Chapter 6
The Status Of Introduced Carp Species In Asia[1]

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6.1 Introduction

Cyprinids are the most important group in aquaculture in Asia, accounting for 49 per cent of the total aquaculture production Asia in 1999 (FAO 2001a), and they also account for a large number of the introductions of tropical/ subtropical finfish in the region (de Silva 1989). Introduction is defined as the act of intentionally or accidentally transporting and releasing an organism into an environment outside its present range (ICES 1988). In fish, the main reasons for deliberate introductions include increased production, employment, generation of foreign exchange, biological control and recreation (FAO 1996). While tremendous benefits can be and have been derived from fish introductions, there are also indications that movement of alien cyprinid species, both across international borders and across watersheds, has led to negative effects in natural ecosystems. The available information on species introductions, however, reports mainly on movements across country boundaries and very seldom on movements across zoogeographical boundaries or watersheds.

The Asian countries, in particular Bangladesh, China, India, Indonesia, Thailand and Vietnam, have vast carp genetic resources that are an important element of their aquaculture production systems. Hence, in recent years, the governments of these countries have been recognizing the need to exercise a precautionary approach in the introduction of any aquatic organism, including carps.

Information on the introduced species is a pre-requisite for implementing programs aimed at the conservation of genetic resources. This chapter discusses the status of introductions of cyprinid species across international borders in Asia. The data used were derived mainly from the FishBase[3] records of fish introductions, the Food and Agriculture Organization (FAO) of the United Nations database on species introductions, the International Network on Genetics in Aquaculture (INGA)[4] records on germplasm transfer and reports from INGA member countries. These include each instance in which a non-native species is moved into a recipient country, even if the species has already been moved into that recipient country before.

6.2 Species introduced and sources

A total of 259 introductions of cyprinid species have been recorded in the 27 countries of Asia. Of these, 72 per cent (186 records) were from countries within Asia, 10 per cent (26 records) were from countries outside Asia and another 18 per cent (47 records) were from "unknown" countries (Annex 6.1). The available records indicate introductions of forty-two cyprinid species. Fig. 1 shows the top five most often introduced cyprinid species based on the number of records. Common carp (*Cyprinus carpio*) was the most often introduced species in the region (52 records), followed by the grass carp (*Ctenopharyngodon idella*) (29 records), silver carp (*Hypopthalmichthys molitrix*) (28 records), bighead carp (*Aristichthys nobilis*) (20 records) and goldfish (*Carassius auratus auratus*) (15 records). The high frequency of introductions of *C. carpio* could be the result of this species having the longest history of culture and domestication among the cyprinids. It is believed that the species has been farmed in China for over 2000 years.

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[3] FishBase is an information system with key data on the biology of all fish. It has been developed by the WorldFish Center (formerly ICLARM) in collaboration with the Food and Agriculture Organization (FAO) of the United Nations and many other partners (Froese and Pauly 2002). Information on fish introductions in FishBase is an updated version of the original of Welcomme (1988) and has been expanded to include records of FAO, INGA and literature searches (Casal and Bartley 2000).

[4] INGA is a global forum for applied fish breeding and genetics. It plays an important role in national, regional and international genetics research aimed at improving productions from aquaculture operations and conservation of aquatic genetic resources. It has a membership of 13 countries from Asia, the Pacific and Africa and 12 advanced scientific institutions, international and regional organizations, with the WorldFish Center as the member coordinator (Gupta and Acosta 2001).

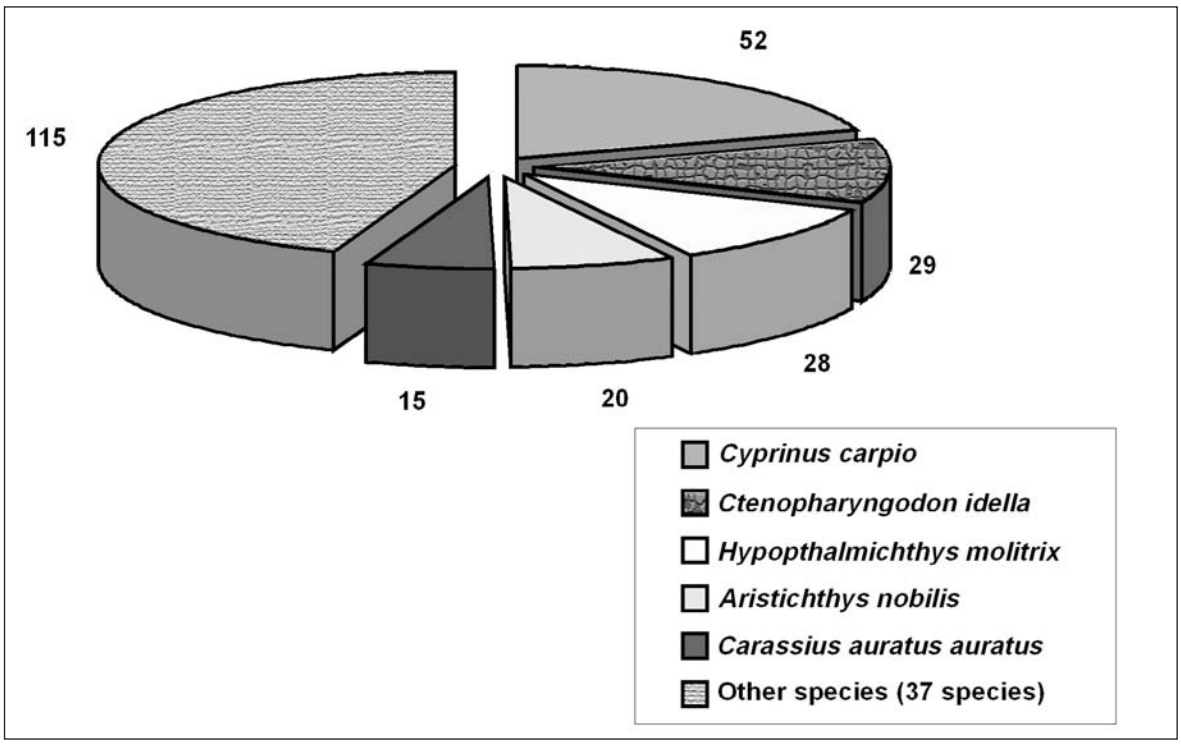

Fig. 6.1. Most commonly introduced cyprinid species based on the number of records (data based on the table in Annex 6.1)

6.3 Dates of introductions

Fig. 6.2 summarizes the number of cyprinid species introduced into the countries in Asia over time. Some of these introductions were made before the 18th century, with 38 records (or 14.7 per cent of the total) before 1950. *C. carpio* was the most frequent species among these early introductions. Apart from common carp, the Chinese carps were also introduced from the Pearl and Yangtze rivers to different provinces of China, Thailand, Singapore and Malaysia. The 4-5 cm fry were transported in wooden tubs on board ships until at least 1948, when fry were successfully transported by air for the first time (Lin 1949).

