

The non-native freshwater fishes of Singapore: an annotated compilation

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Abstract. A total of 123 species of non-native freshwater fish, including seven possible hybrids, are recorded from the inland waters in Singapore. The majority (84 species, 68.3%) are from four families: Cyprinidae (37 species, 30.1%), Cichlidae (30 species, 24.4%), Osphronemidae (9 species, 7.3%), and Poeciliidae (8 species, 6.5%). Of these, 42 species—mainly cichlids (12 species)—are established in Singapore. The likely pathways of introduction and pertinent conservation issues are briefly discussed. Notes on local distribution, species used for biological control, dubious records, early records of native fish species, ornamental fish trade and aquacultural species are also provided. An addendum is included for four more species.

Key words. Alien species, introduction pathway, aquarium/ornamental trade, aquaculture, reservoirs, urban waterways, forest streams, freshwater swamp, Southeast Asia

INTRODUCTION

The first comprehensive listing of the freshwater fish fauna of Singapore was by Alfred (1966a). Prior to that, only sporadic publications covering specific taxonomic groups were published. Alfred's (1966a) study encompassed all the native freshwater fishes recorded from Singapore at that juncture, and also included non-native species. The next comprehensive coverage was by Lim & Ng (1990), which also included non-native species. More recently, updated fauna lists were available from Baker & Lim (2008, 2012). In one of the first dedicated reports of non-native fish species in Singapore, Ng HH & Tan HH (2010) documented 54 species from 14 reservoirs (three more reservoirs have since become operational, making a present total of 17). Ng HH & Tan HH's (2010) exercise did not, however, include records from other types of freshwater habitats in Singapore.

This study presents a consolidated and updated checklist of non-native freshwater fishes from all inland aquatic habitats in Singapore, from lentic water bodies (e.g., reservoirs, storm-water retention ponds, landscape park ponds) to lotic waterways (e.g., urban canals, rural streams, and to a smaller extent natural forest streams) (Yeo & Lim, 2011). It also

draws data from more than 150 published references as well as unpublished data and technical reports (as of 31 December 2017) from an ongoing national water agency-sanctioned study of the aquatic biodiversity and ecology in Singapore's reservoirs supported by PUB Singapore's National Water Agency. The references cover primary data from literature and other sources, as well as secondary data (collected or observed by the authors in this and other related studies).

MATERIAL AND METHODS

Fish specimens were obtained using a range of methods, such as cast/throw nets (4 to 6 m diameter, 2 cm mesh size), long line (multiple baited hooks on line), hook-and-line (angling), push nets (60 × 40 cm frame, 2 mm mesh size), scoop nets (1–2 mm mesh size), gill nets (4–6 cm mesh size), fish traps (baited and un-baited), and electrofishing. Fish species were identified using various references and keys including Kottelat et al. (1993), Larson & Lim (2005), Baker & Lim (2012), Kottelat (2013), Froese (2018), and Fricke et al. (2018). The recent reclassification of the order Cypriniformes by Tan & Armbruster (2018) was not applied to this checklist as the proposed phylogeny is preliminary, and would only confuse readers and conservation managers if introduced presently. Records obtained from internet resources are included if location is mentioned and species can be discerned or identified properly.

Fish specimens obtained were euthanised according to the National University of Singapore's Institutional Animal Care and Use Committee (IACUC) guidelines. These specimens were then fixed in 10% formalin solution, leached in water and subsequently stored in 75% ethanol.

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For natural distribution ranges of the fishes listed in this paper (see Fig. 122), they are grouped into the following categories: North America (NA), Central America (CA), South America (SA), Africa (AF), South Asia (SAs), East Asia (EAs), Southeast Asia (SEA), Australasia (AU).

The notation “SPC” in square parantheses below the fish name indicates that voucher specimens had been deposited in the Zoological Reference Collection of the Lee Kong Chian Natural History Museum, National University of Singapore; and/or the Natural History Museum, London, United Kingdom.

RESULTS

A total of 123 non-native fish species from 28 families and nine orders are recorded, covering a time period of 168 years from 1849 to 2017. Of the 123 species, seven taxa are purported hybrids or varieties. Most of the records are relatively recent, from 1990 onwards (100 of 123 species, 81.3%). Almost all of the earlier records (pre-1990) pertain to imported species of aquacultural importance (see Alfred, 1966a), or incidentals likely to have originated from aquacultural imports, with a small number possibly introduced for biological/vector control. Almost all of the recent records appear to be discards or escapees from the ornamental fish/pet trade, purposeful introduction for recreational angling (Yeo & Chia, 2010), or unknown sources (Yeo et al., 2010).

The majority (84 species, 68.3%) of non-native fish species are from four families: Cyprinidae (37 species, 30.1%), Cichlidae (30 species, 24.4%), Osphronemidae (9 species, 7.3%), and Poeciliidae (8 species, 6.5%); whilst the remaining 39 species are distributed among 24 other families. Of the 123 species, 42 species (~34%) from 15 families have established breeding populations in Singapore, with the dominant family being the Cichlidae (12 species) followed by Cyprinidae (nine species). See Table 1 for an overall listing of the non-native fish species recorded from Singapore’s inland waterways. Colour illustrations of 119 recorded species are also provided before each species account; all were photographed by the first author unless stated otherwise.

COMPILATION OF NON-NATIVE FRESHWATER FISH SPECIES

Order Rajiformes

Family Potamotrygonidae

Potamotrygon motoro (Müller & Henle)
(Fig. 1, SA[SPC])

References. Baker & Lim, 2008, 2012; Ng et al., 2009; Chua G, 2010; Ng et al., 2009; Ng HH & Tan HH, 2010; Chua, 2015; Lai, 2015; Tan & Zeng, 2015; Ho et al., 2016; Tan & Tan, 2018.



Fig. 1. *Potamotrygon motoro*, female 163 mm disc width, Lower Peirce Reservoir.

Distribution. Upper Seletar Reservoir (Ng et al., 2009; Chua G, 2010; Ng HH & Tan HH, 2010; Ho et al., 2016); Lower Peirce Reservoir (Lai, 2015; Ho et al., 2016); Banir stream [direct link to Lower Seletar Reservoir] (Tan & Zeng, 2015); Lower Seletar Reservoir (Ho et al., 2016).

Remarks. Recent observations indicate a breeding population at Lower Peirce Reservoir, where up to six juveniles were sighted at night in shallow water adjacent to a boardwalk (Zhou H, pers. obs., August 2016). This stingray’s diet includes fishes and aquatic macroinvertebrates, including freshwater gastropods, crustaceans, and insect larvae (Tan & Tan, 2018; Kwik et al., in prep.).

Order Lepisosteiformes

Family Lepisosteidae

Atractosteus spatula (Lacepède)
(Fig. 2, NA[SPC])



Fig. 2. *Atractosteus spatula*, ca. 1,200 mm SL, Bedok Reservoir.

References. Ng HH & Tan HH, 2010; Kwik et al., 2013; Yeo, 2013.

Distribution. Bedok Reservoir (Ng HH & Tan HH, 2010); Pandan Reservoir (Ng HH & Tan HH, 2010); Yishun Pond (Kwik et al., 2013); Bishan Park (Yeo, 2013); Marina Reservoir (Anonymous, pers. comm., 2014).

Lepisosteus oculatus Winchell
(Fig. 3, NA)



Fig. 3. *Lepisosteus oculatus*, 119.9 mm SL, trade material.

References. Lim, 2013a; Yeo, 2013.

Distribution. Singapore Botanic Gardens (Lim, 2013a); Bishan Park (Yeo, 2013).

Table 1a. Non-native inland fishes of Singapore. A total of 123 fish species are recorded with 43 species having established breeding populations in Singapore.

Order and Family	Species	Region of Origin	Remarks
ORDER RAJIFORMES			
Family Potamotrygonidae	<i>Potamotrygon motoro</i>	South America	established
ORDER LEPISOSTEIFORMES			
Family Lepisosteidae	<i>Atractosteus spatula</i>	North America	
	<i>Lepisosteus oculatus</i>	North America	
ORDER OSTEOGLOSSIFORMES			
Family Arapaimidae	<i>Arapaima gigas</i>	South America	
Family Notopteridae	<i>Chitala ornata</i>	Southeast Asia	
	<i>Notopterus notopterus</i>	Southeast Asia	established
Family Osteoglossidae	<i>Osteoglossum bicirrhosum</i>	South America	
	<i>Scleropages formosus</i>	Southeast Asia	established
	<i>Scleropages jardini</i>	Australasia	
ORDER CYPRINIFORMES			
Family Cyprinidae	<i>Amblypharyngodon chulabhornae</i>	Southeast Asia	established
	<i>Barbodes rhombeus</i>	Southeast Asia	established
	<i>Barbodes semifasciolatus</i>	East Asia	extirpated
	<i>Barbonymus altus</i>	Southeast Asia	
	<i>Barbonymus gonionotus</i>	Southeast Asia	
	<i>Barbonymus schwanefeldii</i>	Southeast Asia	established
	<i>Carassius auratus</i>	East Asia	
	<i>Cirrhinus molitorella</i>	Southeast Asia	
	<i>Crossocheilus oblongus</i>	Southeast Asia	
	<i>Ctenopharyngodon idella</i>	East Asia	
	<i>Cyprinus carpio</i>	East Asia	
	<i>Danio albolineatus</i>	Southeast Asia	established
	<i>Danio albolineatus</i> × <i>D. rerio</i> hybrid	–	
	<i>Danio rerio</i>	South Asia	
	<i>Danio rerio</i> ‘frankei’	–	
	<i>Dawkinsia filamentosa</i>	South Asia	
	<i>Esomus metallicus</i>	Southeast Asia	
	<i>Hampala macrolepidota</i>	Southeast Asia	established
	<i>Hypophthalmichthys molitrix</i>	East Asia	
	<i>Hypophthalmichthys nobilis</i>	East Asia	
	<i>Labeo rohita</i>	South Asia	
	<i>Leptobarbus rubripinna</i>	Southeast Asia	
	<i>Metzia lineata</i>	East Asia	extirpated
	<i>Morulus chrysophekadion</i>	Southeast Asia	
	<i>Mylopharyngodon piceus</i>	East Asia	
	<i>Neolissochilus</i> sp.	Southeast Asia	
	<i>Osteochilus vittatus</i>	Southeast Asia	established
	<i>Pethia conchonius</i>	South Asia	
	<i>Puntigrus partipentazona</i>	Southeast Asia	established
	<i>Puntigrus tetrazona</i>	Southeast Asia	established
	<i>Puntius sophore</i>	South Asia	
	<i>Rasbora</i> cf. <i>notura</i>	Southeast Asia	
<i>Rasbora trilineata</i>	Southeast Asia	established	
<i>Toxabramis houdemeri</i>	East Asia		
<i>Tor tambra</i>	Southeast Asia		
<i>Tor tambroides</i>	Southeast Asia		
<i>Trigonopoma gracile</i>	Southeast Asia		

