Proceedings of the Nature Reserves Survey Seminar.
Gardens' Bulletin Singapore ***49*** *(1997) 245–265.*

The Diversity and Conservation Status of Fishes in the Nature Reserves of Singapore

PETER K.L. NG AND KELVIN K.P. LIM

Raffles Museum of Biodiversity Research
Department of Biological Sciences
National University of Singapore
Kent Ridge, Singapore 119260

Abstract

An update on the taxonomy and conservation status of the 61 indigenous species of freshwater fishes now known from Singapore is provided. Of these, 26 species (43%) are extinct. Of the 35 extant species, 33 are known in the Nature Reserves and 21 appear to be restricted there. Of the 52 introduced species of fish in Singapore, 17 are present in the Nature Reserves. The conservation status of native fishes in the Nature Reserves is assessed and the survival of highly threatened species discussed. The significance of the Nature Reserves for freshwater fish conservation is highlighted.

Introduction

The freshwater fish fauna of Singapore is among the best studied in the region and has been the subject of many publications (Alfred, 1961, 1966; Johnson, 1973; Munro, 1990; Lim & P.K.L. Ng, 1990; P.K.L. Ng & Lim, 1996). In the first major synopsis of the Singapore ichthyofauna, Alfred (1966) listed a total of 73 native and introduced species from Singapore of which 42 were still extant. Alfred (1968) subsequently listed 35 native species as extant and believed 19 were extinct.

It was 22 years before the next appraisal was made by Lim & P.K.L. Ng (1990) in their guide to the freshwater fishes of Singapore. By then, several developments had taken place with direct implications on local freshwater fish conservation. *Channa gachua*, one of the species presumed extinct by Alfred (1968) was rediscovered (P.K.L. Ng & Lim, 1989), while two others, *Channa melasoma* and *Pseudomystus rugosus* [as *Leiocassis* cf. *siamensis*] were added to the Singapore ichthyofauna (P.K.L. Ng & Lim, 1990; Munro, 1990). P.K.L. Ng & Lim (1996) subsequently reviewed what was known about the freshwater fish fauna of Singapore, listing 104 species of which 59 were regarded as native species, with 23 being extinct.

Over the years, taxonomic revisions of several groups have also shown that some of the old records were misidentifications. From studies by P.K.L. Ng & Kottelat (1994), H.H. Ng & Lim (1995), Tan & P.K.L. Ng (1996) and

Siebert (1997), five species were added to Singapore's known fauna, viz. *Betta tomi* (specimens had been misidentified as *B. pugnax*), *Ompok fumidus* (misidentified as *O. leiacanthus*), *Parakysis longirostris* (misidentified as *P. verrucosus*), *Rasbora paucisqualis* (misidentified as *R. bankanensis*) and *Puntius banksi* (misidentified as *P. binotatus*). Of these, *Betta tomi* and *Ompok fumidus* are now regarded as extinct (P.K.L. Ng & Kottelat, 1994; Tan & P.K.L. Ng, 1996).

A synopsis of the freshwater fish fauna in the Nature Reserves (Central Catchment and Bukit Timah Nature Reserves) of Singapore (Table 1) is provided together with an annotated checklist for native and exotic species, both extant and recently extinct. General localities within the Central Catchment Nature Reserve (CCNR) and the Bukit Timah Nature Reserve (BTNR) where each species is presently known to occur are provided. We also examine how the continued conservation of the remaining forest in the centre of the island (i.e., the Nature Reserves) is necessary for the long-term survival of most of the extant fauna. The emphasis is on species that complete their life cycle in fresh water.

Table 1. Extant indigenous freshwater fish species of Singapore.
(EN = Endangered, CO = Common, UN = Uncommon, FO = Forest waters, OP = Open waters, NSS = Nee Soon Swamp Forest, BTNR = Bukit Timah Nature Reserve, NR = Nature Reserves (excluding NSS and BTNR), OA = Open rural areas, + = present, - = absent)

No.	Species	Status	Habitat	NSS	BTNR	NR	OA
	Family **CYPRINIDAE**						
1.	*Boraras maculatus*	EN	FO	-	-	+	-
2.	*Cyclocheilichthys apogon*	EN	FO	-	-	+	-
3.	*Puntius banksi*	CO	FO	+	+	+	-
4.	*Puntius hexazona*	EN	FO	+	-	-	-
5.	*Puntius lateristriga*	EN	FO	-	+	+	-
6.	*Rasbora einthovenii*	CO	FO	+	+	+	+
7.	*Rasbora elegans*	CO	FO	+	+	+	-
8.	*Rasbora heteromorpha*	EN	FO	+	-	+	-
	Family **BALITORIDAE**						
9.	*Nemacheilus selangoricus*	EN	FO	+	-	-	-
	Family **COBITIDAE**						
10.	*Pangio shelfordii*	EN	FO	+	-	-	-
	Family **SILURIDAE**						
11.	*Silurichthys hasselti*	EN	FO	+	-	-	-