Subsequent introductions took place in the 1950s but the number of records for this period is only 11, or 4.2 per cent. During the 1960s, the frequency of introductions was at its highest (20 per cent or 52 records). The success of induced breeding through hypophysation, that improved fry supply, probably explains the increase of introductions during this decade. Over the next two decades, introductions became less frequent. Only 29 (11 per cent) and 31 (12 per cent) introductions were recorded in the 1970s and 1980s, respectively. From the 1990s to 2001, there was a further reduction in the recorded frequency of introductions (6.6 per cent or 17 records), probably because: (i) most of the non-native species that are good candidates for aquaculture had already been introduced in many countries; (ii) heightened awareness of the risks involved in introductions in terms of impact on the environment, biodiversity and introductions of pathogens; and (iii) there is now greater focus in the countries to improve the genetic quality of their native carp stocks. About 31.3 per cent (81 records) of cyprinid introductions have no indications of the period or year the fish were brought into the country. The period of introduction was listed in FishBase as either "unknown" or left blank. The relatively high number of unknown time of transfer and unrecorded transfer of carps in the region may also be a reflection of accidental introductions or deliberate introductions without authorization from governments. In India, for instance, *A. nobilis*, *Cirrhinus molitorella* and *Mylopharyngodon piceus* have been introduced without authorization (Ponniah 1997).

6.4 Reasons for introductions

The earliest introductions of cyprinids in Asia were carried out mainly by the Chinese who "imported" both exotic species and culture systems into many Southeast Asian countries where they settled, rather than buying and consuming still relatively abundant local wild fish. Hence, it may

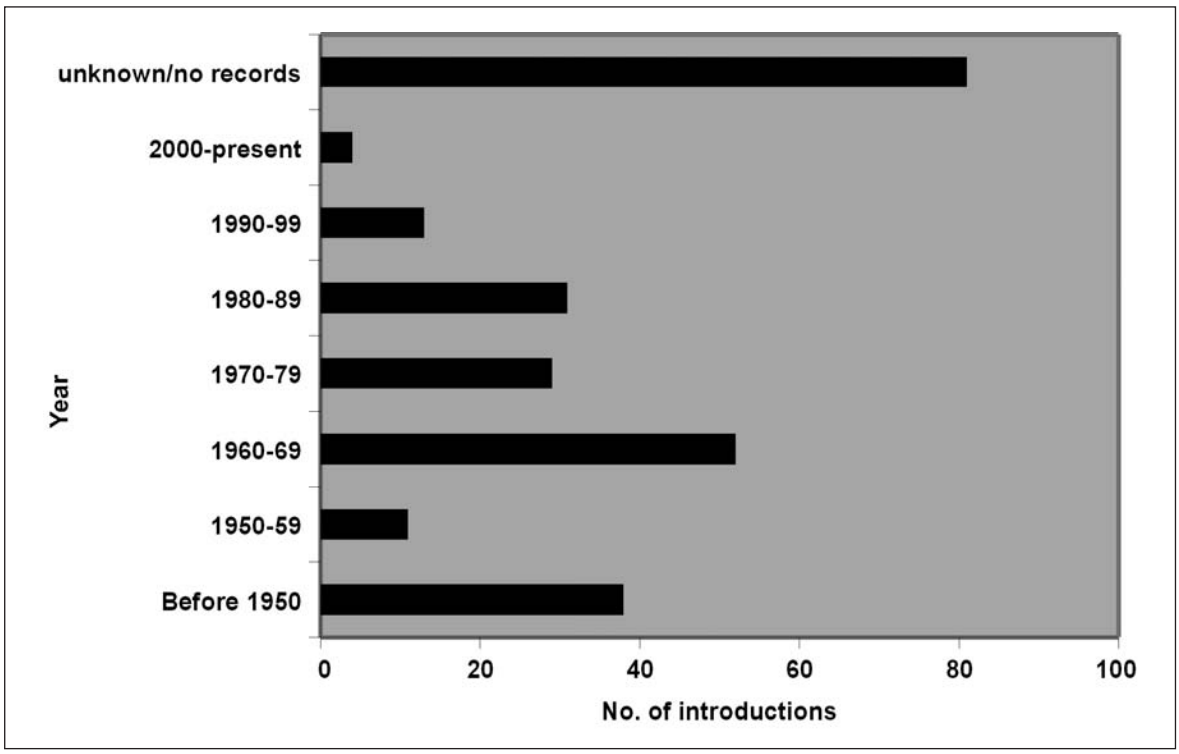

Fig. 6.2. Cyprinid introductions in Asia per decade (data based on the table in Annex 6.1)

be surmised that early introductions were due to cultural preference for Chinese carps based on nostalgia and well-established culinary tradition. Convenience may also have played a role for the predominantly urban-based Chinese in Southeast Asia, because fish culture could provide a predictable, abundant, year-round supply of fish in contrast to often seasonal capture fisheries (Edwards et al. 1997).

Subsequent to early introductions, cyprinids were introduced mainly to enhance fisheries/aquaculture production and thereby to increase the available animal protein sources. Based on FishBase records, Fig. 6.3 summarizes the reasons for introducing carps in Asia. Use in aquaculture operations was the most frequent (69 per cent or 175 records) reason for introducing carps in all countries in the region. The main reason for introduction was primarily to broaden the species spectrum in fish farming and increase yields through better utilization of trophic niches. This reflects the greater focus given by the countries in the region to aquaculture, in contrast to developed countries where fish are most often introduced to support recreational fishery activity. The other major reasons given were ornamental (10.4 per cent or 27 records) and research (9.3 per cent or 24 records). In a few instances, phytoplankton/weed control, snail control and angling/sport were also indicated as the purpose of the introductions (1.5 per cent or 4 records). There were also several cases of accidental or unknown reasons for the introductions (9.7 per cent or 25 records).