Order and Family	Species	Region of Origin	Remarks
Family Botiidae	<i>Chromobotia macracanthus</i>	Southeast Asia	
Family Gyриноcheilidae	<i>Gyrinocheilus aymonieri</i>	Southeast Asia	
ORDER CHARACIFORMES			
Family Characidae	<i>Hemigrammus rodwayi</i>	South America	established
	<i>Paracheirodon innesi</i>	South America	
	<i>Thayeria boehlkei</i>	South America	
Family Serrasalmididae	<i>Piaractus brachypomus</i>	South America	
ORDER SILURIFORMES			
Family Bagridae	<i>Hemibagrus capitulum</i>	Southeast Asia	
	<i>Hemibagrus guttatus</i>	East Asia	extirpated
	<i>Mystus castaneus</i>	Southeast Asia	
	<i>Mystus wolffii</i>	Southeast Asia	
Family Clariidae	<i>Clarias gariepinus</i>	Africa	established
	<i>Clarias macrocephalus</i>	Southeast Asia	
Family Callichthyidae	<i>Corydoras aeneus</i>	South America	
Family Loricariidae	<i>Pterygoplichthys disjunctivus</i>	South America	established
	<i>Pterygoplichthys joselimaianus</i>	South America	established
	<i>Pterygoplichthys pardalis</i>	South America	established
Family Mochokidae	<i>Synodontis eupterus</i>	Africa	
Family Pangasiidae	<i>Pangasius sanitwongsei</i>	Southeast Asia	
	<i>Pangasionodon hypophthalmus</i>	Southeast Asia	
Family Pimelodidae	<i>Phractocephalus hemiliopterus</i>	South America	
ORDER CYPRINODONTIFORMES			
Family Aplocheilidae	<i>Aplocheilus lineatus</i>	South Asia	established
Family Poeciliidae	<i>Gambusia affinis</i>	Central America	established
	<i>Poecilia latipinna</i>	Central America	
	<i>Poecilia reticulata</i>	Central America	established
	<i>Poecilia sphenops</i>	Central America	established
	<i>Poecilia velifera</i>	Central America	
	<i>Xiphophorus hellerii</i>	Central America	
	<i>Xiphophorus maculatus</i>	Central America	
	<i>Xiphophorus variatus</i>	Central America	
ORDER SYNBRANCHIFORMES			
Family Mastacembelidae	<i>Macrognathus siamensis</i>	Southeast Asia	
	<i>Macrognathus zebrinus</i>	Southeast Asia	established
ORDER PERCIFORMES			
Family Ambassidae	<i>Parambassis siamensis</i>	Southeast Asia	established
Family Datnioididae	<i>Datnioides microlepis</i>	Southeast Asia	
Family Monodactylidae	<i>Monodactylus sebae</i>	Africa	

Order and Family	Species	Region of Origin	Remarks
Family Cichlidae	<i>Acarichthys heckelli</i>	South America	established
	<i>Amphilophus citrinellus</i>	Central America	established
	<i>Amphilophus trimaculatus</i>	Central America	
	<i>Apistogramma borelli</i>	South America	established
	<i>Astronotus ocellatus</i>	South America	
	<i>Cichla kelberi</i>	South America	
	<i>Cichla orinocensis</i>	South America	established
	<i>Cichla piquiti</i>	South America	
	<i>Cichla temensis</i>	South America	established
	<i>Coptodon zillii</i>	Africa	
	<i>Etroplus suratensis</i>	South Asia	established
	<i>Geophagus altifrons</i>	South America	established
	<i>Herichthys carpintis</i>	Central America	
	<i>Heros severus</i>	South America	
	<i>Heterotilapia buttkoferi</i>	Africa	established
	<i>Mayaheros urophthalmus</i>	Central America	established
	<i>Mayaheros urophthalmus</i> ×	–	
	<i>Parachromis managuensis</i> hybrid		
	<i>Maylandia estherae</i>	Africa	
	<i>Oreochromis aureus</i>	Africa	
	<i>Oreochromis mossambicus</i>	Africa	established
	<i>Oreochromis niloticus</i>	Africa	established
	<i>Oreochromis mossambicus</i> × <i>O. niloticus</i> hybrid	–	established
	<i>Parachromis managuensis</i>	Central America	established
	<i>Pterophyllum scalare</i>	South America	
	<i>Satanoperca jurupari</i>	South America	
	<i>Thorichthys meeki</i>	Central America	
	<i>Vieja melanura</i>	Central America	established
	Luohan/Flowerhorn cichlid hybrid	–	
	Blood/Red Parrot hybrid	–	
Red Tilapia	–		
Family Gobinellidae	<i>Brachygobius sabanus</i>	Southeast Asia	established
	<i>Rhinogobius similis</i>	East Asia	established
Family Helostomatidae	<i>Helostoma temminckii</i>	Southeast Asia	
Family Osphronemidae	<i>Betta splendens</i>	Southeast Asia	established
	<i>Macropodus opercularis</i>	East Asia	
	<i>Osphronemus goramy</i>	Southeast Asia	established
	<i>Osphronemus latyclavius</i>	Southeast Asia	
	<i>Sphaerichthys osphromenoides</i>	Southeast Asia	
	<i>Trichogaster lalius</i>	South Asia	
	<i>Trichopodus microlepis</i>	Southeast Asia	
	<i>Trichopodus pectoralis</i>	Southeast Asia	established
<i>Trichopsis schalleri</i>	Southeast Asia	established	
Family Channidae	<i>Channa micropeltes</i>	Southeast Asia	established

Table 1b. Fish species listed in addendum.

Order and Family	Species	Region of Origin	Remarks
ORDER SILURIFORMES			
Family Bagridae	<i>Horabagrus brachysoma</i>	South Asia	
Family Claroteidae	<i>Chrysichthys auratus</i>	Africa	
ORDER CHARACIFORMES			
Family Anostomidae	<i>Leporinus fasciatus</i>	South America	
ORDER PERCIFORMES			
Family Cichlidae	<i>Veija</i> × <i>Mayaheros</i> hybrid	–	

Order Osteoglossiformes

Family Arapaimidae

Arapaima gigas (Schinz)

(Fig. 4, SA)



Fig. 4. *Arapaima gigas*, 181.2 mm SL, trade material.

References. fishing_vimal, 2017.

Distribution. Marina Reservoir (fishing_vimal, 2017).

Remarks. Sightings of *Arapaima gigas* (Arapaimidae) have been listed in forums (e.g., <http://forum.fishingkaki.com/discussion/229269/arapaima-in-singapore>); however, these were never substantiated with photographs or locations until recently from Marina Reservoir near the steps along Boat Quay (fishing_vimal, 2017). This species is available in the ornamental fish trade, although in limited quantity. This species grows to be one of the largest freshwater fish (Luna, 2020), and it is unsurprising that larger individuals are discarded or released into artificial water bodies when they out-grow their tanks.

Family Notopteridae

Chitala ornata (Gray)

(Fig. 5, SEA[SPC])



Fig. 5. *Chitala ornata*, 650 mm SL, Pandan Reservoir.

References. Ng & Lim, 1997b; Baker & Lim, 2008, 2012; Ng HH & Tan HH, 2010; Tan HTW et al., 2010.

Distribution. Jurong Lake (Ng HH & Tan HH, 2010); Kranji Reservoir (Ng HH & Tan HH, 2010); Upper Seletar Reservoir (Ng HH & Tan HH, 2010); Lower Seletar Reservoir (Ng & Lim, 1997b; Ng HH & Tan HH, 2010); Pandan Reservoir (Ng HH & Tan HH, 2010); Upper Peirce Reservoir (Ng HH & Tan HH, 2010); MacRitchie Reservoir (unpublished data); Punggol Reservoir (unpublished data).

Notopterus notopterus (Pallas)

(Fig. 6, SEA, SAs[SPC])



Fig. 6. *Notopterus notopterus*, ca. 250 mm SL, Tengoh Reservoir.

References. Baker & Lim, 2008, 2012; Ng HH & Tan HH, 2010; Baker, 2013c; Tan et al., 2016.

Distribution. Jurong Lake (Ng HH & Tan HH, 2010); Murai Reservoir (Ng HH & Tan HH, 2010); Lower Peirce Reservoir (Ng HH & Tan HH, 2010); Lower Seletar Reservoir (Ng HH & Tan HH, 2010); Poyan Reservoir (Ng HH & Tan HH, 2010); Tengoh Reservoir (Ng HH & Tan HH, 2010); Kranji Marsh (Baker, 2013c; Tan et al., 2016); Upper Seletar Reservoir spill gate (Tan HH, pers. obs., 2014); Pandan reservoir (unpublished data).

Family Osteoglossidae

Osteoglossum bicirrhosum (Cuvier)

(Fig. 7, SA)

References. Anonymous, 1988a; Ng & Lim, 1997b; Ng HH & Tan HH, 2010.



Fig. 7. *Osteoglossum bicirrhosum*, 215 mm SL, trade material.

Distribution. Singapore Botanic Gardens (Anonymous, 1988a); Lower Peirce Reservoir (Ng HH & Tan HH, 2010); Sungei Buloh Wetland Reserve (Tan HH, pers. obs., mid-2000s).

***Scleropages formosus* (Müller & Schlegel)**
(Fig. 8, SEA[SPC])



Fig. 8. *Scleropages formosus*, 32.0 mm SL juvenile (top), 490 mm SL adult (bottom), Upper Peirce Reservoir.

