye)	Canada	1993	food
Silurus glanis (European catfish)	France and Hungary	1990	food
Trichogaster trichopterus (spotted gourami)	Thailand	1990's	ornament
Tilapia zilli (red-belly tilapia)	Thailand	1978	food

Cudmore 1999). But after being introduced to China they were used as food, and only rainbow trout (*Oncorhynchus mykiss*) gained popularity. Rainbow trout, which is native to North America, is now among the most widely cultured species on earth. It was imported to Japan in 1877 and entered the Democratic People's Republic of Korea (DPRK) in 1946. Thirteen years later, a certain amount of this species was received as gift by China's government from the chairman of DPRK; hence it began to expand from Northern, Northeastern China down towards the southern parts, cultivated in ponds and cages, providing food as well as angling opportunity for the Chinese people (Liu and Sun 1998).

CHARACIDS

Freshwater clossoma (*Clossoma branchypomus*) was the characid species introduced into China. It is native to North America and Africa. Since 1985 it has spread all over Southern China's inland waters due to its rapid growth, high production and availability of feed. Its colorful body is also attractive to some consumers.

CLARIIDS

Clara (*Clarias lazera*) was probably one of the most influential species in China in the early 1990's because of its wide food habits. It is an omnivorous species that can live on dead animals including dead fish and by-products from abattoir. Artificial feeds will not prevent it from fast growing. Zhu et al. (1996) reported that a fingerling could achieve 650 g weight after 5-month growth. These excited many peasants and local governments, so that clara production soon increased and played an important role in China's freshwater fisheries during the first half of 1990's. However, with the development of aquaculture, this low quality fish was not welcomed by the market and was gradually replaced by other catfishes such as southern catfish (*Silurus meridionalis*) and channel catfish (*Ictalurus punctatus*).

ICTALURIDS

Channel catfish was initially distributed in the drainage of Mississippi River, U.S.A. It was introduced into Central China in 1984, and it rapidly became one of the most efficient aquaculture species. Apart from fast growing and its good quality, it is tame, easy to capture, and fit for monoculture or polyculture in ponds. Now it is more frequently emerging in the cages of great inland waters (Xiong 1997).

TILAPIAS

Since Mozambique tilapia (*Oreochromis mossambicus*) was imported into China via Viet Nam in 1957, it was very easy for tilapias to enter China's inland waters. At least ten species of them have been introduced and many of them were steadily established. Unlike North America, tilapias are usually used as food and seldom employed as biological control organisms in China. They were so prolific that the gross production of tilapias ranked second in the late 1990's among all the freshwater fishes, only less than Chinese carps (FAO 1998). Li (2000) expected that tilapias will no longer be regarded as food for the poor; they can join the food recipe of the middle-class and the rich, too. It is also anticipated that tilapias would become the fishes, which have the greatest competitive capability in the international freshwater product markets after China reentered the WTO. Large-scale trade is associated with tilapias, too.

CENTRARCHIDS

Largemouth bass (*Micropterus salmonides*) is the most popular and widely stocked warm-water species in the U.S.A. (Smith and Reeves 1986). Its fast growth and delicious taste was highly accepted by some Chinese people so that it was also introduced into China's inland waters, regardless of its strict requirement for forages. Zhang and He (1994) reported that largemouth bass grows more quickly in Southern China than in U.S.A., and formulated feeds for largemouth bass were also available.

Intentionally transferred native fishes in China's inland waters

China is one of the countries with high aquatic productions in the world. According to literature consulted and *in situ* surveys, nearly 100 species of China's native freshwater fishes were found to be translocated into other habitats, especially into aquaculture systems (Table 2).

CYPRINIDS

Chinese carps are the highest produced fishes in the world (FAO 1998). The famous "Four Chinese Domestic Carps", silver carp (*Hypophthalmichths molitrix*), bighead carp (*Aristichthys nobilis*), grass carp (*Ctenopharyngodon idella*), and black carp (*Mylopharyngodon piceus*), together with common carp (*Cyprinus carpio*) form the most part of production.