6.5 Effects of introductions

The known effects of introducing carps in Asia are summarized in Annex 1. These are categorized as to whether they are known to have resulted in significant ecological and socioeconomic impacts.

FAO (2001b) reported that among the cyprinids, *A. nobilis, C. auratus, Catla catla, Labeo rohita* and *M. piceus* are the species generally viewed as "beneficial" where introduced. In terms of socioeconomic effects, the introduction of Indian and Chinese major carps in Asian countries has paved the way for the progress made in carp aquaculture. This is more evident in the six main carp producing countries in the region: Bangladesh, China, Indonesia, India, Thailand and Vietnam. In Bangladesh, where a number of exotic major carps (*H. molitrix, A. nobilis, C. idella, M. piceus, C. carpio, Tor putitora* and *Barbonymus gonionotus*) were introduced for aquaculture as early as the 1950s, these species (except for *T. putitora*) have become a part of aquaculture and fishery operations (Hossain 1997), for polyculture in ponds or for stocking in floodplains, rivers and

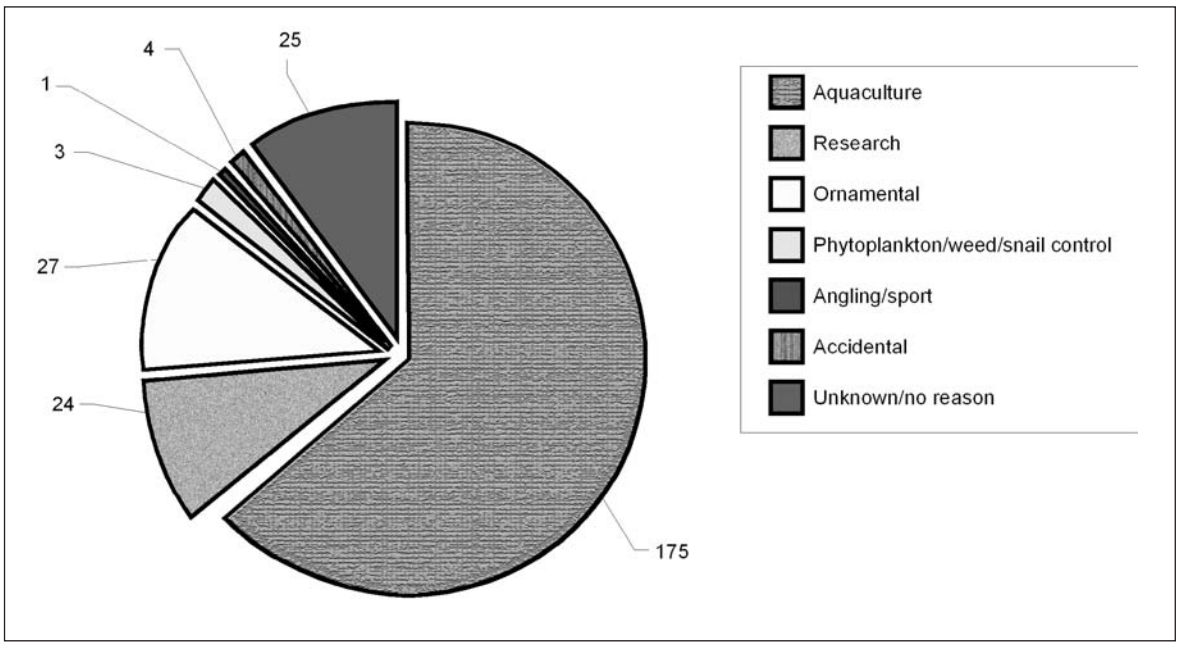

Fig. 6.3. Reasons for introduction of cyprinids based on a number of records

reservoirs to enhance natural fisheries (Gupta et al. 1997). In India, *H. molitrix* and *C. idella*, which occupy two important ecological niches hitherto vacant in the traditional polyculture system, have played a significant role in the country's aquaculture ever since their introduction in 1959 (Tripathi 1989). *H. molitrix* , *C. idella* and different strains of *C. carpio* that have been introduced into India form an important component of polyculture of indigenous and exotic species. In Indonesia, *C. carpio*, which was believed to be the first species introduced in the country, has become the most common fish cultured in freshwater ponds, cages and running water systems (Eidman 1989). In Thailand and Vietnam, the introduced *C. carpio*, *L. rohita*, and *C. cirrhosus* are used for aquaculture. For example, in northern Vietnam, *C. carpio* has been sustained because the species is bred at the household level and rice/ *C. carpio* culture has been carried out locally for generations and been adapted to local circumstances (Edwards et al. 2000). Apart from *C. carpio*, the Indian major carps, *L. rohita* and *C. cirrhosus* have also become economically important cultured species in Vietnam as they are easy to breed in hatcheries and grow fast in different culture systems (Thien and Dan 1997).

While the introduction of major carp species has proven to be a boon in aquaculture and optimized the yield in ponds, the accidental and deliberate stocking of these in open waters has, in a few instances, resulted in negative ecological effects. The introduction of *C. auratus, C. idella, C. carpio* and *H. molitrix* in India is viewed as controversial in that they have created ecological problems of various kinds but are, at the same time, perceived as being extremely useful socioeconomically (FAO 2001a; FAO 2001c). These species have made a substantial contribution to food production but have also been implicated in threatening endemic species in the country. This has been the case in India where *H. molitrix* introduced in Gobindsagar Reservoir reportedly resulted in a sharp decline of the dominant native species *C. catla* due to overlapping feeding habits and habitat. Production of *H. molitrix* in the reservoir increased from 0.60 tonnes to 334 tonnes in 10 years (from 1977-78 to 1987-88), while *C. catla* production, which was 210 tonnes in 1977-78, declined to 36.7 tonnes in 1987-88. Similarly, in Kalgarhi Reservoir the *C. catla* population declined as a result of competition with *H. molitrix* (Das 1997).

In Girna and Krishnarajasagar reservoirs (India), the introduction of *C. carpio* has resulted in the decline of *Cirrhinus* sp. *C. carpio*, because of its habit of stirring up the bottom while feeding, has the reputation of muddying the waters it occupies. This shades out macrophytes, chokes benthic invertebrates, and through the more rapid recycling of phosphate contributes to accelerated eutrophication. As a result, the composition and abundance of the native fish fauna are affected (FAO 2001b).

6.6 Need for and development of a precautionary approach

Global efforts through fisheries regulations, conventions, treaties and agreements are now emerging to protect biodiversity and minimize the risks caused by human actions and development activities.