References. Green, 1928; Anonymous, 1988a, 1989a; Lim & Ng, 1990; Ng et al., 1993; Ng & Lim, 1997a, 1997b; National Parks Board, 2003; Baker & Lim, 2008, 2012; Ng HH & Tan HH, 2010; Baker, 2013b; Kwik et al., 2013; Baker, 2014; Tan, 2014b, 2014c, 2015c, 2016a; Ho et al., 2016.

Distribution. Lim & Ng (1990) listed this species from the Central Catchment reservoirs; Lower Peirce Reservoir (Ng & Lim, 1997a, 1997b; Baker, 2013b); Singapore Botanic Gardens (Anonymous, 1988a); East Coast Park (Anonymous, 1988a); Woodlands Town Garden (Anonymous, 1989a); MacRitchie Reservoir (Ng & Lim, 1997a, 1997b; Ng HH & Tan HH, 2010; Tan, 2016a); Bedok Reservoir (Ng HH & Tan HH, 2010); Upper Seletar Reservoir (Ng HH & Tan HH, 2010); Lower Seletar Reservoir (Ng HH & Tan HH, 2010); Pandan Reservoir (Ng HH & Tan HH, 2010); Upper Peirce Reservoir (Ng HH & Tan HH, 2010); Sungei Buloh Wetland Reserve (National Parks Board, 2003; Baker, 2014); Pangsua Pond (Kwik et al., 2013; Tan, 2014b); Central

Catchment Nature Reserve stream (Tan, 2014c; Ho et al., 2016); Banir (Tan, 2015c); Jurong Lake (unpublished data); Lower Peirce reservoir (unpublished data); Bedok reservoir (unpublished data).

Remarks. This species is protected under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Appendix I and breeding populations are established in the Central Catchment Nature Reserve reservoirs in Singapore (Ng HH & Tan HH, 2010). One of the documented sources is from then-PPD (Primary Productions Department; presently divided into National Parks Board and Singapore Food Agency) (see Ng HH & Tan HH, 2010, for a more detailed account). The Singapore variants are of questionable sources, and probably the consequence of artificial crosses between recognised colour variants (Andy Yap, pers. comm.).

***Scleropages jardini* (Saville-Kent)**
(Fig. 9, AU)



Fig. 9. *Scleropages jardini*, ca. 350 mm SL, trade material.

References. None. This is a new record for Singapore.

Distribution. Singapore Botanic Gardens, Swan Lake (Lim KKP, pers. obs., October 2010).

Order Cypriniformes

Family Cyprinidae

***Amblypharyngodon chulabhornae* Vidthayanon & Kottelat**
(Fig. 10, SEA[SPC])



Fig. 10. *Amblypharyngodon chulabhornae*, ca. 25 mm SL, Kranji Marsh.

References. Ng et al., 1993; Ng & Lim, 1997a, 1997b; Baker & Lim, 2012; Lim & Tan, 2012; Lim et al., 2013; Tan et al., 2016.

Distribution. Choa Chu Kang pond (Ng & Lim, 1997a; Lim & Tan, 2012); Kranji Marsh (Lim & Tan, 2012; Lim et al., 2013; Tan et al., 2016).

Remarks. Both juveniles and adults have been obtained from Kranji Marsh, suggesting an established breeding population there.

***Barbodes rhombeus* (Kottelat)**
(Fig. 11, SEA[SPC])



Fig. 11. *Barbodes rhombeus*, 57.5 mm SL, Bishan Park.

References. Subaraj et al., 1995 (as *Puntius binotatus*); Ng & Lim, 1997a (as *Puntius binotatus*); Ng & Lim, 1997b (as *Puntius binotatus*); Tan et al., 2013 (as *Systemus rhombeus*); Tan & Low, 2014; Kwik & Yeo, 2015 (as *Puntius binotatus*); Ho et al., 2016.

Distribution. Mandai area (Subaraj et al., 1995; Tan & Low, 2014); Andrew Road drain (Ng & Lim, 1997a); Bukit Brown (Tan et al., 2013); Venus Drive (Tan HH, pers. obs., 2010); Pandan river (Tan HH, pers. obs., March 2014); outskirts of Nee Soon Swamp Forest (Ho et al., 2016); Tengah area (Cai YX, pers. obs., 11 January 2017); Bishan Park (unpublished data).

***Barbodes semifasciolatus* (Günther) [Extirpated]**
(Fig. 12, SEA, EAs[SPC])



Fig. 12. *Barbodes semifasciolatus*, 42.2 mm SL, wild type from Vietnam (top); ca. 30 mm SL, xanthic trade material (bottom).

References. de Beaufort, 1933 (as *Puntius sachsi*); Tweedie, 1936 (as *Puntius sachsi*); Fowler, 1938 (as *Barbus sachsi*); Johnson, 1964 (as *Puntius semifasciolatus*); Alfred, 1966a (as *Puntius semifasciolatus*, as early as 1912); Johnson, 1973a (as *Puntius semifasciolatus*); Anonymous, 1988a (as *Capoeta semifasciolatus*); Lim, 1989 (as *Puntius semifasciolatus*); Lim & Ng, 1990 (as

Puntius semifasciolatus, as early as 1900s); Munro, 1990 (as *Puntius semifasciolatus*); Ng et al., 1993 (as *Puntius semifasciolatus*); Lever, 1996 (as *Barbus semifasciolatus*); Ng & Lim, 1997a (as *Puntius semifasciolatus*); Ng & Lim, 1997b (as *Puntius semifasciolatus*); Baker & Lim, 2008, 2012 (as *Puntius semifasciolatus*); Tan HH et al., 2010 (as *Puntius semifasciolatus*).

Distribution. Probably extirpated in Singapore as there have been no recent records; previously recorded from Serangoon area (de Beaufort, 1933; Tweedie, 1936; Alfred, 1966a; Munro, 1990); Bukit Timah area (Alfred, 1966a; Ng & Lim, 1997a); MacRitchie Reservoir (Alfred, 1966a; Anonymous, 1988a); Kallang River (Alfred, 1966a; Tan HH et al., 2010); Sungei Seletar (Alfred, 1966a); Lower Peirce Reservoir (Ng & Lim, 1997a, 1997b); Central Catchment Nature Reserve — Sime Road forest (Lim, 1989; Ng & Lim, 1997a, 1997b).

Remarks. This species was an accidental introduction with imported fish fry from China (Johnson, 1964), possibly as early as 1912 (Alfred, 1966a).

***Barbonymus altus* (Günther)**
(Fig. 13, SEA[SPC])



Fig. 13. *Barbonymus altus*, 110.8 mm SL, Pangsua Pond.

References. Ng & Lim, 1997a (as *Barbodes altus*); Ng HH & Tan HH, 2010.

Distribution. Jurong Lake (Ng HH & Tan HH, 2010).

***Barbonymus gonionotus* (Bleeker)**
(Fig. 14, SEA)



Fig. 14. *Barbonymus gonionotus*, 140.0 mm SL, trade material (specimen with aberrant body scale pattern).

References. Alfred, 1966a (as *Puntius gonionotus*); Anonymous, 1989a (as *Puntius gonionotus*); Lim & Ng, 1990 (as *Barbodes gonionotus*); Ng et al., 1993 (as *Barbodes*

gonionotus); Ng & Lim, 1997a (as *Barbodes gonionotus*); Ng & Lim, 1997b (as *Barbodes gonionotus*).

Distribution. Woodlands Town Garden (Anonymous, 1989a).

Remarks. This species was introduced as a food fish during the Japanese Occupation of Singapore (1942–1945) (Alfred, 1966a; Mohsin & Ambak, 1983; Lim & Ng, 1990; Ng & Lim, 1997a), but failed to gain popularity. There have not been any recent records (i.e., post-1990).

***Barbonymus schwanefeldii* (Bleeker)**
(Fig. 15, SEA[SPC])



Fig. 15. *Barbonymus schwanefeldii*, 95.8 mm SL, trade material.

References. Alfred, 1966a (as *Puntius schwanefeldii*, first recorded in 1937); Baker & Lim, 2008, 2012; Ng HH & Tan HH, 2010.

Distribution. Jurong area (Alfred, 1966a); MacRitchie Reservoir (Ng HH & Tan HH, 2010); Marina Reservoir (unpublished data); Jurong Lake (unpublished data).

Remarks. Recorded as extinct in Singapore (Alfred, 1966a); recent records probably represent non-native introductions (Ng HH & Tan HH, 2010).

***Carassius auratus* (Linnaeus)**
(Fig. 16, EAs[SPC])



Fig. 16. *Carassius auratus*, ca. 35 mm SL, Yishun Pond.

References. Lim & Ng, 1990; Ng et al., 1993; Ng & Lim, 1997a, 1997b; Ng HH & Tan HH, 2010; Tan HH et al., 2010.

Distribution. Bedok Reservoir (Ng HH & Tan HH, 2010); Kallang River (now part of Marina Reservoir; Tan HH et al., 2010).

Remarks. This species was most probably introduced from Java for aquaculture (Mohsin & Ambak, 1983). Present records are mainly from escapees or releases, as this species is a very popular ornamental fish and frequently used as feeder fish (Lim & Ng, 1990; Ng & Lim, 1997a).

***Cirrhinus molitorella* (Valenciennes, in Cuvier & Valenciennes)**
(Fig. 17, SEA)



Fig. 17. *Cirrhinus molitorella*, 99.5 mm SL, trade material.

References. Herre & Myers, 1937; Le Mare, 1949 (as *Cirrhina molitorella*); Tham, 1973 (as *Cirrhina molitorella*); Munro, 1990; Ng & Lim, 1997a, 1997b.

Distribution. Not known.

Remarks. Herre & Myers' (1937) record was an escapee from cultivation, and this may not have established in Singapore. Tham (1973) commented that this is a rarely used fish for aquaculture, with fry imported from China. Presently, the juveniles of this fish are used quite extensively as feed for predatory fish in the ornamental fish trade (Tan HH, pers. obs.).

***Crossocheilus oblongus* Kuhl & van Hasselt, in van Hasselt**
(Fig. 18, SEA[SPC])



Fig. 18. *Crossocheilus oblongus*, 112.7 mm SL, Punggol Reservoir.