Common carp is the earliest species of fish cultured in China's inland waters. It was reported that no later than the Yin Dynasty (about 1600's B.C.-1000's B.C.) common carp was raised in ponds; till the Han Dynasty it was introduced to many artificial ponds and even great inland waters and became established. Artificial reproduction of the "domestic carps" had not been achieved until 1950's, but during the Tang Dynasty (618-907) these fishes were already stocked in inland waters. Fry and fingerling were captured from rivers and delivered to ponds. The culture of goldfish, white bream (*Parabramis pekinensis*) and Chinese blunthead bream (*Megalobrama amblycephala*) is a long history-story, too (Empirical Summarizing Committee of China's Freshwater Fishes Culture 1973).

Recently the transfer and husbandry of native carps in China's inland waters is very intensive. They are really ubiquitous: extending to various kinds of freshwaters including rivers, lakes, reservoirs, ponds and even rice fields etc; being monocultured, polycultured and cultivated in cages and net-enclosures; emerging in each province of China. Consequently carps are the most important freshwater species and their gross production is much higher than other species.

As a fast-growing herbivorous fish appreciated by Chairman Mao, Chinese blunthead bream is another kind of intensively raised carp. Sometimes it is used as a substitute of grass carp and functioned more efficiently (Cao 1960; Li et al. 1991).

Table 2. Main intentionally transferred native fishes in China' inland waters

Species name	Main purpose	New habitat	Culture pattern
Acipenser dabryanus (river sturgeon)	food and sale	reservoirs and ponds	extensive stocking
Acipenser ruthenus (sterlet)	food and sale	great inland waters	extensive stocking
Acipenser schrenckii (Amur sturgeon)	food and sale	great inland waters	extensive stocking
Acipenser sinensis (Chinese sturgeon)	conservation	reservoirs	extensive stocking
Angurilla japonica (Japanese eel)	food	ponds and reservoir	intensive
Aristichthys nobilis (bighead carp)	food	all kinds of inland waters	all patterns
Bostrichthys sinensis (Chinese occelated gudgeon)	food	ponds	intensive
Brachymystax lenok (Siberian salmonid fish)	conservation	ponds	intensive
Carassius auratus (goldfish)	food and ornament	all kinds of inland waters	all patterns
Carassius auratus gibelio (Prussian carp)	food	all kinds of inland waters	all patterns
Carassius carassius (crucian carp)	food	all kinds of inland waters	all patterns
Channa argus (Chinese snakehead)	food	ponds and cages	intensive
Channa asiatica (Chinese fish)	food and bio-control	ponds and cages	intensive
Channa maculata (snakehead mullet)	food	ponds and cages	intensive
Cirrhina molitorella (mud carp)	food and prey	ponds	intensive
Coilia brachygnathus (shortjaw tapertail anchovy)	food	great inland waters	extensive stocking
Coilia ectenes (estuarine tapertail anchovy)	food	great inland waters	extensive stocking
Coilia mystus (long-tailed anchovy)	food	great inland waters	extensive stocking
Ctenogobius shennongensis (Shennong goby)	conservation	bream	extensive stocking
Ctenopharyngodon idellus (grass carp)	food and bio-control	all kinds of inland waters	all patterns
Culter erythropterus (redfin culter)	food	great inland waters	extensive stocking
Cyprinus carpio (common carp)	food	all kinds of inland waters	all patterns
Diptychus dybowskii (naked osman)	conservation	ponds and lakes	extensive stocking
Distoechodon tumirostris (roundsnout)	food and bio-control	all kinds of inland waters	extensive stocking
Elopichthys bambusa (yellow-cheek carp)	food and bio-control	all kinds of inland waters	extensive
Erythroculter dabryi (blue-fin culter)	food	great inland waters	extensive stocking
Erythroculter erythropterus (whitefish)	food	great inland waters	extensive stocking
Erythroculter ilishaeformis (top-mouth)	food	great inland waters	extensive stocking
Erythroculter mongolicus (Mongolian redfin)	food	great inland waters	extensive stocking
Esox reicherti (Amur pike)	food and bio-control	all kinds of inland waters	extensive stocking
Fugu obscurus (obscure puffer)	food and sale	ponds and cages	intensive
Fugu rubripes (tiger puffer)	food and sale	ponds and cages	intensive
Gymnocypris przewalskii (Tsinhai Lake naked carp)	food	great inland waters	extensive stocking
Hemibarbus labeo (skin carp)	food	great inland waters	extensive stocking
Hemibarbus maculatus (spotted steed)	food	great inland waters	extensive stocking
Hemiculter leucisculus (sharp-belly)	food	all kinds of inland waters	extensive stocking
Hucho taimen (taimen)	conservation	ponds	intensive
Huso dauricus (Siberian great sturgeon)	food and sale	ponds	intensive
Hypophthalmichthys molitrix (silver carp)	food and bio-control	all kinds of inland waters	all patterns
Leiocassis longirostris (long-snout catfish)	food and sale	ponds and cages	intensive
Leptobotia elongata (simple-spined sand-loach)	food and ornament	ponds and cages	intensive
Leuciscus waleckii (Amur ide)	food	ponds	intensive
Liza haematocheila (mullet)	food	all kinds of inland waters	extensive stocking
Macrura reevesii (shad)	food	ponds and rivers	intensive and stocking