No.	Species	Status	Habitat	NSS	BTNR	NR	OA
	Family **CLARIIDAE**						
12.	*Clarias batrachus*	CO	OP	-	-	+	+
13.	*Clarias teijsmanni*	EN	FO	+	+	+	-
	Family **AKYSIDAE**						
14.	*Parakysis longirostris*	EN	FO	+	-	-	-
	Family **BAGRIDAE**						
15.	*Mystus gulio*	CO	OP	-	-	-	+
16.	*Pseudomystus rugosus*	EN	FO	+	-	-	-
	Family **APLOCHEILIDAE**						
17.	*Aplocheilus panchax*	CO	OP	+	+	+	+
	Family **ADRIANICHTHYIDAE**						
18.	*Oryzias javanicus*	CO	OP	-	-	-	+
	Family **HEMIRAMPHIDAE**						
19.	*Dermogenys pusilla*	CO	OP/FO	+	+	+	+
20.	*Hemirhamphodon pogonognathus*	EN	FO	+	-	+	-
	Family **NANDIDAE**						
21.	*Nandus nebulosus*	EN	FO	-	+	+	-
	Family **GOBIIDAE**						
22.	*Gobiopterus birtwistlei*	CO	OP	-	-	+	+
23.	*Oxyeleotris marmorata*	CO	OP/FO	+	+	+	+
	Family **ANABANTIDAE**						
24.	*Anabas testudineus*	CO	OP/FO	+	+	+	+
	Family **OSPHRONEMIDAE**						
25.	*Betta imbellis*	UN	OP/FO	-	-	+	+
26.	*Betta pugnax*	CO	FO	+	+	+	-
27.	*Luciocephalus pulcher*	EN	FO	+	-	+	-
28.	*Trichogaster trichopterus*	CO	OP	-	+	+	+
29.	*Trichopsis vittata*	CO	OP/FO	+	+	+	+
	Family **CHANNIDAE**						
30.	*Channa gachua*	EN	FO	+	+	+	-
31.	*Channa lucius*	CO	FO	+	+	+	-
32.	*Channa melasoma*	EN	FO	+	-	+	-
33.	*Channa striata*	CO	OP/FO	+	+	+	+
	Family **MASTACEMBELIDAE**						
34.	*Macrognathus maculatus*	EN	FO	+	-	-	-
	Family **SYNBRANCHIDAE**						
35.	*Monopterus albus*	CO	OP/FO	+	+	+	+

Unless otherwise stated, material has been examined of all species found in the Nature Reserves. These are deposited in the Zoological Reference Collection (ZRC) of the Raffles Museum of Biodiversity Research, Department of Biological Sciences, National University of Singapore. Much of the findings came from surveys conducted under the purview of the National Parks Board. However, recent surveys on the fish fauna of the Nature Reserves have not been exhaustive as some streams and reservoir inlets are difficult to access. Measurements are of the standard length (SL) unless otherwise stated. Taxonomic and ecological notes on each species already mentioned in Alfred (1966), Lim & P.K.L. Ng (1990) and P.K.L. Ng & Lim (1996) are not repeated. Systematic classification follows Nelson (1994) with some modifications.

Annotated Checklist

Extant Native Species in the Nature Reserves

Order Cypriniformes

Family Cyprinidae

Boraras maculatus (Duncker)
CCNR: streams and swamps in Sime Road forest and along southern shore of MacRitchie Reservoir.

Cyclocheilichthys apogon (Valenciennes)
CCNR: MacRitchie Reservoir, and streams in Sime Road forest.
The probability of this species having been introduced many years ago cannot be ascertained as it is widely distributed in Southeast Asia.

Puntius banksi Herre
CCNR: common in streams in the Nee Soon Swamp Forest, Lower Peirce forest and Sime Road forest. BTNR: swamp along eastern boundary.

Puntius hexazona Weber & de Beaufort
CCNR: apparently restricted to the Nee Soon Swamp Forest.

Puntius lateristriga (Valenciennes)
CCNR: streams in the Sime Road and Lower Peirce forests. BTNR: swamp along eastern boundary.

Rasbora einthovenii (Bleeker)
CCNR: common in streams throughout area. BTNR: swamp along eastern boundary.

Rasbora elegans Volz
CCNR: common in streams throughout the area. BTNR: swamp along eastern boundary.

Rasbora heteromorpha Duncker
CCNR: streams in the Sime Road forest and Nee Soon Swamp Forest.

Family Balitoridae

Nemacheilus selangoricus Duncker
CCNR: apparently restricted to streams in the Nee Soon Swamp Forest.

Family Cobitidae

Pangio shelfordii (Popta)
CCNR: apparently restricted to streams in the Nee Soon Swamp Forest. The species name is mis-spelt as *sheldfordii* by P.K.L. Ng & Lim (1996: 111).

Order Siluriformes

Family Siluridae

Silurichthys hasseltii Bleeker
CCNR: apparently restricted to streams in the Nee Soon Swamp Forest. The genus *Silurichthys* was recently revised by H.H. Ng & P.K.L. Ng (1998: 302).