References. None. This is a new record for Singapore.

Distribution. Punggol Reservoir (unpublished data).

Remarks. This is probably a discarded pet, as this species is actively promoted in the ornamental fish trade as an algae eater and for algae control (Tan HH, pers. obs.).

***Ctenopharyngodon idella* (Valenciennes, in Cuvier & Valenciennes)**
(Fig. 19, EAs)



Fig. 19. *Ctenopharyngodon idella*, 83.7 mm SL, trade material.

References. Herre & Myers, 1937; Le Mare, 1949 (as *Ctenopharyngodon idellus*); Tham, 1973 (as *Ctenopharyngodon idellus*); Mohsin & Ambak, 1983; Yang, 1984; Lim & Ng, 1990; Munro, 1990; Public Utilities Board, 1991; Ng et al., 1993; Ng & Lim, 1997a, 1997b.

Distribution. Upper Seletar Reservoir (previously known as Seletar Reservoir; Yang, 1984).

Remarks. Herre & Myers' (1937) record came from an experimental fish pond, and this may not have established in Singapore. Tham (1973) commented that it was the most popular fish cultured in fish ponds and the fry were imported from China. This species was reared in experimental floating cages in reservoirs as early as 1972, and subsequently used primarily for control of submerged macrophytes (Yang, 1984).

***Cyprinus carpio* Linnaeus**
(Fig. 20, EAs[SPC])



Fig. 20. *Cyprinus carpio*, 220 mm SL, Pangsua Pond.

References. Herre & Myers, 1937; Le Mare, 1949; Tham, 1973; Mohsin & Ambak, 1983; Yang, 1984; Lim & Ng, 1990; Munro, 1990; Ng et al., 1993; Ng & Lim, 1997a, 1997b; National Parks Board, 2003; Ng HH & Tan HH, 2010; Tan HTW et al., 2010; Yeo & Chia, 2010; Davison et al., 2012 (as carp); Kwik et al., 2013; Tan, 2016b; Tan HH et al., 2017b.

Distribution. Upper Seletar Reservoir (previously known as Seletar Reservoir; Yang, 1984); Sungei Buloh Wetland Reserve (National Parks Board, 2003); Catchment Pond (Tan HH, pers. obs., 2000s); Bedok Reservoir (Ng HH & Tan HH, 2010); Pandan Reservoir (Ng HH & Tan HH, 2010); Kent Ridge Park pond (Tan HTW et al., 2010; Tan, 2016b); Pangsua pond (Kwik et al., 2013); Singapore Botanic Gardens (Tan HH, pers. obs., 2015); Singapore Quarry (Tan HH et al., 2017b); Bishan Park (unpublished data).

Remarks. Herre & Myers' (1937) record came from an experimental fish pond, and this species may not have established in Singapore then and presently (Lim & Ng, 1990). Tham (1973) commented that this was a popular cultured fish, which was bred locally. Many of the recent records refer to the colourful variants, indicative of discarded pets or mercy/religious release.

***Danio albolineatus* (Blyth)**
(Fig. 21, SEA[SPC])



Fig. 21. *Danio albolineatus*, 26.0 mm SL, Mandai area.

References. Lim & Tan, 2011; Baker & Lim, 2012; Tan et al., 2013; Tan & Low, 2014.

Distribution. Mandai area (Lim & Tan, 2011; Tan & Low, 2014); Bukit Brown (Tan et al., 2013); Bukit Timah area (Tan HH, pers. obs., February 2015); Tengah area (Cai YX, pers. obs., 11 January 2017).

Danio albolineatus* × *D. rerio
(Fig. 22 [SPC])



Fig. 22. *Danio albolineatus* × *D. rerio* hybrid, 27.2 mm SL, Mount Pleasant.

References. Tan et al., 2013.

Distribution. Bukit Brown (Tan et al., 2013).

Remarks. The presence of this hybrid was reported by Tan et al. (2013).

***Danio rerio* (Hamilton)**
(Fig. 23, SEA[SPC])



Fig. 23. *Danio rerio*, 35.6 mm SL, Mount Pleasant.

References. Tan et al., 2013.

Distribution. Bukit Brown (Tan et al., 2013).

***Danio rerio* ‘frankei’**
(Fig. 24 [SPC])



Fig. 24. *Danio rerio* ‘frankei’, 37.6 mm SL, Mount Pleasant.

References. Tan et al., 2013.

Distribution. Bukit Brown (Tan et al., 2013).

***Dawkinsia filamentosa* (Valenciennes, in Cuvier & Valenciennes)**
(Fig. 25, SAs[SPC])



Fig. 25. *Dawkinsia filamentosa*, 77.9 mm SL, Woodlands Pond (Kwik JTB).

References. Kwik, 2013; Kwik et al., 2013.

Distribution. Woodlands Town Park pond (Kwik, 2013; Kwik et al., 2013).

***Esomus metallicus* Ahl**
(Fig. 26, SEA)



Fig. 26. *Esomus metallicus*, ca. 40 mm SL, trade material (note the diagnostic character of long barbels).

References. Anonymous, 1988a; Lim & Ng, 1990; Munro, 1990; Ng et al., 1993; Ng & Lim, 1997a, 1997b; Baker & Lim, 2008, 2012.

Distribution. Sungei Sembawang — Senoko (Anonymous, 1988a; Ng & Lim, 1997a); Mandai Road area (Anonymous, 1998a; Ng & Lim, 1997a); Lower Seletar Reservoir (Tan HH, pers. obs., early 1990s).

Remarks. This species is occasionally sold as live feed in the ornamental fish trade (Tan HH, pers. obs.).

***Hampala macrolepidota* Kuhl & van Hasselt, in van Hasselt**
(Fig. 27, SEA[SPC])



Fig. 27. *Hampala macrolepidota*, ca. 250 mm SL female, Upper Peirce Reservoir.

References. Herre & Myers, 1937; Alfred, 1966a; Ng & Lim, 1997b; Baker & Lim, 2008, 2012; Ng HH & Tan HH, 2010; Tan HTW et al., 2010; Yeo & Lim, 2010.

Distribution. Upper Peirce Reservoir (Ng & Lim, 1997b; Ng HH & Tan HH, 2010); Lower Peirce Reservoir (Ng HH & Tan HH, 2010); Singapore Botanic Gardens (Yeo & Lim, 2010).

Remarks. Alfred (1966a) considered this species extinct in Singapore. Recent populations are probably intentional releases or from Johor, Peninsular Malaysia, via raw water transfer (Ng & Lim, 1997b; Ng HH & Tan HH, 2010).

***Hypophthalmichthys molitrix* (Valenciennes, in Cuvier & Valenciennes)**
(EAs)

References. Le Mare, 1949; Tham, 1973; Mohsin & Ambak, 1983; Yang, 1984; Munro, 1990; Ng et al., 1993; Ng & Lim, 1997b.

Distribution. Upper Seletar Reservoir (previously known as Seletar Reservoir; Yang, 1984).

Remarks. This species is cultivated in ponds for food, and the fry stock is imported from China (Le Mare, 1949; Tham, 1973; Munro, 1990; Ng et al., 1993). This species was reared in experimental floating cages in reservoirs as early as 1972 (Yang, 1984).

***Hypophthalmichthys nobilis* (Richardson)**
(Fig. 28, EAs)

References. Le Mare, 1949 (as *Aristichthys nobilis*); Tham, 1973 (as *Aristichthys nobilis*); Mohsin & Ambak, 1983 (as *Aristichthys nobilis*); Yang, 1984 (as *Aristichthys nobilis*); Lim & Ng, 1990; Munro, 1990; Public Utilities Board, 1991; Ng et al., 1993; Ng & Lim, 1997a, 1997b; Ng HH & Tan HH, 2010.

Distribution. Pandan Reservoir (Lim & Ng, 1990; Ng HH & Tan HH, 2010); Upper Seletar Reservoir (Yang, 1984; Lim



Fig. 28. *Hypophthalmichthys nobilis*, 104.3 mm SL, trade material.

& Ng, 1990; Ng HH & Tan HH, 2010); Kranji Reservoir (Ng HH & Tan HH, 2010); Jurong Lake (Lim KKP, pers. obs., 2011).

Remarks. This species is popular as food fish and fry were imported from China (Le Mare, 1949; Tham, 1973). This species was used extensively by the Public Utilities Board (PUB) to control plankton levels in reservoirs as early as 1972 (Yang, 1984; Lim & Ng, 1990; Ng & Lim, 1997a); however, this species is not known to breed in the tropics and all stock for aquaculture is imported (Ng & Lim, 1997b).

***Labeo rohita* (Hamilton)**
(Fig. 29, SAs)



Fig. 29. *Labeo rohita*, 240 mm SL, trade material.

References. Ng HH & Tan HH, 2010.

Distribution. MacRitchie Reservoir (Ng HH & Tan HH, 2010).

Remarks. This fish species is sometimes sold in wet markets and supermarkets in Singapore (Tan HH, pers. obs.).

***Leptobarbus rubripinna* (Fowler)**
(Fig. 30, SEA[SPC])



Fig. 30. *Leptobarbus rubripinna*, ca. 300 mm SL, Jurong Lake.

References. Lim & Ng, 1990 (as *L. hoeveni*); Ng et al., 1993 (as *L. hoeveni*); Ng & Lim, 1997a (as *L. hoeveni*); Ng & Lim, 1997b (as *L. hoeveni*); Ng HH & Tan HH, 2010; Tan, 2016b.

Distribution. Jurong Lake (Ng HH & Tan HH, 2010); Lower Peirce Reservoir (Ng HH & Tan HH, 2010); Lower Seletar Reservoir (Ng HH & Tan HH, 2010); Kent Ridge Park pond (Tan, 2016b); Punggol Reservoir (unpublished data).

Remarks. This species is not established in Singapore as no breeding populations are known (Lim & Ng, 1990; Ng & Lim, 1997a).

***Metzia lineata* (Pellegrin) [Extirpated]**
(Fig. 31. EAs[SPC])



Fig. 31. *Metzia lineata*, 41.9 mm SL, Vietnam.