continued...

Table 2 continued...

Species name	Main purpose	New habitat	Culture pattern
Megalobrama amblyocephala (Wuchang bream)	food	all kinds of inland waters	all patterns
Megalobrama terminalis (black bream)	food	all kinds of inland waters	all patterns
Megalobramahoffmanni (Guangdong black myers)	food	ponds and cages	intensive
Misgurnus anguillicaudatus (oriental weatherfish)	food	ponds and ricefields	intensive
Monop terus albus (rice-field eel)	food	ponds and ricefields	intensive
Mugil cephalus (common mullet)	food	all kinds of inland waters	intensive and stocking
Mugil soiuy (mullet)	food	all kinds of inland waters	intensive and stocking
Mylopharyngodon piceus (black carp)	food and bio-control	all kinds of inland waters	all patterns
Mystus guttatus (large-fin longbarbel catfish)	food	ponds	intensive
Mystus macropteus (spotted longbarbel catfish)	food	ponds	intensive
Neosalanx jordani (Jordan's icefish)	sale	great inland waters	stocking
Neosalanx pseudotaihuensis	sale	great inland waters	stocking
Neosalanx tangkahkeii taihuensis (Taihu lake icefish)	sale	great inland waters	stocking
Odontobutis obscura (dark sleeper)	food	ponds	intensive
Odontobutis potamophila (river sleeper)	food	ponds	intensive
Oncorhynchus gorbuscha (pink salmon)	food	ponds and rivers	intensive and stocking
Oncorhynchus keta (chum salmon)	food	ponds and rivers	intensive and stocking
Oncorhynchus masou (Masu salmon)	food	ponds and rivers	intensive and stocking
Opsarichthys biden (Korean piscivorous chub)	food and prey	all kinds of inland waters	stocking
Parabramis pekinensis (white bream)	food	all kinds of inland waters	all patterns
Paramisgurnus dabryamus (loach)	food	ponds and ricefields	intensive
Parasilurus asotus (catfish)	food	all kinds of inland waters	intensive and stocking
Pelteobagrus fluvidraco (yellow catfish)	food	all kinds of inland waters	intensive and stocking
Pelteobagrus nitidus (shinning catfish)	food	all kinds of inland waters	intensive and stocking
Pelteobagrus vachelli (darkbarbel catfish)	food	all kinds of inland waters	intensive and stocking
Perca fluviatilus (freshwater perch)	food	great inland waters	stocking
Plagiognathops microlepis (small-scale yellowfin)	food	great inland waters	stocking
Plecoglossus altivelis (sweetfish)	food and sale	great inland waters	stocking
Procypris merus (Chinese ink-carp)	food	ponds	intensive
Protosalanx hyalocranius (large icefish)	sale	great inland waters	stocking
Pseudolaubuca sinensis	food	great inland waters	stocking
Salvelinus malma (dolly varden charr)	conservation	rivers	stocking
Scaphesthes macrolepis (largescale shoveljaw fish)	food	ponds	intensive
Schizopygopsis malacanthus (weakspine schizothoracin)	conservation	rivers	stocking
Schizothorax grahami (Kunming schizothoracin)	conservation	rivers and ponds	stocking
Schizothorax prenanti (Prenant's schizothoracin)	conservation	rivers and ponds	stocking
Silurus asotus (oriental sheatfish)	food	all kinds of inland waters	intensive and stocking
Silurus meridionalis (southern catfish)	food	all kinds of inland waters	intensive and stocking
Silurus soldatovi (northern catfish)	food	all kinds of inland waters	intensive and stocking