Family Bagridae

Pseudomystus rugosus (Regan)
CCNR: known only from streams in the Nee Soon Swamp Forest. Identified as *Pseudomystus* cf. *siamensis* by P.K.L. Ng & Lim, (1996: 112, Fig. 2), the specimens appear to fit the descriptions for *Pseudomystus rugosus* best, but lack black markings on the caudal fin. Conspecific examples are also known from Pulau Bintan, the large Indonesian island off the southeastern coast of Singapore.

Family Akysidae

Parakysis longirostris Ng & Lim
CCNR: apparently confined to streams in the Nee Soon Swamp Forest. This species was recently described from Singapore (type locality) by H.H. Ng & Lim (1995).

Family Clariidae

Clarias batrachus (Linnaeus)
CCNR: drainages along boundary and in exposed areas. BTNR: drainages along boundary.

Clarias teijsmanni Bleeker
CCNR: Nee Soon Swamp Forest.
This species appears to be confined to shaded streams, while *Clarias batrachus* frequents exposed habitats.

Order Cyprinodontiformes

Family Aplocheilidae

Aplocheilus panchax (Hamilton)
CCNR: common in open bodies of water, especially the MacRitchie Reservoir and streams in the adjacent Sime Road forest and Seletar Reservoir Park.

Order Beloniformes

Family Hemiramphidae

Dermogenys pusilla van Hasselt
CCNR: MacRitchie Reservoir and adjacent streams in Sime Road forest. Also in streams in the Upper Seletar Reservoir Park and along Lorong Banir.
The populations in the MacRitchie Reservoir and Sime Road forest are land-locked.

Hemirhamphodon pogonognathus (Bleeker)
CCNR: streams in the Nee Soon Swamp Forest and Sime Road forest.

Order Perciformes

Family Nandidae

Nandus nebulosus (Gray)
CCNR: streams in the Sime Road and Lower Peirce forests. BTNR: swamp along eastern boundary.

Family Gobiidae
The family Eleotrididae in which *Oxyeleotris marmorata* used to belong, has been included in the Gobiidae (see Hoese & Gill, 1993; Lim & Larson, 1994).

Gobiopterus birtwistlei (Herre)
CCNR: Lower Peirce Reservoir.
Although it is mainly found in brackish water of estuarine areas, this species appears to be able to breed under land-locked conditions as in the Tengeh Reservoir in the Western Catchment.

Oxyeleotris marmorata Bleeker
CCNR: common in the Upper Seletar and Lower Peirce Reservoirs, and their adjacent streams.

Family Anabantidae

Anabas testudineus (Bloch)
CCNR: common in streams and swamps.

Family Osphronemidae
The families Belontiidae and Luciocephalidae are presently part of the Osphronemidae (Britz *et al.*, 1995).

Betta imbellis Ladiges
CCNR: streams in the Sime Road forest and along Lorong Banir.

Betta pugnax (Cantor)
CCNR: common in small streams and swamps throughout area. BTNR: swamp along eastern boundary, Jungle Fall Valley.
This is the most common anabantoid in forest areas and is the only fish present in small streams in the interior of the Bukit Timah Nature Reserve.

Luciocephalus pulcher (Gray)
CCNR: appears to be restricted to streams in the Nee Soon Swamp Forest.

Trichogaster trichopterus (Pallas)
CCNR: exposed water bodies.

Trichopsis vittata (Cuvier)
CCNR: common in exposed and weed-choked water bodies. BTNR: swamp along eastern boundary.

Family Channidae

Channa gachua (Hamilton)
CCNR: small streams in the Nee Soon Swamp Forest and the Chestnut Drive area.
The population from the Bukit Timah Nature Reserve (Johnson, 1973: 110 as *Ophicephalus gachua*) has not been seen in recent years.

Channa lucius (Cuvier)
CCNR: streams in the Nee Soon Swamp Forest and Sime Road forest, and Lower Peirce Reservoir. BTNR: swamp along eastern boundary.

Channa melasoma (Bleeker)
CCNR: small streams in the Nee Soon Swamp Forest and Lower Peirce Forest.

Channa striata (Bloch)
CCNR: common in water bodies.

Order Synbranchiformes

Family Synbranchidae

Monopterus albus (Zuiew)
CCNR: in streams and swamps.

Family Mastacembelidae

Macrognathus maculatus (Valenciennes)
CCNR: appears to be restricted to streams in the Nee Soon Swamp Forest and adjacent areas.

Recently Extinct Native Species

Alfred (1966) has already discussed in some detail the freshwater fish species previously known from Singapore (Table 2). Some species, (e.g., *Wallago leerii* and *Tor tambroides*) which were supposed to have occurred in Singapore in the past but are now extinct, and whose presence in Singapore has been debated have been discussed by Johnson (1973) and Lim & P.K.L. Ng (1990). One species which Alfred (1966) listed as extinct has since been refound (*Channa gachua*, fide P.K.L. Ng & Lim, 1989). In addition, *Channa melasoma* and *Pseudomystus rugosus* (P.K.L. Ng & Lim, 1990, 1992, respectively) are new records.