References. Regan, 1913 (described as *Rasborichthys altior*); Weber & de Beaufort, 1916 (as *Rasborichthys altior*); Tweedie, 1936 (as *Rasborichthys altior*); Herre & Myers, 1937 (as *Rasborichthys altior*); Blythe, 1951 (as *Rasborichthys altior*); Johnson, 1964 (as *Rasborichthys altior*); Alfred, 1966a (as *Rasborichthys altior*); Bănărescu, 1971 (as *Rasborinus lineatus*); Johnson, 1973a (as *Rasborichthys altior*); Lim & Ng, 1990 (as *Rasborinus lineatus*, as early as late 1800s or early 1900s); Munro, 1990 (as *Rasborinus lineatus*); Ng et al., 1993 (as *Rasborinus lineatus takakii*); Ng & Lim, 1997a (as *Rasborinus lineatus takakii*); Ng & Lim, 1997b (as *Rasborinus lineatus*); Tan HH et al., 2010; Tan HTW et al., 2010 (as *Rasborinus lineatus takakii*); Baker & Lim, 2008, 2012.

Distribution. Probably extirpated in Singapore as there have been no recent records (Ng & Lim, 1997a, 1997b); previously recorded from Singapore Botanic Gardens (Tweedie, 1936; Alfred, 1966a); Serangoon area (Tweedie, 1936; Alfred, 1966a); Mandai Road area (Herre & Myers, 1937); MacRitchie Reservoir (Alfred, 1966a); Sungei Seletar (Alfred, 1966a); Sungei Whampoe (Alfred, 1966a); Kallang River (Alfred, 1966a; Tan HTW et al., 2010); Bukit Timah campus (Alfred ER, pers. comm., 2007); Lower Peirce Reservoir (Ng & Lim, 1997a); Upper Seletar Reservoir (Ng & Lim, 1997a).

Remarks. Regan (1913) described this fish species on the presumption that it was endemic to Singapore. Weber & de Beaufort (1916) followed suit in regarding the species as native and endemic, as did subsequent workers (Tweedie, 1936; Herre & Myers, 1937; Alfred, 1966a; Johnson, 1973a). The taxonomy was only resolved by Bănărescu in 1971, and its endemic/native status debunked. This species is now understood to be an accidental import, along with fingerlings of food fish species, imported from Hong Kong and southern China (Lim & Ng, 1990).

***Morulus chrysophekadion* (Bleeker)**
(Fig. 32, SEA[SPC])



Fig. 32. *Morulus chrysophekadion*, 375 mm SL, Punggol Reservoir.

References. None. This is a new record for Singapore.

Distribution. Punggol Reservoir (unpublished data).

***Mylopharyngodon piceus* (Richardson)**
(Fig. 33, EAs)



Fig. 33. *Mylopharyngodon piceus*, ca. 500 mm SL, Tengah ponds (Yeo DCJ).

References. Herre & Myers, 1937 (as *Mylopharyngodon aethiops*).

Distribution. Not known.

Remarks. Herre & Myers' (1937) record came from an experimental fish pond, and this species may not have established in Singapore. Presently, this species can be occasionally found in ponds stocked for angling purposes (Yeo DCJ, pers. obs.).

***Neolissochilus* sp.**
(Fig. 34, SEA[SPC])



Fig. 34. *Neolissochilus* sp., ca. 250 mm SL, Pandan Reservoir.

References. Ng HH & Tan HH, 2010.

Distribution. MacRitchie Reservoir (Ng HH & Tan HH, 2010).

Remarks. This species could not be identified to species level as the taxonomic status is complicated and remains unresolved.

***Osteochilus vittatus* (Valenciennes, in Cuvier & Valenciennes)**
(Fig. 35, SEA[SPC])



Fig. 35. *Osteochilus vittatus*, ca. 150 mm SL, Sime forest.

References. Ng & Lim, 1997a (as *O. hasselti*); Ng & Lim, 1997b (as *O. hasselti*); Baker & Lim, 2008, 2012 (as *O. hasselti*); Ng HH & Tan HH, 2010; Baker, 2013a; Tan, 2013c, 2013d; Kwik & Yeo, 2015; Ho et al., 2016; Li et al., 2016.

Distribution. Upper Seletar Reservoir (Ng & Lim, 1997a, 1997b); Lower Seletar Reservoir (Ng HH & Tan HH, 2010); Upper Peirce Reservoir (Ng HH & Tan HH, 2010); Lower Peirce Reservoir (Ng HH & Tan HH, 2010); Banir (Baker, 2013a); Central Catchment Nature Reserve — Sime forest (Tan, 2013c, 2013d; Ho et al., 2016); Central Catchment Nature Reserve — Nee Soon Swamp Forest (Ho et al., 2016; Li et al., 2016); Bishan Park (unpublished data); MacRitchie reservoir (unpublished data).

***Pethia conchonius* (Hamilton)**
(Fig. 36, SAs[SPC])



Fig. 36. *Pethia conchonius*, 42.8 mm SL, trade material.

References. Anonymous, 1990; Ng et al., 1993 (as *Puntius conchonius*); Ng & Lim, 1997a (as *Puntius conchonius*); Ng & Lim, 1997b (as *Puntius conchonius*).

Distribution. Reported as an escapee in Sime Road forest (Anonymous, 1990) in Central Catchment Nature Reserve; this species is not an established species (Ng & Lim, 1997a).

***Puntigrus partipentazona* (Fowler)**
(Fig. 37, SEA[SPC])



Fig. 37. *Puntigrus partipentazona*, 31.0 mm SL, Banir stream.

References. Boeseman, 1957 (as *Puntius partipentazona*); Anonymous, 1990 (as *Puntius partipentazona*); Lim & Ng, 1990 (as *Puntius partipentazona*); Munro, 1990 (as *Puntius partipentazona*); Ng, 1991 (as *Puntius partipentazona*); Ng et al., 1993 (as *Puntius partipentazona*); Lim, 1995 (as *Puntius partipentazona*); Lim et al., 1995 (as *Puntius partipentazona*); Subaraj et al., 1995 (as *Puntius partipentazona*); Ng & Lim, 1997a (as *Puntius partipentazona*); Ng & Lim, 1997b (as *Puntius partipentazona*); Baker & Lim, 2008, 2012 (as *Systemus partipentazona*).

Distribution. MacRitchie Reservoir (Lim & Ng, 1990; Ng & Lim, 1997b); Central Catchment Nature Reserve — Nee Soon Swamp Forest (Munro, 1990); MacRitchie Reservoir (Subaraj et al., 1995); Sime Road forest (Ng & Lim, 1997a, 1997b); Bukit Timah Nature Reserve — eastern boundary, Catchment Pond (Lim, 1995; Ng & Lim, 1997b); Upper Seletar Reservoir (Munro, 1990); Lower Peirce Reservoir (Anonymous, 1990; Lim et al., 1995; Ng & Lim, 1997a, 1997b); Sungei Seletar (Banir confluence; Tan HH, pers. obs?, March 2017).

Remarks. This species is occasionally sold as live feed in the ornamental fish trade (Tan HH, pers. obs.).

***Puntigrus tetrazona* (Bleeker)**
(Fig. 38, SEA[SPC])



Fig. 38. *Puntigrus tetrazona*, 46.6 mm SL, Bukit Batok Quarry.

References. Herre & Myers, 1937 (as *Puntius tetrazona*); Anonymous, 1988a (as *Capoeta tetrazona*); Lim & Ng, 1990 (as *Puntius tetrazona*); Munro, 1990 (as *Barbus tetrazona* and *Puntius tetrazona*); Ng et al., 1993 (as *Puntius*

tetrazona); Lim et al., 1995 (as *Puntius tetrazona*); Ng & Lim, 1997a, 1997b (as *Puntius tetrazona*); National Parks Board, 2003 (as *Systemus tetrazona*); Baker & Lim, 2008, 2012 (as *Systemus tetrazona*); Ng HH & Tan HH, 2010 (as *Puntius tetrazona*); Ho et al., 2016; Li et al., 2016; Lim et al., 2016; Tan, 2016b.

Distribution. Herre & Myers (1937) obtained a single specimen from Singapore and commented that it had an aberrant barring pattern, but provided no location details; Central Catchment Nature Reserve — Nee Soon Swamp Forest (Anonymous, 1988a; Munro, 1990; Ng & Lim, 1997a; Ho et al., 2016; Li et al., 2016); Bukit Timah — Catchment Pond (Anonymous, 1988a); Upper Seletar Reservoir (Munro, 1990; Lim et al., 1995; Ng HH & Tan HH, 2010); Seletar Reservoir Park (Munro, 1990); Seletar area (Ng et al., 1993); Sungei Buloh Wetland Reserve (National Parks Board, 2003); Upper Peirce Reservoir (Ng HH & Tan HH, 2010); Lower Peirce Reservoir (Ng HH & Tan HH, 2010); Lower Seletar Reservoir (Ng HH & Tan HH, 2010); MacRitchie Reservoir (Ng HH & Tan HH, 2010); Murai Reservoir (Ng HH & Tan HH, 2010); Tekong Reservoir (Ng HH & Tan HH, 2010; Lim et al., 2016); Tengah Reservoir (Ng HH & Tan HH, 2010); Kent Ridge Park ponds (Tan, 2016b).

Remarks. Ng HH & Tan HH (2010) only recorded this species as they listed species located from reservoirs. This species can be distinguished from its congener (*P. partipentazona*) that is also present and non-native to Singapore, on basis of the width of black bars (vs. slimmer), depth of body (vs. less deep), and larger overall adult size (vs. smaller).

***Puntius sophore* (Hamilton)**
(Fig. 39, SAs[SPC])



Fig. 39. *Puntius sophore*, 60.0 mm SL, Sungei Buloh.

al., 2013; Kwik & Yeo, 2015; Tan et al., 2016.

Distribution. Sungei Seletar (Lim & Tan, 2011); Kranji Marsh (Lim & Tan, 2011; Tan et al., 2016); Sungei Buloh Wetland Reserve (Lim & Tan, 2011; Lim et al., 2013).