One of the risks associated with species introductions is the spread of disease. International codes of practice, technical guidelines which describe, at least in part, standardized protocols for minimizing the risks of disease associated with movements of aquatic animals are currently available (Subasinghe et al. 2001). Examples of these are the International Council for Exploration of the Sea (ICES) Code of Practice on the Introductions and Transfer of Marine Organisms (ICES 1995) and the European Inland Fisheries Advisory Commission (EIFAC) Codes of Practice and Manual of Procedures for Consideration of Introductions and Transfer of Marine and Freshwater Organisms (Turner 1988). Within the Asia-Pacific region, the Network of Aquaculture Centres in the Asia-Pacific (NACA), in cooperation with the Office International des Epizooties (OIE) and FAO have initiated measures to minimize disease risks caused by the transboundary movement of aquatic organisms. These include, among others, the establishment of a disease surveillance and reporting system in the region (Subasinghe et al. 2001) and production of a set of technical guidelines on health management for the responsible movement of live aquatic animals in Asia (FAO and NACA 2000, 2001). These efforts complemented the existing FAO Code of Conduct for Responsible Fisheries that provides a global framework for the sustainable use and conservation of biological diversity (FAO 1995).

Naylor (1994) stressed the importance of institutionalizing quarantine programs in developing countries to minimize the risks of disease and other factors that may contribute to loss of biodiversity and damage to ecosystems as a result of species introductions. Although existing agreements, international codes of practice and guidelines have placed emphasis on precautionary measures such as quarantine, these are still left to the responsibility of individual countries. Hence, in many instances of species introductions, these measures have not been fully implemented. International cooperation is one mechanism to ensure effective implementation of these regulatory measures. The INGA, which the WorldFish Center has been coordinating since 1993, provides assistance to 13 developing member countries (9 are from Asia) in the exchange of fish germplasm, for evaluation, direct use in aquaculture or utilization in breeding programs. Protocols and quarantine procedures formulated by the network based on international codes of practice and the Material Transfer Agreement are being followed in the transfer of germplasm through the network (Gupta and Acosta 2001). To avoid the risk of contaminating wild gene pools through interbreeding, it has been the policy of INGA not to transfer species that are endemic to potential recipient countries. INGA has also not made any new introductions, i.e. brood stock exchange has only been supported where a non-endemic species has previously been introduced into the recipient country.

Globally, governments and the international community have recognized that one of the major threats today to native biodiversity is the impact of alien invasive species.[5] In response to this, the IUCN has drawn up guidelines for the prevention of biodiversity loss caused by such species. Its intention is to assist all governments and management agencies to give effect to Article 8 (h) of the Convention on Biological Diversity, which states that: "Each Contracting Party 'shall, as far as possible and as appropriate: …(h) prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species'" (IUCN 2001). The Conference of the Parties to the Convention on Biological Diversity elaborated this during discussions at the Sixth Meeting of the Subsidiary Body on Scientific, Technical and Technological Advice in April 2002 and this version states that "no first-time intentional introduction of an alien species should take place without the authorization from a competent authority unless it is known that an alien species poses no threat to biological diversity. A science-based risk assessment, including environmental impact assessment, should be carried out as part of the evaluation process before coming to a decision on whether or not to authorize a proposed introduction. States should make all efforts to knowingly permit only those species that are unlikely to cause unacceptable harm to ecosystems, habitats or species" (UNEP/CBD/COP 2001).

[5] Alien invasive species means an alien species that becomes established in natural or semi-natural ecosystems or habitat, is an agent of change, and threatens native biological diversity (IUCN 2001).

The WorldFish Center addresses research and policy issues that have impacts on aquatic biodiversity through its contributions to the work of the Convention on Biological Diversity, FAO, IUCN and other international bodies/ organizations (ICLARM 1999). In line with this effort and prompted by the need to promote public awareness and strict implementation of conservation measures, the WorldFish Center, in collaboration with its partners, held expert consultation meetings on ecological risk assessment of introductions of genetically improved and modified aquatic organisms and conservation of biodiversity (Gupta et al. 2004; WorldFish Center 2002, 2003). The meeting, organized in Bangladesh in 2003 (WorldFish Center 2003), recognized that existing institutional mechanisms, polices and legal frameworks related to introductions do not adequately cover issues posed by improved strains and suggested that effective institutional frameworks, monitoring and enforcement mechanisms be established at national and local levels as appropriate. The meeting also suggested that transparent, objective and practical methodologies be adopted and promoted for assessment of risks associated with the dissemination of improved strains of fish (WorldFish Center 2003).

6.7 Conclusion

The benefits derived from introductions of cyprinid species in the region are evident in terms of improving overall fish yields through aquaculture. The introductions of this group of fish for aquaculture has resulted in significant contributions to improve human nutrition and alleviate rural poverty. The development of world aquaculture has been mostly in freshwater environments (58.7 per cent) and mainly in Asia (FAO 2000). The freshwater aquaculture production in this region is dominated by finfish, particularly the major carp species.

Although problems have been reported in a few cases, none of the carp species introduced has been regarded as a pest,[6] nor have any carps caused major negative environmental impacts. However, the many cases of "unknown" introductions of carp species in the region that are probably unauthorized by the governments, as evidenced by the incomplete entries in some of the FishBase records, and the few reported negative effects of alien cyprinid species on endemic species still merit attention. This indicates that stringent regulatory measures are still lacking in many of these countries and careful assessment of the risks was probably not done when the exotic carp species were introduced. This affirms the need for implementation of control measures on movements across international boundaries and across watersheds, of any aquatic organism, even if previous introductions of such a species have been generally perceived as beneficial.

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[6] A pest is defined as an introduced species whose behavior makes it useless for anything but forage for other fish and causes a disproportionate amount of environmental nuisance (FAO 2001b).