Table 2. Extinct indigenous freshwater fish species.
(FO = Forest waters, OP = Open waters, LRF = large river fauna, + = present, - = absent)

No.	Species	Habitat	LRF
	Family **CYPRINIDAE**		
1.	*Barbodes schwanenfeldii*	FO/OP	+
2.	*Discherodontus halei*	FO	+
3.	*Hampala macrolepidota*	FO	+
4.	*Labiobarbus festivus*	FO	+
5.	*Osteochilus melanopleura*	FO	+
6.	*Osteochilus spilurus*	FO	-
7.	*Oxygaster anomalura*	FO	+
8.	*Puntius dunckeri*	FO	-
9.	*Rasbora cephalotaenia*	FO	-
10.	*Rasbora paucisqualis*	FO/OP	-
11.	*Tor tambroides*	FO	+
	Family **COBITIDAE**		
12.	*Pangio semicincta*	FO	-
	Family **SILURIDAE**		
13.	*Micronema micronema*	FO	+
14.	*Ompok bimaculatus*	FO	+
15.	*Ompok fumidus*	FO	-
16.	*Wallago leerii*	FO	+
	Family **CLARIIDAE**		
17.	*Clarias meladerma*	FO	+
	Family **SISORIIDAE**		
18.	*Glyptothorax fuscus*	FO	+
	Family **BAGRIDAE**		
19.	*Hemibagrus nemurus*	FO	+

No.	Species	Habitat	LRF
	Family **PRISTOLEPIDAE**		
20.	*Pristolepis fasciata*	FO	+
	Family **GOBIIDAE**		
21.	*Pseudogobiopsis oligactis*	OP/FO	-
22.	*Pseudogobiopsis siamensis*	OP/FO	-
	Family **OSPHRONEMIDAE**		
23.	*Belontia hasselti*	FO	-
24.	*Betta tomi*	FO	-
	Family **MASTACEMBELIDAE**		
25.	*Macrognathus aculeatus*	FO	-
26.	*Mastacembelus armatus*	FO	+

P.K.L. Ng *et al.* (1994) subsequently published a selective list of Singapore freshwater fishes which they believed were under threat, listing 18 as extinct and 17 as locally endangered species. Three species, *Rasbora paucisqualis* (as *R. bankanensis*), *Pangio semicincta* and *Glyptothorax fuscus* were listed as being probably extinct as there had been no recent records. All three are relatively common species in southern Malaysia where they are easily found in disturbed areas adjacent to forests. The failure to obtain these species in Singapore for so many years is a good indication that they are no longer extant.

Alfred (1966, 1968) believed that one species originally described from Singapore, *Hemibagrus elongatus*, was extinct. Kottelat *et al.* (1998) believe this species is actually a Chinese and Vietnamese one, and should be excluded from the Singapore faunal list.

Family Cyprinidae

Rasbora paucisqualis Ahl
Since its rediscovery by Alfred (1966: 17 as *Rasbora bankanensis*), it has not been seen again.

Family Cobitidae

Pangio semicincta (Fraser-Brunner)
Earlier identified as *Pangio kuhlii* (Alfred, 1966; P.K.L. Ng & Lim, 1996: 111) under which *P. semicincta* was synonymised (Kottelat & Lim, 1993)

M. Kottelat (*pers. comm.*) now believes *P. kuhlii* is restricted to its type locality in Java. The forms on Sumatra, the Malay Peninsula (and Singapore) and Borneo are *P. semicincta*. This fish has not been encountered since 1966 and we believe that it is locally extinct.

Family Sisoridae

Glyptothorax fuscus Fowler
Previously referred to as *Glyptothorax major* by P.K.L. Ng & Lim (1996: 112). However, *G. major* appears to be restricted to Borneo, and is a larger and more robust species. The local form should be called *G. fuscus*, a species described from southeastern Thailand (H.H. Ng, *pers. comm.*). There is an unconfirmed record of this fish in 1988 from a stream at Seletar Reservoir Park on the outskirts of Nee Soon Swamp Forest (Richard Yeong, *pers. comm.*). The specimen, however, was not retained.

Family Gobiidae

Pseudogobiopsis oligactis (Bleeker)
We have not been able to find *Pseudogobiopsis oligactis* in recent surveys. All recent goby specimens collected from the Central Catchment Nature Reserve and other inland freshwaters by the authors and their colleagues have been the introduced *Rhinogobius*.

Pseudogobiopsis siamensis (Fowler)
There was only one record of this species from the Nee Soon Swamp Forest area. Both *Pseudogobiopsis oligactis* and *P. siamensis* were misidentified as *Stigmatogobius poicilosoma* by Alfred (1966).

Introduced Taxa

Fishes discussed under this section (Table 3) are present in the wild state through human intervention. They may be foreign species, which are native to South America or Africa, or even taxa that have been recorded as indigenous fauna in the past and presently regarded as extinct as they were not recorded by Alfred (1966) in his fairly thorough survey of the island's freshwater fish fauna. Their presence strongly indicates introduction by human means (e.g., *Hampala macrolepidota*). The aquarium fish trade and the food fish trade are the main contributors to the alien fish diversity in Singapore. Many species have adapted well to conditions independent of human husbandry, and have established self-sustaining populations in the

wild. However, their survival may not be long-term. For instance, *Rasborinus lineatus*, which was once common in Singapore and occurred in areas now under the Nature Reserves, appears to have died out (P.K.L. Ng & Lim, 1996). The species listed have either established thriving populations in the Nature Reserves, or have good potential of doing so as they are found in similar habitats and occur naturally in neighbouring areas.