***Rasbora borapetensis* Smith**
(Fig. 40, SEA[SPC])

References. Anonymous, 1988a, 1988b, 1990; Lim & Ng, 1990; Munro, 1990; Ng, 1991; Lim & Ng, 1992; Ng et al., 1993; Subaraj et al., 1995; Ng & Lim, 1997a, 1997b; Baker & Lim, 2008, 2012; Ng HH & Tan HH, 2010; Yeo & Lim, 2010; Lim et al., 2013; Ng HH & Tan HH, 2013; Tan HH



Fig. 40. *Rasbora borapetensis*, 25.0 mm SL, Kranji Marsh.

et al., 2015; Li et al., 2016; Tan, 2016a, 2016b; Ho et al., 2016; Li et al., 2016; Tan et al., 2016.

Distribution. Singapore Botanic Gardens (Anonymous, 1988a; Lim & Ng, 1990; Munro, 1990; Ng & Lim, 1997a; Yeo & Lim, 2010); Bukit Timah — Institute of Education pond (Anonymous, 1988b); MacRitchie Reservoir (Subaraj et al., 1995); Sungei Sembawang — Senoko (Ng & Lim, 1997a); Choa Chu Kang (Ng & Lim, 1997a); Cluny Road drain (Ng & Lim, 1997a); Mandai Road area (Ng & Lim, 1997a); Upper Seletar Reservoir streams (Anonymous, 1988a, 1990; Ng & Lim, 1997a, 1997b); Lower Seletar Reservoir (Ng HH & Tan HH, 2010); MacRitchie Reservoir (Ng HH & Tan HH, 2010; Tan, 2016a); Kranji Marsh (Lim et al., 2013; Tan et al., 2016); Punggol Reservoir (Ng HH & Tan HH, 2013); Serangoon Reservoir (Ng HH & Tan HH, 2013); Pasir Panjang canal (Tan HH et al., 2015); Central Catchment Nature Reserve — Nee Soon Swamp Forest (Lim & Ng, 1992; Ho et al., 2016; Li et al., 2016); Kent Ridge Park ponds (Tan, 2016b); Yew Tee canal (Tan HH, pers. obs., 2016); Marina South (Tan HH, pers. obs., 2016); Bishan Park (Liew JH, pers. obs., 2016); Sungei Seletar (Banir confluence; Tan HH, pers. obs., March 2017).

Remarks. This species is occasionally sold as live feed in the ornamental fish trade (Tan HH, pers. obs.).

***Rasbora cf. notura* Kottelat**
(Fig. 41, SEA[SPC])



Fig. 41. *Rasbora cf. notura*, 57.8 mm SL, Banir stream.

References. Kwik, 2014; Kwik & Yeo, 2015.

Distribution. Banir (Kwik, 2014; Kwik & Yeo, 2015).

Remarks. Originally thought to be a non-native species, it could potentially represent a new taxon or hybrid (Tan HH, in prep.).

***Rasbora trilineata* Steindachner**
(Fig. 42, SEA[SPC])



Fig. 42. *Rasbora trilineata*, 33.0 mm SL, Catchment Pond.

References. Ng & Lim, 1997a, 1997b; Lim & Tan, 2011; Baker & Lim, 2012; Tan & Zeng, 2014.

Distribution. Old Mandai Road area (Ng & Lim, 1997a); Bukit Timah Nature Reserve — Catchment Pond (Lim & Tan, 2011; Tan & Zeng, 2014).

Remarks. This species appears to be established at one location although many individuals from this population appear to be inbred and deformed (see Tan & Zeng, 2014).

***Tor tambra* (Valenciennes, in Cuvier & Valenciennes)**
(Fig. 43, SEA[SPC])



Fig. 43. *Tor tambra*, 80.0 mm SL, Sabah.

References. Ng HH & Tan HH, 2010.

Distribution. Pandan Reservoir (Ng HH & Tan HH, 2010).

***Tor tambroides* (Bleeker)**
(Fig. 44, SEA)



Fig. 44. *Tor tambroides*, 168.0 mm SL, Sarawak.

References. Herre & Myers, 1937; Alfred, 1966a.

Distribution. Not known.

Remarks. Herre & Myers' (1937) record came from an unnamed stream in Singapore, and no further details were available. No records of this taxon recently. Species from the genus *Tor* are unlikely to be native to Singapore, due to lack of suitable habitat. *Tor* species are found typically in large river habitats, which geologically never existed in Singapore.

***Toxabramis houdemeri* Pellegrin**
(Fig. 45, EAs[SPC])



Fig. 45. *Toxabramis houdemeri*, 75.7 mm SL, Yishun Pond.

References. Lim & Kwik, 2012 (as *Toxabramis houdemeri*); Kwik et al., 2013 (as *Toxabramis houdemeri*).

Distribution. Yishun Pond (Lim & Kwik, 2012; Kwik et al., 2013).

Remarks. This species is sold as live feed for in the ornamental fish trade (Tan HH, pers. obs.).

***Trigonopoma gracile* (Kottelat)**
(Fig. 46, SEA)



Fig. 46. *Trigonopoma gracile*, 32.0 mm SL, Sumatra.

References. Ng & Lim, 1997b (as *Rasbora gracilis*).

Distribution. Not known.

Remarks. Probably an escapee from the ornamental fish trade (Ng & Lim, 1997b). Earlier workers (pre-1990) used the name *Rasbora taeniata* (Kottelat, 1991).

Family Botiidae

***Chromobotia macracanthus* (Bleeker)**
(Fig. 47, SEA[SPC])



Fig. 47. *Chromobotia macracanthus*, ca. 250 mm SL, Kranji Reservoir.

References. Ng HH & Tan HH, 2010.

Distribution. Kranji Reservoir (Ng HH & Tan HH, 2010).

Remarks. This record is probably an escapee, as this species is very popular in the ornamental fish trade, being seasonally available after monsoon season (Tan HH, pers. obs.).

Family Gyриноcheilidae

***Gyrinocheilus aymonieri* (Tirant)**
(Fig. 48A, B, SEA[SPC])



Fig. 48. *Gyrinocheilus aymonieri*, 136.0 mm SL, trade material (top); 117.4 mm SL, xanthic variety, Bedok Reservoir (bottom).

References. None. This is a new record for Singapore.

Distribution. Bedok Reservoir (Anonymous, pers. comm., 2015).

Remarks. This is probably a discarded pet, as the specimen obtained was a xanthic variant with a bright yellow orange body but with normal pigmented eyes. A normal coloured individual is illustrated in Fig. 48 for reference.

Order Characiformes

Family Characidae

***Hemigrammus rodwayi* Durbin**
(Fig. 49, SA[SPC])



Fig. 49. *Hemigrammus rodwayi*, 26.5 mm SL, Kranji Reservoir.

References. Admin, 2006.

Distribution. Sungei Buloh Wetland Reserve (Chim CK, pers. comm., 2006); Kranji Reservoir (Admin, 2006, identified as *Chanda* sp.; Lim RHB, pers. comm., 2018); Murai Reservoir (Lim RHB, pers. comm., 2018).

Remarks. The first record of this species (deposited in ZRC in 2006) was from a brackish water pond at Sungei Buloh Wetland Reserve and could have been flushed out from one of the fish farms adjacent to the reserve (Tan HH, pers. obs.). In 2006, and more recently in 2018, this species has been observed in large schools in Kranji and Murai Reservoir (Admin, 2006; Lim RHB, pers. obs.). This fish has been occasionally found in waters with varying degrees of salinity (Froese, 2018). The persistence of this fish in Kranji Reservoir from 2006 to present suggests that it has established a viable breeding population.

***Paracheirodon innesi* (Myers)**
(Fig. 50, SA)



Fig. 50. *Paracheirodon innesi*, 26.8 mm SL, trade material.

References. Ng et al., 1993; Ng & Lim, 1997a, 1997b.

Distribution. Recorded as an escapee in the Mandai area and not an established species (Ng & Lim, 1997a).

***Thayeria boehlkei* Weitzman**
(Fig. 51, SA)



Fig. 51. *Thayeria boehlkei*, 25.5 mm SL, trade material.

References. None. This is a new record for Singapore.

Distribution. Based on a sighting at Bukit Batok Nature Park (Lim KKP, pers. obs., 2010).

Family Serrasalmidae

***Piaractus brachypomus* (Cuvier)**
(Fig. 52, SA)

References. Lim & Ng, 1990 (as *Colossoma* sp.); Ng et al., 1993 (as *Colossoma macropomum*); Ng & Lim, 1997a (as *Colossoma macropomum*); Ng & Lim, 1997b (as *Colossoma macropomum*); Ng HH & Tan HH, 2010; Baker, 2013e; Tan & Leong, 2015; Tan, 2016b.

Distribution. Jurong Lake (Ng HH & Tan HH, 2010); MacRitchie Reservoir (Ng HH & Tan HH, 2010); Bukit



Fig. 52. *Piaractus brachypomus*, 220 mm SL, Serangoon Reservoir.

Timah Nature Reserve — Catchment Pond (Baker, 2013e); Punggol Reservoir (Tan & Leong, 2015); Kent Ridge Park pond (Tan, 2016b); Serangoon reservoir (unpublished data).

Remarks. This species is not known to breed in Singapore (Ng & Lim, 1997a). All recent records are released/discarded pets (Ng HH & Tan HH, 2010).

Order Siluriformes

Family Bagridae

***Hemibagrus capitulum* (Popta)**
(Fig. 53, SEA[SPC])



Fig. 53. *Hemibagrus capitulum*, ca. 350 mm SL, Jurong Lake.

References. Alfred, 1966a (as *Mystus nemurus*); Ng HH & Tan HH, 2010 (as *Hemibagrus nemurus*).

Distribution. Jurong Lake (Ng HH & Tan HH, 2010).

Remarks. Ng & Kottelat (2013b) recently revised the taxonomy of the Asian *Hemibagrus*, and resolved many issues with existing species. The common lowland species found throughout most of the lower Sundaic drainages has been re-identified as *H. capitulum*; whereas *H. nemurus*, which was the name erroneously used for the species in Singapore previously, is restricted to the island of Java.

***Hemibagrus guttatus* (Lacepède) [Extirpated]**
(EAs)

References. Günther, 1864 (as *Macrones elongatus*); Fowler, 1938 (as *Mystus elongatus*); Alfred, 1966a (as *Mystus elongatus*); Ng et al., 1993; Ng & Lim, 1997b; Ng & Kottelat, 1998.