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Annex 6.1

History of carp introductions in Asia

Country	Species	English name	Source	Year introduced	Reason for introduction	Significant ecological effects	Significant socioeconomic effects	Reference
Afghanistan	*Ctenopharyngodon idella*	Grass carp	China	-	Aquaculture	-	Yes-beneficial	Welcomme 1988
	Cyprinus carpio	Common carp	China	Unknown (1970-79)	Aquaculture	-	-	Welcomme 1988
Bangladesh	*Aristichthys nobilis*	Bighead carp	Nepal	1981	Aquaculture	-	-	Hussain and Mazid 1997
	Barbonymus gonionotus	Silver barb	Thailand	1977	Aquaculture	-	Yes-beneficial	Rahman 1989
			Thailand	1987, 1994	Research			Hussain and Mazid 1997
			Indonesia	1994	Research			Hussain and Mazid 1997
	C. idella	Grass carp	Hong Kong	1966	Aquaculture	-	-	Hussain and Mazid (this volume)
			Hong Kong	1969	Aquaculture	-	-	Welcomme 1988
			Japan	1970	Aquaculture	-	-	Hussain and Mazid 1997
			Nepal	1979	Aquaculture	-	-	Hussain and Mazid 1997
	C. carpio	Common carp	China	1960	Aquaculture	-	-	Hussain and Mazid (this volume)
		Common carp	Hungary	1982, 1996	Aquaculture	-	-	Hussain and Mazid (this volume)
		Common carp	Vietnam	1995	Research	-	-	INGA 2002
	C. carpio	Mirror carp	Nepal	1979	Aquaculture	-	-	Hussain and Mazid 1997
	Hypopthalmichthys molitrix	Silver carp	Hong Kong	1969	-	-		Hussain and Mazid (this volume)
	Mylopharyngodon piceus	Black carp	China	1983	Aquaculture	-	-	Hussain and Mazid (this volume)
	Tor putitora	Putitor Mahseer	Nepal	1991	Unknown	Unknown	Unknown	FAO 1997; Hussain and Mazid (this volume)
Bhutan	*A. nobilis*	Bighead carp	Nepal	1983	Aquaculture			Csavas 1983
	Cirrhinus cirrhosus	Mrigal	Unknown	1985	Aquaculture	-	-	Welcomme 1988
	C. idella	Grass carp	Nepal	1983	Aquaculture	-	-	Csavas 1983

	C. carpio	Common carp	Nepal	1983	Aquaculture	-	-	Csavas 1983
	H. molitrix	Silver carp	Unknown	1984	-	No		
	Labeo rohita	Rohu	India	1985	Aquaculture	-	-	Welcomme 1988
	T. putitora	Putitor mahseer	India	1969	Ornamental	Unknown	Unknown	FAO 1997
Brunei	*C. carpio*	Common carp	Unknown	-	Aquaculture	-	Yes-beneficial	FAO 1996
Cambodia	*C. idella*	Grass carp	Unknown	-	Aquaculture	-	-	Davidson 1975
	C. carpio	Common carp	Unknown	-	Aquaculture	-	-	Alikunhi 1966
China	*A. nobilis*	Bighead carp	Hong Kong	Unknown	Aquaculture			
	B. gonionotus	Silver barb	Thailand	1986	Aquaculture	-	Yes-beneficial	Welcomme 1988
	Carassius auratus	Goldfish	Japan	1976	Aquaculture	-	Yes-beneficial	Welcomme 1988
	C. cuvieri	-	Japan	1976	Aquaculture	-	-	Tan, Y. and H.E. Tong 1989
	Catla catla	Catla	India	1973	Aquaculture	Probably no-undecided	Unknown	FAO 1997
			Bangladesh	1973	Aquaculture	Probably no-undecided	Unknown	Tan, Y. and H.E. Tong 1989
	C. carpio	Common carp	F. Germany	1982	-	-	-	Tan Jo-Jun and Tong He-Yi 1989
	L. rohita	Rohu	Thailand	1978	Aquaculture	Probably no-undecided	Probably no-beneficial	FAO 1997
	Orthodon microlepidotus	Sacramento blackfish	USA	1982	Aquaculture	-	-	Welcomme 1988
	Pseudorasbora parva	Stone moroko	Unknown	Unknown (1970-79)	Accidental	Yes-adverse	-	Kottelat and Whitten 1996
Hong Kong	*C. molitorella*	Mud carp	Unknown	-	Aquaculture	-	-	Roberts 1997
	C. idella	Grass carp	China	Unknown	Aquaculture	-	-	Shireman and Smith 1983
	C. carpio	Common carp	Unknown	-	Aquaculture	-	-	Man. and Hodgkiss 1981
	Opsariichthys bidens	-	China	1994	Aquaculture	Probably no-undecided	Unknown	FAO 1997
India	*A. nobilis*	Bighead carp	Bangladesh	1987	Aquaculture	Probably yes-undecided	Probably no-undecided	FAO 1997
			Japan	1987	Aquaculture	Probably yes-undecided	Probably no-undecided	FAO 1997
	B. gonionotus	Silver barb	Indonesia	1972	Aquaculture	-	-	Shetty, Nandeesha and Jhingran 1989
	C. auratus	Goldfish	Japan	Unknown	Ornamental	Yes-undecided	Probably no-undecided	FAO 1997
	C. carassius	Crucian carp	UK	1870	Ornamental	Probably yes-adverse	Probably yes-undecided	FAO 1997

	C. idella	Grass carp	Hong Kong	1959	Aquaculture	Probably no-beneficial	Yes-beneficial	FAO 1997
	C. carpio (German strain)	Common carp	Sri Lanka	1939	Aquaculture	Yes-adverse	Yes-beneficial	Jhingran 1991; FAO 1997
	(Bangkok strain)		Thailand	1957	Aquaculture	-	-	Jhingran 1991
			Vietnam	1995	Research	-	-	INGA 2002
			Hungary	2000	Research	-	-	INGA 2002
	(wild Amur carp)		Hungary	2000	Research	-	-	INGA 2002
			Indonesia	2001	Research	-	-	INGA 2002
	H. molitrix	Silver carp	Japan	1959	Aquaculture	Probably yes-adverse	Probably yes-beneficial	Shetty et al. 1989
	H. molitrix	Silver carp	Hong Kong	1959	Aquaculture	Probably yes-adverse	Probably yes-adverse	Shetty et al. 1989
	Puntius lateristriga	Spanner barb	Malaysia	-	Unknown; ornamental	Probably no-undecided	Probably no-undecided	FAO 1997
	P. oligolepis	Checkered barb	Indonesia	-	Ornamental	Probably no-undecided	Probably no-undecided	FAO 1997
	P. semifasciolatus	Chinese barb	Japan	-	Ornamental	Probably no-undecided	Probably no-undecided	FAO 1997
	P. tetrazona	Sumatra barb	Unknown	-	Ornamental	Probably no-undecided	Probably no-undecided	FAO 1997
	Tinca tinca	Tench	UK	1870	Phytoplankton control	-	-	Welcomme 1988
Indonesia	*A. nobilis*	Bighead carp	Taiwan	1969	Aquaculture			Eidman 1989
	B. gonionotus	Java barb	Unknown	1963	Aquaculture			
	C. auratus	Goldfish	China	Unknown	Aquaculture	-	Yes-beneficial	Welcomme 1988
		Goldfish	Taiwan	1987	Research	-	-	Eidman 1989
	C. chinensis	Chinese mud carp	Taiwan	1969	Aquaculture	-	Yes-beneficial	Eidman 1989
			Unknown	-	Aquaculture	-	-	Roberts 1997
	C. idella	Grass carp	Singapore	1915	Research	-	-	Welcomme 1988
			Thailand	1915	Research	-	-	Welcomme 1988
			Japan	1915	Research	-	-	Welcomme 1988
			Malaysia	1915	Research	-	-	Welcomme 1988
	C. carpio	Common carp	China	-	Aquaculture	-	Yes-beneficial	Welcomme 1988
			Netherlands	1927	Aquaculture	-	-	Eidman 1989
			Taiwan					Schuster 1950
			Japan					Schuster 1950
			Germany					Schuster 1950
	H. molitrix	Silver carp	China, Japan	1964	Research	-	-	Eidman 1989
					Research	-	-	Eidman 1989