Because the taste and cooking technique is consistent with the eating habits of Chinese, small-scale yellowfin (*Plagiognathops microlepis*), yellowtail (*Xenocypris davidi*) and some culters were developed in great inland freshwaters (Luo et al. 1997; Ma and Yang 1997).

PERCHES

Chinese freshwater perches were praised in many ancient Chinese poems. Rough-skin sculpin (*Trachidermus fasciatus*) is regarded as the champion of "the four most famous Chinese freshwater fishes" (Ye 1999). Mandarin fish (*Siniperca chuatsi*) is a traditional first-rate species that is now widely moved to ponds and great inland waters successfully, although this carnivorous fish is apt to die before its first feeding (Gong 1989; Zhang et al. 2000).

CATFISHES

Compared with "veteran" Chinese carps, catfishes are indeed "recruits" of China's freshwaters aquaculture species (Yuan 2000). Nevertheless in the last decade, many farmers are attracted by their market price. Both southern catfish (*Silurus meridionalis*) and yellow catfish (*Pelteobagrus fulvidraco*) were transferred into ponds and cages in lakes and reservoir for their fine quality, and they become increasingly popular.

ICEFISHES

The prelude in the introduction of icefishes in China was facilitated by the thriving of the Taihu Lake icefish (*Protosalanx tihuenensis*) in Dianchi Lake, Yunnan, China, which provided more yield than its native habitat, Taihu, Jiangsu, China. Henceforth, icefishes were introduced into a great number of lakes and reservoirs. However, it turned out that in the northern part of China, temperature was fit to the reproduction of these semelparous species (Qin et al. 1999).

Main purpose of fish introduction

Lou (2000) pointed out that introduction and transfer could enrich fish breeding materials and modify fish fauna hence yield and quality would be improved. However, the purpose of introduction and transfer of different species were different.

AQUACULTURE

Providing new food resources to the local people may have been the first purpose of some regions in China during the last 30 years. Large-scale introduction and transfer of fishes actually helped to provide food security to local people. This was highlighted by the transfer and introduction of Chinese carps and tilapias, reflecting the situations of developing countries.

With the development of economy and society, more Chinese people accepted "Healthy Consumption". Recreative fishing is now developing. Some suitable species were selected for the purpose and introduced or transferred to meet the requirement. Several goldfishes and trouts are good candidates to support sport fishing.

In the list of China's top-class freshwater fishes, many of which are carnivorous, the increase in the cultivation of these species has often made it necessary to simultaneously introduce a certain quantity of food fishes. In many ponds, southern catfish fed on exotic common carps and goldfishes (Wang and Zha 2000). Fry or fingerlings of Chinese carps were appropriate preys for juvenile mandarin fish (Gong 1989).

ORNAMENT

The history of ornamental fish culture in China was traced back to the Song Dynasty (960-1279); goldfishes were raised then in ponds or domestic containers (Empirical Summarizing Committee of China's Freshwater Fishes Culture 1973). Presently ornamental fish culture has become very fashionable especially in big cities. Carp and tropical species were dispersed quickly.

CONSERVATION OF FISHERIES RESOURCES

To prevent the extinction of some endangered or endemic fishes, introduction is naturally considered as a basic rescue measure (Liu and Cao 1992). When inland waters suffered from disastrous damage, introduction was also employed as a remedy to restore fisheries resources (Li 1993; Le 1995). After a dry-up or heavy pollution, the water in a reservoir might be refreshed, then a similar composition of original fauna is exposed to introductions (Shi 2000).