Distribution. Not known.

Remarks. This species was imported accidentally through the food fish route (Alfred, 1966a; Ng et al., 1993; Ng & Lim, 1997b), and appears to be extirpated in Singapore, as there had been no recent records. Ng & Kottelat (1998) clarified the taxonomy of the species, and *H. elongatus*, the name used previously, is a subjective junior synonym to *H. guttatus*.

***Mystus castaneus* Ng**
(Fig. 54, SEA[SPC])



Fig. 54. *Mystus castaneus*, ca. 65 mm SL, Upper Peirce Reservoir inlet.

References. Ng HH & Tan HH, 2010.

Distribution. Upper Peirce Reservoir stream (Ng HH & Tan HH, 2010).

***Mystus wolffii* (Bleeker)**
(Fig. 55, SEA[SPC])



Fig. 55. *Mystus wolffii*, ca. 200 mm SL, Upper Seletar Reservoir.

References. Ng HH & Tan HH, 2010; Ng, 2012; Ng HH & Tan HH, 2013.

Distribution. Lower Peirce Reservoir (Ng HH & Tan HH, 2010); Upper Seletar Reservoir (Ng HH & Tan HH, 2010).

Remarks. Ng (2012) has clarified the status of *Mystus wolffii* in Singapore. The estuarine and dammed river-reservoir records probably represent native populations (i.e., Murai and Lower Seletar Reservoirs in Ng HH & Tan HH [2010]; Punggol and Serangoon Reservoirs in Ng PX & Tan HH [2013]), but the records from the inland reservoirs are probably non-native stock from raw water transferred from Johor, Peninsular Malaysia.

Family Clariidae

***Clarias gariepinus* (Burchell)**
(Fig. 56, AF[SPC])

References. Baker & Lim, 2008, 2012; Ng HH & Tan HH, 2010; Tan HH et al., 2010; Tan HTW et al., 2010; Yeo &



Fig. 56. *Clarias gariepinus*, 240 mm SL, Upper Seletar Reservoir.

Lim, 2010; Baker, 2013d; Baker & Lim, 2013; Kwik et al., 2013; Ng et al., 2013; Yeo, 2013; Tan, 2014a; Kwik & Yeo, 2015; Tan & Koh, 2015; Ho et al., 2016; Lim et al., 2016; Tan et al., 2016; Tan et al., 2017b.

Distribution. Bedok Reservoir (Ng HH & Tan HH, 2010); Jurong Lake (Ng HH & Tan HH, 2010); Kranji Reservoir (Ng HH & Tan HH, 2010); Upper Seletar Reservoir (Ng HH & Tan HH, 2010; Baker & Lim, 2013); Lower Seletar Reservoir (Ng HH & Tan HH, 2010); Pandan Reservoir (Ng HH & Tan HH, 2010); Upper Peirce Reservoir (Ng HH & Tan HH, 2010); Rochor canal (now part of Marina Reservoir; Tan HH et al., 2010); Singapore Botanic Gardens (Yeo & Lim, 2010); Lower Peirce Reservoir (Baker, 2013d); Pangsua pond (Kwik et al., 2013); Woodlands Town Park pond (Kwik et al., 2013); Yishun pond (Kwik et al., 2013); Bishan Park (Yeo, 2013; Tan & Koh, 2015); West Coast Park marsh pond (Tan, 2014a); Singapore Botanic Gardens (Tan HH, pers. obs., 2015); Pulau Tekong (Lim et al., 2016); Kranji Marsh (Tan et al., 2016); Singapore Quarry (Tan et al., 2017b).

Remarks. This African species appears to have displaced the native congener, *Clarias batrachus* in many of its known habitats in Singapore, and is the subject of present research by Low BW (Ng et al., 2013). The juveniles of this species range from 1–2 cm to 15 cm length, and are commonly sold as live feed in the ornamental fish trade (Tan HH, pers. obs.). The species has been observed to be the subject of mercy/religious release (Yeo DCJ, pers. obs.).

***Clarias macrocephalus* Günther**
(SEA)

References. Tan HTW et al., 2010.

Distribution. Not known.

Remarks. Hybrids between *C. macrocephalus* and *C. gariepinus* have been used for aquaculture (Tan HTW et al., 2010).

Family Callichthyidae

***Corydoras aeneus* (Gill)**
(Fig. 57, SA)

References. Anonymous, 1988b; Ng & Lim, 1997a, 1997b.

Distribution. Recorded as an escapee in Mandai area and not an established species (Anonymous, 1988b; Ng & Lim, 1997a).



Fig. 57. *Corydoras aeneus*, 33.6 mm SL, trade material.

Remarks. This species is occasionally sold as live feed in the ornamental fish trade (Tan HH, pers. obs.).

Family Loricariidae

***Pterygoplichthys disjunctivus* (Weber)**
(Fig. 58, SA[SPC])



Fig. 58. *Pterygoplichthys disjunctivus*, 355 mm SL, Woodlands Pond (dorsal, lateral, and ventral views).

References. Ng & Lim, 1989 (as *Pterygoplichthys* sp.); Munro, 1990 (as *Pterygoplichthys* sp.); Ng et al., 1993 (as *Pterygoplichthys* sp.); National Parks Board, 2003 (as *Liposarcus* spp.); Page & Robins, 2006; Baker & Lim, 2008, 2012; Ng HH & Tan HH, 2010; Kwik et al., 2013; Kwik & Yeo, 2015 (as *Pterygoplichthys* sp.); Ho et al., 2016; Tan, 2016c.

Distribution. Sungei Sembawang (Ng & Lim, 1989); Hong Kah (Ng & Lim, 1989); Lim Chu Kang (Ng & Lim, 1989); Stamford Canal (Ng & Lim, 1989); Pandan Reservoir (Ng & Lim, 1989); Upper Seletar Reservoir (Ng & Lim, 1989);

Central Catchment Nature Reserve — Nee Soon Swamp Forest (Ng & Lim, 1989); Sungei Buloh Wetland Reserve (National Parks Board, 2003); Choa Chu Kang ponds (Page & Robins, 2006); Mandai area (Ng & Lim, 1989; Page & Robins, 2006); Bedok Reservoir (Ng HH & Tan HH, 2010); Jurong Lake (Ng & Lim, 1989; Ng HH & Tan HH, 2010); Kranji Reservoir (Ng & Lim, 1989; Ng HH & Tan HH, 2010); Upper Peirce Reservoir (Ng & Lim, 1989; Ng HH & Tan HH, 2010); Lower Peirce Reservoir (Ng HH & Tan HH, 2010); MacRitchie Reservoir (Ng & Lim, 1989; Ng HH & Tan HH, 2010); Pandan canal (Ng & Lim, 1989); Woodlands Town Park pond (Kwik et al., 2013); Bishan Park (Tan, 2016c); Marina Reservoir (unpublished data); Serangoon Reservoir (unpublished data).

Remarks. Ng & Lim (1989) reported the presence of this species in the early 1980s although it is uncertain if there was more than one taxon as both *P. disjunctivus* and *P. pardalis* were extensively available in the ornamental fish trade (Page & Robins, 2006).

***Pterygoplichthys joselimaianus* (Weber)**
(Fig. 59, SA[SPC])



Fig. 59. *Pterygoplichthys joselimaianus*, 270 mm SL, Pangsua Pond (dorsal, lateral, and ventral views).

References. Ng HH & Tan HH, 2010; Tan, 2014g, 2016c; Ho et al., 2016.

Distribution. Pandan Reservoir (Ng HH & Tan HH, 2010); Lower Seletar Reservoir (Ng HH & Tan HH, 2010); Banir (Tan, 2014g; Ho et al., 2016); Bishan Park (Tan, 2016c); Jurong Lake (unpublished data); Marina Reservoir (unpublished data); Serangoon Reservoir (unpublished data).

***Pterygoplichthys pardalis* (Castelnau)**
(Fig. 60, SA[SPC])



Fig. 60. *Pterygoplichthys pardalis*, 320 mm SL, Bishan Park (dorsal, lateral, and ventral views).

References. Anonymous, 1988a (as *Hypostomus* sp.); Anonymous, 1988b (as *Hypostomus ?plecostomus*); Ng & Lim, 1989 (as *Pterygoplichthys* sp.); Lim & Ng, 1990 (as *Hypostomus* sp.); Ng, 1991 (as *Pterygoplichthys* sp.); Lim & Ng, 1992 (as *Liposarcus pardalis*); Ng & Lim, 1997a (as *Liposarcus pardalis*); Ng & Lim, 1997b (as *Liposarcus pardalis*); Goh et al., 2002 (as *Liposarcus* sp.); National Parks Board, 2003 (as *Liposarcus* spp.); Page & Robins, 2006; Baker & Lim, 2008, 2012; Ng HH & Tan HH, 2010; Tan HTW et al., 2010; Kwik et al., 2013 (as *Pterygoplichthys pardalis*); Ho et al., 2016.

Distribution. Mandai area rural streams (Anonymous, 1988b); Sungei Sembawang (Ng & Lim, 1989; Lim & Ng, 1992; Page & Robins, 2006); Hong Kah (Ng & Lim, 1989); Lim Chu Kang (Ng & Lim, 1989); Stamford Canal (Ng & Lim, 1989); Pandan Reservoir (Ng & Lim, 1989; Ng HH & Tan HH, 2010); Pandan Canal (Ng & Lim, 1989); Upper Seletar Reservoir (Ng & Lim, 1989); Central Catchment Nature Reserve — Nee Soon Swamp Forest (Ng & Lim, 1989); Kranji Reservoir (Ng & Lim, 1989, 1997a, 1997b; Ng HH & Tan HH, 2010); Mandai area (Ng & Lim, 1989; Page & Robins, 2006); Jurong Lake (Ng & Lim, 1989); Upper Peirce Reservoir (Anonymous, 1988a; Ng & Lim, 1989); Lower Peirce Reservoir (Ng & Lim, 1997a, 1997b); Upper Seletar Reservoir (Ng & Lim, 1989, 1997a, 1997b); Sungei Buloh Wetland Reserve (National Parks Board, 2003); Choa Chu Kang ponds (Page & Robins, 2006); Lower Seletar Reservoir (Ng HH & Tan HH, 2010); MacRitchie Reservoir (Ng & Lim, 1989; Ng HH & Tan HH, 2010); Pangsua pond

(Kwik et al., 2013); Singapore Botanic Gardens (Tan HH, pers. obs., 2015); Jurong Lake (unpublished data); Bishan Park (unpublished data); Bedok Reservoir (unpublished data); Marina Reservoir (unpublished data); Serangoon Reservoir (unpublished data); Punggol Reservoir (unpublished data).