Table 3. List of known introduced species and their status in Singapore.
(Status: CU = cultured, ES = escapee, FE = feral (established), NA = native, EX = extinct
Use: AQ = aquarium fish, FF = food fish, IN = incidental (no use), PC = pest control)

No.	Species	Status	Use
	Family **OSTEOGLOSSIDAE**		
1.	*Scleropages formosus*	FE?	AQ
2.	*Osteoglossum bicirrhosum*	ES	AQ
	Family **NOTOPTERIDAE**		
3.	*Chitala ornata* *	FE?	AQ
	Family **CYPRINIDAE**		
4.	*Amblypharyngodon chulabornae*	ES	AQ?
5.	*Barbodes gonionotus*	CU	FF
6.	*Carasius auratus*	FE	FF
7.	*Cirrhinus molitorella*	CU	FF
8.	*Ctenopharyngodon idella*	CU	FF
9.	*Cyprinus carpio*	FE	AQ/FF
10.	*Esomus metallicus*	FE	AQ
11.	*Hampala macrolepidota*	ES?	AQ?
12.	*Hypopthalmichthys molitrix*	CU	FF
13.	*Hypopthalmichthys nobilis*	CU	FF
14.	*Leptobarbus hoeveni*	CU	FF
15.	*Osteochilus hasselti*	FE?	AQ?
16.	*Puntius binotatus*	FE	AQ?
17.	*Puntius conchonius*	ES	AQ
18.	*Puntius partipentazona*	FE	AQ
19.	*Puntius semifasciolatus*	FE	IN
20.	*Puntius tetrazona*	ES?	AQ
21.	*Rasbora borapetensis*	FE	AQ
22.	*Rasbora gracilis*	ES	AQ
23.	*Rasbora trilineata*	ES	AQ
24.	*Rasborinus lineatus*	EX	IN

No.	Species	Status	Use
	Family **CHARACIDAE**		
25.	*Colossoma macropomum*	CU	FF/AQ
26.	*Paracheirodon innesi*	ES	AQ
	Family **PANGASIIDAE**		
27.	*Pangasius hypophthalmus*	CU	FF/AQ
	Family **PIMELODIDAE**		
28.	*Phractocephalus hemioliopterus* *	ES	AQ
	Family **CALLICHTHYIDAE**		
29.	*Corydoras aeneus*	ES	AQ
	Family **LORICARIIDAE**		
30.	*Liposarcus pardalis*	FE	AQ
	Family **POECILIIDAE**		
31.	*Poecilia reticulata*	FE	AQ/PC
32.	*Poecilia sphenops*	FE	AQ
33.	*Poecilia latipinna*	FE?	AQ
34.	*Xiphophorus helleri*	ES	AQ
35.	*Xiphophorus maculatus*	FE?	AQ
36.	*Gambusia holbrookii*	FE	AQ/PC
	Family **AMBASSIDAE**		
37.	*Parambassis siamensis*	FE	AQ/IN
	Family **CICHLIDAE**		
38.	*Astronotus ocellatus*	ES	AQ
39.	*Cichla ocellaris*	FE?	AQ
40.	*Oreochromis aureus*	ES	FF
41.	*Oreochromis mossambicus*	FE	FF
42.	*Oreochromis niloticus*	ES	FF
43.	*Thorichthys meeki*	ES	AQ
44.	*Tilapia zillii*	FE?	FF
	Family **GOBIIDAE**		
45.	*Rhinogobius giurinus*	FE	IN
	Family **OSPHRONEMIDAE**		
46.	*Betta splendens*	ES	AQ
47.	*Osphronemus goramy*	FE	FF
48.	*Sphaerichthys osphromenoides*	ES	AQ
49.	*Trichogaster microlepis*	FE?	AQ
50.	*Trichogaster pectoralis*	FE	FF

No.	Species	Status	Use
	Family **CHANNIDAE**		
51.	*Channa micropeltes*	CU/FE	FF
	Family **MASTACEMBELIDAE**		
52.	*Macrognathus siamensis*	ES	AQ

* The Clown Knifefish, *Chitala ornata*, a native of Thailand, was reported from the Sungei Seletar Reservoir where some ten examples were obtained (but not kept) by rod and line in early 1998 (Tan Yit Wee, *pers. comm.*). There is a record of a 4 ft. (25 kg) Red-tailed Catfish, *Phractocephalus hemioliopterus*, native to tropical South America, fished off the Pandan River in 1996 (Lianhe Wanbao, 4 Aug. 1996: 4&8 with photographs). Being popular aquarium fish that attain large eventual sizes, they may have been deliberately released when their owners could not cope.