			Taiwan	1967	-	-	-	Eidman 1989
	C. molitorella	Mud carp	Malaysia and Singapore	1915	Aquaculture	-	-	Eidman 1989
	Osteochilus hasseltii	Silver sharkminnow	Indonesia	1937	Unknown	-	-	Welcomme 1988
	T. tinca	Tench	Netherlands	1927	Unknown	-	-	Welcomme 1988
Iran	*A. nobilis*	Bighead carp	unknown	-	Aquaculture			
	C. auratus	Goldfish	unknown	-	Aquaculture	-	-	Coad 1996
	C. carpio	Common carp	unknown	-	Aquaculture	-	Yes-beneficial	Coad 1996
	H. molitrix	Silver carp	USA	-		Probably no	Probably yes	
			Unknown	-	Fisheries	Yes-adverse	-	Coad 1996
Iraq	*C. auratus*	Goldfish	Unknown	-	Aquaculture	Probably yes-beneficial	Unknown	FAO 1997
	C. idella	Grass carp	Japan	1968	Aquaculture	-	-	Shireman and Smith 1983
	H. molitrix	Silver carp	Unknown	1966-69	-	Yes	Probably no	
Israel	*A. nobilis*	Bighead carp	Germany	1973	Aquaculture	-	-	Golani and Mires 2000
	C. auratus	Goldfish	Germany	1985	Ornamental	-	-	Golani and Mires 2000
	C. carassius	Crucian carp	Unknown	-	Angling/sport	-	-	Welcomme 1988
	C. catla	Catla	India	1953	Aquaculture	-	-	Golani and Mires 2000
	C. idella	Grass carp	China	1965	Weed control	-	-	Golani and Mires 2000
	C. carpio	Common carp	Yugoslavia	1927-28	Aquaculture	-	Yes-beneficial	Golani and Mires 2000
	H. molitrix	Silver carp	Japan	1966	Aquaculture	-	Yes-beneficial	Golani and Mires 2000
	M. piceus	Black carp	Unknown	-	Snail control	-	-	Golani and Mires 2000
Japan	*A. nobilis*	Bighead carp	China	Unknown	Aquaculture			
	C. catla	Catla	India	1960	Aquaculture	-	-	Welcomme 1988
			Pakistan	1960	Aquaculture	-	-	Welcomme 1988
	C. chinensis	Chinese mud carp	China	1965	Aquaculture	-	-	Welcomme 1988
	C. cirrhosus	Mrigal	India	1960	Aquaculture	-	-	Chiba et al. 1989
	C. idella	Grass carp	China	1878	Fisheries	-	-	Chiba et al. 1989
	C. carpio	Common carp	Germany	1905	-	-	-	Chiba et al. 1989
	H. molitrix	Silver carp	Nepal	1967		Unknown	Unknown	
			China	1878-1940	Accidental	-	-	Chiba et al. 1989
	L. rohita	Rohu	India	1960	Aquaculture	-	-	Welcomme 1988
	M. piceus	Black carp	China	1970	Accidental	-	-	Welcomme 1988
	T. tinca	Tench	Netherlands	1961	Unknown	-	-	-
Jordan	*A. nobilis*	Bighead carp	Germany	1973	Aquaculture			Krupp and Schneider 1989

	C. auratus	Goldfish	Unknown	-	Unknown	-	-	Krupp and Schneider 1989
	C. catla	Catla	Unknown	-	Unknown	-	-	Krupp and Schneider 1989
	C. idella	Grass carp	Japan	1965	Unknown	-	-	Krupp and Schneider 1989
	C. carpio	Common carp	Yugoslavia	Unknown (1931-34)	Aquaculture	-	Yes-beneficial	Krupp and Schneider 1989
	H. molitrix	Silver carp	Japan	1966	-			Krupp and Schneider 1989
	M. piceus	Black carp	Unknown	-	Unknown	-	-	Krupp and Schneider 1989
Korea	*A. nobilis*	Bighead carp	Taiwan	1963	Aquaculture		-	Welcomme 1988
	C. auratus	Goldfish	Japan	1972	Aquaculture	-	Yes-beneficial	Welcomme 1988
	C. idella	Grass carp	Japan	1963	Aquaculture	-	-	Welcomme 1988
	C. carpio	Common carp	Israel	1973	Aquaculture	-	-	Welcomme 1988
	H. molitrix	Silver carp	Japan	1963	Aquaculture	-	-	Welcomme 1988
Lao PDR	*C. catla*	Catla	Thailand	1977	Aquaculture	-	-	ICCILMB 1981*
	C. cirrhosus	Mrigal	India	1977	Aquaculture	-	-	ICCILMB 1981
			Thailand	1977	Aquaculture			ICCILMB 1981
	C. idella	Grass carp	Unknown	-	Aquaculture	-	-	Davidson 1975
	C. carpio	Common carp	India	1977	Aquaculture	-	-	ICCILMB 1981
			Thailand	1977	Aquaculture	-	-	ICCILMB 1981
	C. carpio (Hungarian)	Common carp	Vietnam	1996, 1998	Aquaculture	-	-	INGA 2002
	L. rohita	Rohu	India	1977	Aquaculture	-	-	
Malaysia	*A. nobilis*	Bighead carp	China	19th century	Aquaculture	-	Yes-beneficial	Welcomme 1988
	B. gonionotus	Silver barb	Indonesia	1958	Aquaculture (polyculture in ponds)			
	C. catla	Catla	India	1960	Aquaculture	-	-	Ang et al. 1989
	C. chinensis	Chinese mud carp	China	-	Aquaculture	-	-	Welcomme 1988
	C. cirrhosus	Mrigal	India	1960	Aquaculture	-	-	Welcomme 1988
	C. idella	Grass carp	China	Unknown (18th century)	Aquaculture	-	-	Welcomme 1988
	C. carpio	Common carp	China	Unknown (18th century)	Aquaculture	-	Yes-beneficial	Welcomme 1988
	H. molitrix	Silver carp	China	18th century	Aquaculture		Yes-beneficial	FAO 1997
	L. rohita	Rohu	India	1960	Aquaculture	-	-	Welcomme 1988