BIOLOGICAL CONTROL

The classical definition of biological control is the importation and release of an organism outside its natural range for the purpose of controlling a pest species. It is widely applied in the inland waters of China. In the beginning of aquaculture in inland waters, grass carp was usually recruited as an "exploiter" to control over thriving macrophytes. Silver carp is thought of as a good algal feeding fish and used to control "algal bloom" (Chen et al.. 1991; Liu and Huang 1997). Mosquitofish (*Gambusia affinis*) was imported to eliminate mosquito larvae whose adults are vectors of malaria spread. Similarly, the eradication of snail (*Oncomelania*), intermediate host of blood fluke (*Schistosoma makangi*), is suggested to be the purpose of introducing black carp and other benthic feeding fish species.

SALE

Some special fishery products occupy a considerable international market, so enthusiasm of relative introductions is easy to stimulate. The once-prevailing

icefish introductions and the newly commenced sturgeon introductions are good examples (Qin et al. 1999; Liu and Hu 2000). Some introduction and transfer are only for commercial benefit of individual people. They used to find some new-cultured species, especially exotic, and tried to convince the fish farmers or consumers that these species had many merits and good market prospects. Thus introduction and transfer are expanded.

Impacts of fish introductions

Benefits from fish introduction and transfer were often accompanied by negative and even disastrous results (Chen and Cui 1993; Alan and Coscarelli 1999). In America, this was well illustrated by case histories (Alan and Coscarelli 1999). In contrast to America, it seemed less apparent in China because economic efficiency was more important there. However, there has been a growing concern about the impact of fish introduction and transfer (Chen and Cui 1993; Li and Cai 1995; Lou 2000; Shi 2000).

ECOLOGICAL IMPACTS

Introduction is evaluated by some ecologists as “ecological roulette” or “a game of chance” and so on (Charles and Cooley 1999). It is possible to connect a decrease in the population of indigenous species to an increase in the population of non-indigenous ones, in a qualitative view. This is attributed to competition for food and space, predation, damage to the habitat of local species and the exotic pathogens (Lassuy 1995; Beamesderfer 2000; Tyus and Saunders 2000).

Chen and Cui (1993) believed that the loss of biodiversity of several lakes in Yunnan, especially the extinction of some endemic fishes including small whitefish silvery belly-keeled-dace (*Anabarilius alburnops*) and *A. polylepis* in Dianchi Lake, China, was mainly caused by the introduction of exotic fishes, which predated on and competed with the vulnerable endemic species. Mistakes were made by the famous “exploiter” grass carp in many lakes in China. The over stocking of herbivorous species wiped out the macrophytes. It increases the speed of eutrophication and results in growth of algal blooms (Jao and Zhang 1980). Some disease break-outs were due to the entrance of pathogens attached to introduced and transferred fishes, too (Lou 2000). Hybridization between non-indigenous and indigenous fishes tends to incur reproductive disturbance. Li and Cai (1995) found introgression in tilapias, and suggested that action should be taken to protect genetic pools.

ECONOMIC IMPACTS

Once an introduced species was established, it is hard to control especially when it becomes a “nuisance” species due to overpopulation (Beamesderfer 2000; Tyus and Saunders 2000). In some reservoirs, after the increase of yellowcheek carp (*Elopichthys bambusa*), and other voracious carnivorous fishes, fingerlings are unable to escape from predations thus tremendous eco-

nomic loss was experienced. Restoration of reservoir's fauna also brought about elimination of such species (Shi 2000).

Countermeasures to introduction and transfer

It is high time that effective measures be taken to deal with the risks of fish introductions. Through cooperation of legislation, education, administration and technical assistance, the initial good intention of fish introduction will be accomplished.

The first legislation towards introduction control in U.S.A. was passed in 1900 (Benson 1999). Recently there are many acts of this kind implemented in U.S.A. and Canada. Nevertheless in China, special laws aimed at introduction and transfer are lacking. Enforcement of legislation for controlling fish introduction and transfer is urgently needed in China.

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