Single individuals of *Puntius conchonius* (Cyprinidae) and *Macrognathus siamensis* (Mastacembelidae) have been recorded from streams in the CCNR. Specimens of Chinese major carps, for example, *Cyprinus carpio* and *Hypopthalmichthys nobilis*, can sometimes be observed in the reservoirs. These exotic species are frequently imported as food or aquarium fish. Occasionally, individuals may be encountered in the wild state, having escaped from ponds and cages, or released as unwanted aquarium pets. However, there is no evidence of them having established self-sustaining populations in the wild. They are therefore not included in the list.

Family Osteoglossidae

Scleropages formosus (Müller & Schlegel)
CCNR: Lower Peirce and MacRitchie Reservoirs.

Family Cyprinidae

Hampala macrolepidota Kuhl & van Hasselt
CCNR: Upper Peirce Reservoir (Robert Teo, *pers. comm.*, in 1998).
Although it was considered extinct in Singapore (Alfred, 1966), the present population seems most likely to be the result of deliberate introduction. As this is a common fish in streams and lakes throughout Peninsular Malaysia, it should adapt well to conditions in the Central Catchment reservoirs.

Osteochilus hasselti (Valenciennes)
CCNR: stream at Upper Seletar Reservoir Park.

Puntius partipentazona Fowler
CCNR: MacRitchie and Lower Peirce Reservoirs, and streams in Sime Road forest. BTNR: swamp along eastern boundary.

Puntius semifasciolatus (Günther)
CCNR: stream in Sime Road forest, Lower Peirce Reservoir.

Puntius tetrazona (Bleeker)
CCNR: stream in Upper Seletar Reservoir Park.

Rasbora borapetensis Smith
CCNR: stream in Upper Seletar Reservoir Park.

Family Loricariidae

Liposarcus pardalis (Castelnau)
CCNR: Lower Peirce and Upper Seletar Reservoirs.

Family Poeciliidae

Gambusia holbrookii (Girard)
CCNR: Lower Peirce Reservoir.

Poecilia reticulata Peters
CCNR and BTNR: present in exposed water bodies along peripheral areas.

Family Ambassidae

Parambassis siamensis (Fowler)
CCNR: Upper and Lower Peirce Reservoirs.

Family Cichlidae

Cichla ocellaris Bloch & Schneider
CCNR: Lower Peirce Reservoir.
Previously referred to as *Cichla* cf. *monoculus* (P.K.L. Ng & Lim, 1997: 123). This popular game and aquarium fish originates from South America.

Oreochromis mossambicus (Peters)
CCNR: present in all reservoirs and adjacent drainages.

Family Gobiidae

Rhinogobius giurinus (Rutter)
CCNR: Lower Peirce Reservoir, and a stream in the Upper Seletar Reservoir Park.
This species is native to China and Japan.

Family Osphronemidae

Osphronemus goramy Lacépède
CCNR: MacRitchie Reservoir.

Trichogaster pectoralis (Regan)
CCNR: Nee Soon Swamp Forest.

Family Channidae

Channa micropeltes (Cuvier)
CCNR: present in all reservoirs.

Conservation Status

The state of knowledge of Singapore's freshwater biodiversity is generally regarded as excellent (Kottelat & Whitten, 1996). This knowledge, together with Singapore's small size, makes conservation easier than is the case in most Asian countries. Over the past two decades, the landscape of Singapore has changed very drastically, and the pressures on natural fresh waters have been great (P.K.L. Ng, 1991, 1994; P.K.L. Ng & Lam, 1995). Many native species reported by Alfred (1966) have since become rare or perhaps even extinct. P.K.L. Ng *et al.* (1994) listed 18 extinct and 17 locally endangered species, and regarded three species as being possibly extinct. Moreover, the flourishing aquarium [which accounted for over S$80 million in 1994] (Ngiam, 1994; P.K.L. Ng & Tan, 1997) and food fish trade appear to have contributed more foreign species to the local fauna by way of deliberate or accidental introductions or escapees.

The list of extant native fish species known from Singapore thus now stands at 35 (Table 1), whilst the number of extinct species is 26 (Table 2). That is, 43% of Singapore's known native fish fauna is now extinct. It is

important to note that 21 of the 35 extant indigenous fish species (60%) are confined to waterways under forest cover. The five species that have recently become extinct (*Rasbora paucisqualis, Pangio semicincta, Glyptothorax fuscus, Pseudogobiopsis oligactis* and *P. siamensis*) were also collected mainly from the Nature Reserves. This strongly suggests that the loss of Singapore's forest over the last 150 years has contributed substantially to the loss of fish fauna on the island.

It is pertinent to note here that many of the extinct species are actually large river species and there are doubts as to whether they were actually found in Singapore at all. Many of these records are old [pre-World War II] (Herre & Myers, 1937) and are unsubstantiated. Singapore never had large rivers that could support large and typically riverine species like *Barbodes schwanenfeldii*, *Tor tambroides*, *Osteochilus melanopleura*, *Labiobarbus festivus*, *Hampala macrolepidota* (Cyprinidae), *Micronema micronema*, *Wallago leerii* (Siluridae) and *Hemibagrus nemurus* (Bagridae), and there is every chance that the specimens on which the old records are based actually came from neighbouring Peninsular Malaysia.