Myanmar	*C. idella*	Grass carp	India	1969	Aquaculture	-	-	Shireman and Smith 1983
	C. carpio	Common carp	Unknown	-	Aquaculture	-	-	Alkunhi 1966
	Devario malabaricus	Malabar danio	Unknown	-	Ornamental	-	-	Welcomme 1988
Nepal	*A. nobilis*	Bighead carp	Hungary	1971	Aquaculture	Unknown	Probably yes-beneficial	FAO 1997
	C. carassius	Crucian carp	Unknown	-	Aquaculture	-	Yes-beneficial	Shrestra 1994
	C. idella	Grass carp	India	1965	Aquaculture	Unknown	Probably no-beneficial	FAO 1997
	C. carpio	Common carp	India	1956	Aquaculture	Unknown	Probably yes-beneficial	FAO 1997
	H. molitrix	Silver carp	India	1965	Aquaculture	Unknown	Probably yes-beneficial	FAO 1997
			Japan	1967	Aquaculture	Unknown	Probably beneficial	Manandhar 1995
Pakistan	*A. obilis*	Bighead carp	China	Unknown	Unknown			
	C. catla	Catla	India	Unknown	Aquaculture	-	-	Welcomme 1988
	C. cirrhosus	Mrigal	India	Unknown	Aquaculture	-	-	Welcomme 1988
	C. idella	Grass carp	China	1964	Aquaculture; weed control	Probably no	Probably yes-beneficial	FAO 1997
	C. carpio	Common carp	UK	1964	Aquaculture	Unknown	Yes-beneficial	FAO 1997
			Thailand	1964	Aquaculture	Unknown	Yes-beneficial	FAO 1997
	H. molitrix	Silver carp	China	1982-83	Aquaculture	Yes	Probably no	FAO 1997
			Nepal	1982-83	Aquaculture	Yes	Probably no	FAO 1997
	L. rohita	Rohu	India	-	Aquaculture	-	-	Welcomme 1988
Philippines	*A. nobilis*	Bighead carp	Taiwan	1968	Aquaculture			Juliano et al. 1989
	Balantiocheilos melanopterus	Tricolor sharkminnow	Unknown	Unknown (1970-79)	Ornamental			
	Danio albolineatus	-	Unknown	Unknown	Ornamental			Aquarium Science Association of the Phil., Inc. (ASAP) 1996
	B. gonionotus	Silver barb	Indonesia	1956	Aquaculture (introduced as pituitary donor)			Juliano et al. 1989
	Barbonymus schwanenfeldii	Tinfoil barb	Unknown	Unknown	Ornamental	-	-	ASAP 1996
	C. auratus	Goldfish	Unknown	Unknown	Ornamental	-	-	ASAP 1996
	C. carassius	Crucian carp	Unknown	1964	Aquaculture	-	Yes-beneficial	Welcomme 1988
	C. catla	Catla	India	1967	Aquaculture	-	-	Juliano et al. 1989
	C. cirrhosus	Mrigal	India	1967	Aquaculture	-	Yes-beneficial	Welcomme 1988

	C. idella	Grass carp	China	1964	Aquaculture	-	Probably yes-beneficial	Welcomme 1988
	C. carpio	Common carp	Hong Kong	1915	Aquaculture	-	Yes-beneficial	Juliano et al. 1989
			Vietnam	1995	Research	-	-	INGA 2002
	Devario aequipinnatus	Giant danio	Unknown	Unknown	Ornamental	-	-	ASAP 1996
	D. devario	Sind danio	Unknown	-	Ornamental	-	-	ASAP 1996
	D. malabaricus	Malabar danio	Unknown	Unknown	Ornamental	-	-	ASAP 1996
	D. rerio	Zebra danio	Unknown	Unknown	Ornamental	-	-	ASAP 1996
	H. molitrix	Silver carp	China	1964	Aquaculture	-	-	Welcomme 1988
			Taiwan					
	L. rohita	Rohu	India	1964	Aquaculture	-	-	Welcomme 1988
	Leptobarbus hoevenii	Mad barb	Unknown	(1980-89)	Ornamental	-	-	ASAP 1996
	O. hasseltii	Silver sharkminnow	Indonesia	1957	Unknown	-	-	Juliano et al. 1989
	P. conchonius	Rosy barb	Unknown	-	Ornamental	-	-	ASAP 1996
	P. lateristriga	Spanner barb	Unknown	-	Ornamental	-	-	ASAP 1996
	P. tetrazona	Sumatra barb	Unknown	-	Ornamental	-	-	ASAP 1996
	P. titteya	Cherry barb	Unknown	(1970-79)	Ornamental	-	-	ASAP 1996
	Rasbora caudimaculata	Greater scissortail	Unknown	-	Ornamental	-	-	ASAP 1996
	R. dorsiocellata	Eyespot rasbora	Unknown	-	Ornamental	-	-	ASAP 1996
	R. elegans	Twospot rasbora	Unknown	-	Ornamental	-	-	ASAP 1996
	Tanichthys albonubes	White cloud mountain minnow	Unknown	-	Ornamental	-	-	ASAP 1996
Singapore	*A. nobilis*	Bighead carp	China	Unknown	Aquaculture			
	C. auratus	Goldfish	Japan	Unknown (1900-97)	Ornamental	Probably yes-beneficial	Probably yes-beneficial	FAO 1997
			China	Unknown	Ornamental	Probably yes-beneficial	Probably yes-beneficial	FAO 1997
	C. chinensis	Chinese mud carp	China	Unknown	Aquaculture	-	-	Welcomme 1988
			Unknown	Unknown	Aquaculture	-	-	Roberts 1997
	C. idella	Grass carp	China	Unknown	Aquaculture	-	-	Welcomme 1988
	C. carpio	Common carp	China	Unknown	Aquaculture	-	-	Welcomme 1988
	P. semifasciolatus	Chinese barb	China	Unknown	Accidental	-	-	Lever 1996
	H. molitrix	Silver carp	China	Unknown	-	No	-	
Sri Lanka	*A. nobilis*	Bighead carp	China	1948	Aquaculture			
	B. gonionotus	Silver barb	Indonesia	1968	Aquaculture	-	-	Welcomme 1988
	C. carassius	Crucian carp	Europe	1915	Unknown	-	-	Welcomme 1988
	C. catla	Catla	India	1942	Aquaculture	Unknown	Probably yes-beneficial	FAO 1997