Of the extant species, 21 of the 35 species are present only in the Nature Reserves which illustrates the crucial importance of the Nature Reserves for the contiuned existence of these species (Table 1). More worrying is that the Nee Soon Swamp Forest has a disproportionately large number of native species, which are only known from or have their major populations there. Eight species (*Puntius hexazona*, *Nemacheilus selangoricus*, *Pangio shelfordii*, *Silurichthys hasselti*, *Pseudomystus rugosus*, *Parakysis longirostris*, *Channa melasoma* and *Macrognathus maculatus*) are only known from this area while another three species (*Rasbora heteromorpha*, *Luciocephalus pulcher* and *Channa gachua*) have their major populations in the Nee Soon Swamp Forest (P.K.L. Ng & Lim, 1992). As it now stands, with the Nee Soon Swamp Forest suffering from possible excess drainage etc., some species would likely become extinct over the next few decades. Prime candidates for extinction because of their apparently fastidious habitat requirements and current low populations would be *Nemacheilus selangoricus*, *Pangio shelfordii*, *Silurichthys hasselti*, *Pseudomystus rugosus* and *Parakysis longirostris*. The threats to the native freshwater fish are thus particularly serious as all of them are primary freshwater species and most are very stenotopic in their habitat requirements.

About 52 introduced species have been recorded in Singapore's freshwaters, 17 of which have established feral populations here (Table 3). This is a substantial number, considering that Singapore's extant indigenous freshwater fish fauna is only 35 species. Despite the large proportion of introduced fauna, it has not been shown that they have caused substantial

reduction in population size or the extinction of any native species (P.K.L. Ng *et al.*, 1993).

Acknowledgements

Many colleagues have assisted in documenting the present records over the years. Thanks are especially due to Richard Yeong, Joseph Tan, Ng Hock Ping, George Tay, C. M. Yang, Yeo Keng Loo, Lua Hui Keng, Daphne Chung, Tommy Tan, Ng Heok Hee, Tan Heok Hui, Tan Swee Hee, Oliver Chia, Darren Yeo, Adrian Ou, Tay Joe Boy, Tan Yit Wee, Tay Hui Cheng, Serena Teo, Robert Teo, Cheryl Chia and R. Subharaj. We have received a substantial amount of help and guidance from Maurice Kottelat and Tyson Roberts on many aspects on fish taxonomy, and for this, we are most grateful. Eric Alfred was responsible for providing the original impetus for this paper and the many discusions and informal conversations we have had proved most helpful in enabling it to come together. Permission by the National Parks Board to carry out studies in the Nature Reserves is much appreciated.

References

Alfred, E.R. 1961. Singapore freshwater fishes. *Malayan Nature Journal.* **15**: 1–19.

Alfred, E.R. 1966. The fresh-water fishes of Singapore. *Zoologische Verhandelingen, Leiden.* **78**: 1–68, 8 plates.

Alfred, E.R. 1968. Rare and endangered freshwater fishes of Malaya and Singapore. In: *Technical Session IV - Threatened Species, Conference on Conservation of Nature and Natural Resources in Tropical South-east Asia, Bangkok.* IUCN Publications, n.s., No. 10, (4): 325–331.

Britz, R., M. Kokoscha & R. Riehl. 1995. The anabantoid genera *Ctenops*, *Luciocephalus*, *Parasphaerichthys*, and *Sphaerichthys* (Teleostei: Perciformes) as a monophyletic group: evidence from egg surface structure and reproductive behaviour. *Japanese Journal of Ichthyology.* **42**: 71–79.

Herre, A.W.C.T. & G.S. Myers. 1937. A contribution to the ichthyology of the Malay Peninsula. Part II. Fresh-water fishes. *Bulletin of the Raffles Museum.* **13**: 53–74, pls. 5–7.

Hoese, D. F. & A. C. Gill, 1993. Phylogenetic relationships of eleotridid

fishes (Perciformes: Gobioidei). *Bulletin of Marine Science*. **52**: 415–440.

Johnson, D.S. 1973. Freshwater life. In: S.H. Chuang (ed.). *Animal Life and Nature in Singapore*. Singapore University Press. pp. 103–127.

Kottelat, M. & K.K.P. Lim. 1993. A review of the eel-loaches of the genus *Pangio* (Teleostei: Cobitidae) from the Malay Peninsula, with descriptions of six new species. *Raffles Bulletin of Zoology*. **41**: 203–249.

Kottelat, M. & T. Whitten. 1996. *Freshwater Biodiversity in Asia with Special Reference to Fish*. World Bank Technical Paper No. 343. pp. ix + 59. Washington, D.C., U.S.A.

Kottelat, M., H.H. Ng & P.K.L. Ng, 1998. Notes on the identity of *Hemibagrus elongatus* (Günther, 1864) and other East Asian species allied to *H. guttatus* (La Cepède, 1803) (Teleostei: Bagridae). *Raffles Bulletin of Zoology*. **46**: 565–572.