	C. cirrhosus	Mrigal	India	1981	Aquaculture	Unknown	-	Welcomme 1988
	C. idella	Grass carp	China	1948	Aquaculture; weed control	Unknown	Unknown	FAO 1997
	C. carpio	Common carp	Europe	1915	Aquaculture	Unknown	Unknown	FAO 1997
	H. molitrix	Silver carp	China	1948	Aquaculture	Unknown	Unknown	De Zylva 1994
	L. rohita	Rohu	India	1981	Aquaculture	-	-	Welcomme 1988
Syria	*C. carpio*	Common carp	Unknown	Unknown	Aquaculture	-	-	Welcomme 1988
Taiwan	*A. nobilis*	Bighead carp	China	Unknown	Aquaculture			
	C. auratus	Goldfish	China	Unknown	Aquaculture	-	Yes-beneficial	Welcomme 1988
	C. cuvieri	-	Japan	-	Aquaculture	-	-	Shen (ed.) 1993
	C. chinensis	Chinese mud carp	China	-	Aquaculture	-	Yes-beneficial	Welcomme 1988
	C. molitorella	Mud carp	Unknown	-	Aquaculture	-	-	Roberts 1997
	C. idella	Grass carp	China	Unknown	Aquaculture	-	Yes-beneficial	Welcomme 1988
	C. carpio	Common carp	Japan	Unknown	Aquaculture	-	Yes-beneficial	Welcomme 1988
	L. hoevenii	Mad barb	Indonesia	1979	Research	-	-	Welcomme 1988
	M. piceus	Black carp	China	-	Aquaculture	-	Yes-beneficial	Welcomme 1988
	H. molitrix	Silver carp	China	Pre-18th century	Aquaculture		No	Welcomme 1988
Thailand	*A. nobilis*	Bighead carp	China	1932	Aquaculture		No	Welcomme 1988
	C. auratus	Goldfish	China	Unknown	Ornamental			Welcomme 1988
	C. carassius	Crucian carp	Japan	1980	Aquaculture	-	-	Welcomme 1988
	C. catla	Catla	Bangladesh	1979	Aquaculture	-	-	Welcomme 1988
	C. chinensis	Chinese mud carp	China	-	Aquaculture	Unknown	-	Welcomme 1988; Rainboth 1996
	C. cirrhosus	Mrigal	Japan	1980	Aquaculture	-	-	Piyakarnchana 1989
			Bangladesh	1980	Aquaculture			
			Lao PDR	1982	Aquaculture			
	C. idella	Grass carp	China	1922	Aquaculture			
			China	1932	Aquaculture	No	-	Welcomme 1988
			Hong Kong	1932	Aquaculture	No	-	Welcomme 1988
	C. carpio	Common carp	China	1912, 1913	Aquaculture	-	Yes-beneficial	Welcomme 1988
			Germany	1913	Aquaculture	-	Yes-beneficial	Welcomme,1988
			Japan	1913	Aquaculture	-	Yes-beneficial	Welcomme 1988
			Japan	1964, 1971	Aquaculture			
			Germany	1970	Aquaculture			

			Hungary	1985	Aquaculture			
			Israel	-	Aquaculture	-	Yes-beneficial	Welcomme 1988
	(selected strain)		Vietnam	1997-98	Research	-	-	Pongthana (this vol.)
	(*Rajadanu* strain)		Indonesia	1998	Research	-	-	INGA 2002
	H. molitrix	Silver carp	China	1913	Aquaculture	Yes-beneficial	Yes-beneficial	FAO 1997
	H. molitrix	Silver carp	China	1932	Aquaculture			
	L. rohita (wild population)	Rohu	India	1968-69	Aquaculture	-	-	Welcomme 1988; Pongthana (this vol.)
	L. rohita (genetically improved)	Rohu	India	1998	Research	-	-	
	M. piceus	Black carp	China	1913	Aquaculture	-	-	Welcomme 1988
Vietnam	*A. nobilis*	Bighead carp	China	1958	Aquaculture	Yes-beneficial	Yes-beneficial	FAO 1997
	C. auratus	Goldfish	China	Unknown	Aquaculture	-	Yes-beneficial	Welcomme 1988
	C. catla	Catla	Lao PDR	1984	Aquaculture	Probably yes-undecided	Probably yes-undecided	FAO 1997
	C. cirrhosus	Mrigal	Lao PDR	1984	Aquaculture	Yes-beneficial	Yes-beneficial	FAO 1997
			India	1997	Research	-	-	INGA 2002
	C. idella	Grass carp	China	1958	Aquaculture	Yes-beneficial	Yes-beneficial	FAO 1997
	C. carpio	Common carp	Hungary	1971, 1975	Aquaculture	Yes-beneficial	Yes-beneficial	FAO 1997, Thien (this vol.)
			Indonesia	Before 1975	-	-	-	Thien, this vol.
	H. molitrix	Silver carp	China	1958, 1964, 2000	Aquaculture	Yes-beneficial	Yes-beneficial	FAO 1997; Thien (this vol.)
	L. rohita	Rohu	Thailand	1982	Aquaculture	Yes-beneficial	Yes-beneficial	FAO 1997
			Lao PDR	1982	Aquaculture	Yes-beneficial	Yes-beneficial	FAO 1997

*ICCILMB 1981 = Interim Committee for Coordination of Investigations of the Lower Mekong Basin, 1981.