Lim, K.K.P. 1995. Fishes. In: S.C. Chin, R.T. Corlett, Y.C. Wee & S.Y. Geh (eds.). *Rain Forest in the City: Bukit Timah Nature Reserve, Singapore. Gardens' Bulletin Singapore. Suppl.* **3**: 159–163.

Lim, K.K.P. & H.K. Larson. 1994. A preliminary checklist of the gobiid fishes of Singapore. In: S. Sudara, C.R. Wilkinson & L.M. Chou (eds.). *Proceedings of the Third ASEAN-Australia Symposium on Living Coastal Resources*, Chulalongkorn University. 2 (Research papers): 257–262.

Lim, K.K.P. & P.K.L. Ng. 1990. *A Guide to the Freshwater Fishes of Singapore*. Singapore Science Centre, Singapore. pp. 160. First edition.

Munro, A.D. 1990. The freshwater fishes of Singapore. In: L.M. Chou & P.K.L. Ng (eds.). *Essays in Zoology*. Department of Zoology, National University of Singapore. pp. 97–126.

Nelson, J.S. 1994. *Fishes of the World*. John Wiley & Sons. xvii + pp. 600. Third edition.

Ng, H.H. & K.K.P. Lim. 1995. A revision of the Southeast Asian catfish genus *Parakysis* (Teleostei: Akysidae), with descriptions of two new species. *Ichthyological Exploration of Freshwaters*. **6**: 255–266.

Ng, H.H. & P.K.L. Ng. 1995. Fishes of the forest. *Nature Watch*. Nature Society (Singapore). **3**: 14–17.

Ng, H.H. & P.K.L. Ng. 1998. A revision of the South-east Asian catfish genus *Silurichthys*. *Journal of Fish Biology*. **52**: 291–333.

Ng, P.K.L. 1991. Native Southeast Asian freshwater fishes. Conservation of a precarious resource. In: *Proceedings of the 1991 Annual ASAIHL Seminar "Role of ASAIHL Universities in Promoting Preservation of the Environment"*, Airlangga University, Surabaya, Indonesia, pp. 373–381.

Ng, P.K.L. 1994. Freshwater habitats. In: Y.C. Wee & P.K.L. Ng (eds.). *A First Look at Biodiversity in Singapore*. National Council on the Environment, Singapore. pp. 23–34.

Ng, P.K.L. & M. Kottelat. 1994. Revision of the *Betta waseri* species group (Teleostei: Belontiidae). *Raffles Bulletin of Zoology*. **42**: 593–611.

Ng, P.K.L. & T.J. Lam. 1995. The conservation of biodiversity in Singapore: status and research prospects. *Wallaceana*, Kuala Lumpur. **76**: 1–5.

Ng, P.K.L. & K.K.P. Lim. 1989. Rediscovery of the Dwarf Snakehead, *Channa gachua* (Hamilton, 1822) (Channidae) in Singapore. *Raffles Bulletin of Zoology*. **37**: 172–174.

Ng, P.K.L. & K.K.P. Lim. 1990. The Black Snakehead, *Channa melasoma* (Bleeker, 1851) (Channidae): first record from Singapore. *Raffles Bulletin of Zoology*. **38**: 21–24.

Ng, P.K.L. & K.K.P. Lim. 1992. The conservation status of the Nee Soon Freshwater Swamp Forest of Singapore. *Aquatic Conservation: Marine and Freshwater Ecosystems*. **2**: 255–266.

Ng, P.K.L.& K.K.P. Lim. 1996. The freshwater fishes of Singapore. *Journal of the Singapore National Academy of Science*. **22–24**: 109–124, figs. 1–6, 1 table.

Ng, P.K.L. & H.H. Tan. 1997. Freshwater fishes of Southeast Asia: potential for the aquarium fish trade and conservation issues. *Aquatic Science and Conservation*. **1**: 79–90.

Ng, P.K.L, L.M. Chou & T.J. Lam. 1993. The status and impact of introduced freshwater animals in Singapore. *Biological Conservation*. **64**: 19–24.

Ng, P.K.L., J. Low & K.K.P. Lim. 1994. Fish. In: P.K.L. Ng & Y.C. Wee (eds.). *The Singapore Red Data Book. Threatened Plants and Animals of Singapore*. Nature Society (Singapore). pp. 185–207.

Ngiam, T.T. 1994. Agrotechnology: its development in Singapore. In: C.S. Loh, S.K. Lee, T.M. Lim & T.K. Tan (eds.). *Proceedings of the*

International Conference on Agrotechnology. Commonwealth: Focus 21st Century, Singapore. National University of Singapore. pp. 199.

Siebert, D.R. 1997. The identities of *Rasbora paucisqualis* Ahl in Schreitmüller, 1935, and *Rasbora bankanensis* (Bleeker, 1853), with the designation of a lectotype for *R. paucisqualis* (Teleostei: Cyprinidae). *Raffles Bulletin of Zoology*. **45**: 29–37.

Tan, T.H.T. & P.K.L. Ng. 1996. Blackwater catfishes of the *Ompok leiacanthus* (Bleeker, 1853) species group (Teleostei: Siluridae) from Southeast Asia, with description of a new species. *Raffles Bulletin of Zoology*. **44**: 531–542.