Remarks. See earlier remarks on *P. disjunctivus*.

Family Mochokidae

***Synodontis eupterus* Boulenger**
(Fig. 61, AF[SPC])



Fig. 61. *Synodontis eupterus*, 183 mm SL, Pandan Reservoir.

References. Ng HH & Tan HH, 2010.

Distribution. Pandan Reservoir (Ng HH & Tan HH, 2010).

Remarks. This individual appears to be a discarded pet.

Family Pangasiidae

***Pangasionodon hypophthalmus* (Sauvage)**
(Fig. 62, SEA)



Fig. 62. *Pangasionodon hypophthalmus*, 131.0 mm SL, trade material.

References. Lim & Ng, 1990 (as *Pangasianodon sutchi*); Ng et al., 1993 (as *Pangasius sutchi*); Ng & Lim, 1997a (as *Pangasius hypophthalmus*); Ng & Lim, 1997b (as *Pangasius hypophthalmus*).

Distribution. Jurong Lake (Lim KKP, pers. obs., 2011).

Remarks. This species is commonly stocked in ponds for aquacultural and angling purposes (Ng & Lim, 1997a).

***Pangasius sanitwongsei* Smith**
(Fig. 63, SEA)



Fig. 63. *Pangasius sanitwongsei*, 102.7 mm SL, trade material.

References. Tan & Yusfiandi, 2015.

Distribution. Marina Reservoir (Tan & Yusfiandi, 2015).

Family Pimelodidae

***Phractocephalus hemiliopterus* (Bloch & Schneider)**
(Fig. 64, SA[SPC])



Fig. 64. *Phractocephalus hemiliopterus*, 700 mm SL, Pandan Reservoir.

References. Ng & Lim, 1997b; Ng HH & Tan HH, 2010.

Distribution. Pandan River (Ng & Lim, 1997b, based on a 1996 newspaper report); Pandan Reservoir (Ng HH & Tan HH, 2010); Bedok Reservoir (Anonymous, 2014).

Remarks. These reported individuals are likely discarded pets. This species is common in the ornamental fish trade as juveniles (less than 10 cm). Once fishes reach sub-adulthood, they are typically too large to be accommodated in home aquaria and are conveniently discarded in public ponds and reservoirs (Ng HH & Tan HH, 2010). Recently, an artificial hybrid between *Phractocephalus hemiliopterus* and *Pseudoplatystoma fasciatum* became available through the ornamental fish trade (Tan HH, pers. obs.). This artificial hybrid can grow to a large size as both parental species exceed 90 cm in size, and introductions can be expected in the near future in the artificial water bodies in Singapore.

Order Cyprinodontiformes

Family Aplocheilidae

***Aplocheilus lineatus* (Valenciennes, in Cuvier & Valenciennes)**
(Fig. 65, SAs[SPC])



Fig. 65. *Aplocheilus lineatus*, 47.4 mm SL male (top), 38.9 mm SL female (centre), 20.1 mm SL juvenile (bottom); Pandan.

References. Yeo & Lim, 2010; Baker & Lim, 2012; Kwik & Yeo, 2015; Tan et al., 2017a.

Distribution. Bukit Batok Nature Park (Yeo & Lim, 2010; Kwik & Yeo, 2015); Singapore Botanic Gardens (Yeo & Lim, 2010); Sungei Pandan feeder stream (Tan et al., 2017a).

Remarks. This species has established breeding populations in Bukit Batok Nature Park (Yeo & Lim, 2010), and Sungei Pandan feeder stream (Tan et al., 2017a).

Family Pocciliidae

***Gambusia affinis* (Baird & Girard)**
(Fig. 66, CA[SPC])



Fig. 66. *Gambusia affinis*, 23.8 mm SL female (top), 19.5 mm SL male (bottom); Upper Seletar Reservoir inlet.

References. Johnson, 1973a; Johnson, 1973b (as *Gambusia* spp.); Anonymous, 1988a; Lim & Ng, 1990 (as *Gambusia holbrooki*); Munro, 1990 (as *G. holbrooki*); Ng et al., 1993 (as *G. holbrooki*); Fernando & Phang, 1994; Lim et al., 1995 (as *G. holbrooki*); Subaraj et al., 1995 (as *G. holbrooki*); Lever, 1996; Ng & Lim, 1997a (as *G. holbrooki*); Ng & Lim, 1997b (as *G. holbrooki*); Baker & Lim, 2008, 2012; Ng HH & Tan HH, 2010; Tan HTW et al., 2010; Yeo & Lim, 2010; Davison et al., 2012; Ng HH & Tan HH, 2013; Tan, 2014d, 2016a; Kwik & Yeo, 2015; Ho et al., 2016; Lim et al., 2016; Tan et al., 2016; Tan et al., 2017b.

Distribution. Seletar Reservoir Park (Munro, 1990); Sungei Whampoa (Munro, 1990); Lornie Forest stream (Subaraj et al., 1995); Ulu Sembawang/Lorong Gambas (Lim et al.,

1995); Bedok Reservoir (Ng HH & Tan HH, 2010); Jurong Lake (Ng HH & Tan HH, 2010); Kranji Reservoir (Ng HH & Tan HH, 2010); Lower Peirce Reservoir (Anonymous, 1988a; Lim et al., 1995; Ng & Lim, 1997a, 1997b; Ng HH & Tan HH, 2010); Kent Ridge Park pond (Ng & Lim, 1997a); Lower Seletar Reservoir (Ng HH & Tan HH, 2010); Murai Reservoir (Ng HH & Tan HH, 2010); Tengah Reservoir (Ng HH & Tan HH, 2010); Upper Peirce Reservoir (Ng HH & Tan HH, 2010); Upper Seletar Reservoir (Ng HH & Tan HH, 2010; Tan, 2014d); Singapore Botanic Gardens (Yeo & Lim, 2010); Punggol Reservoir (Ng HH & Tan HH, 2013); Serangoon Reservoir (Ng HH & Tan HH, 2013); MacRitchie Reservoir (Subaraj et al., 1995; Tan, 2016a); outskirts of Nee Soon Swamp Forest (Ho et al., 2016); Pulau Tekong (Lim et al., 2016); Kranji Marsh (Tan et al., 2016); Singapore Quarry (Tan et al., 2017b).

Remarks. This species had often been introduced as a mosquito control agent but its efficacy is questionable (Lever, 1996). This species is commonly sold with either *Poecilia reticulata* or *Poecilia sphenops* as live feed in the ornamental fish trade (Tan HH, pers. obs.).

***Poecilia latipinna* (Lesueur)**
(CA)

References. Welcomme, 1988; Lim & Ng, 1990; Munro, 1990; Ng et al., 1993; Fernando & Phang, 1994; Lever, 1996; Ng & Lim, 1997a (as *Poecilia* cf. *latipinna*), 1997b (as *P. latipinna*).

Distribution. Widespread in canals and brackish water habitats (Lim & Ng, 1990). It may have hybridised with *P. sphenops* (Lim & Ng, 1990).

***Poecilia reticulata* Peters**
(Fig. 67, CA[SPC])



Fig. 67. *Poecilia reticulata*, 14.8 mm SL male (top), 20.0 mm SL female (bottom); Mandai area.

References. Hanitsch, 1912 (as *Girardinus poeciloides*); Herre, 1940 (as *Lebistes reticulatus*); Johnson, 1964 (as *Lebistes reticulatus*); Alfred, 1966a (as *Lebistes reticulatus*); Johnson, 1973b; Tham, 1973 (as *Lebistes reticulatus*); Anonymous, 1989b; Lim & Ng, 1990; Munro, 1990; Ng, 1991; Ng et al., 1993; Fernando & Phang, 1994 (introduced as early as 1937); Lim, 1995; Lever, 1996; Ng & Lim, 1997a, 1997b; Goh et al., 2002; National Parks Board, 2003; Baker

& Lim, 2008, 2012; Ng HH & Tan HH, 2010; Tan HTW et al., 2010; Yeo & Chia, 2010; Yeo & Lim, 2010; Ng PX & Tan HH, 2013; Tan et al., 2013; Tan & Low, 2014; Kwik & Yeo, 2015; Ho et al., 2016; Tan, 2016b.

Distribution. Widespread in Singapore, except in forest streams (Maxwell, 1921; Alfred, 1966a; Lim & Ng, 1990); MacRitchie Reservoir (Alfred, 1966a); Upper Seletar Reservoir (Alfred, 1966a; Ng & Lim, 1997a, 1997b); Upper Peirce Reservoir (Anonymous, 1989b); Central Catchment Nature Reserve — Nee Soon Swamp Forest (Munro, 1990); Napier Road and Bukit Timah Road (Munro, 1990); Seletar Reservoir Park (Munro, 1990); Kent Ridge Park (Ng & Lim, 1997a); Pandan Canal (Ng & Lim, 1997a); Cluny Road drain (Ng & Lim, 1997a); Bukit Timah Nature Reserve peripheral streams (Lim, 1995; Ng & Lim, 1997b); Sungei Buloh Wetland Reserve (National Parks Board, 2003); Lower Seletar Reservoir (Ng HH & Tan HH, 2010); Bukit Batok Nature Park (Yeo & Lim, 2010); Punggol Reservoir (Ng PX & Tan HH, 2013); Serangoon Reservoir (Ng PX & Tan HH, 2013); Bukit Brown (Tan et al., 2013); Greenbank Park (Tan HH, pers. obs., 1990s); Kranji Reservoir (Tan HH, pers. obs., 2010); Commonwealth area (Tan HH, pers. obs., 2010); Mandai area (Tan & Low, 2014); Tai Seng area (Tan HH, pers. obs., 2016); outskirts of Nee Soon Swamp Forest (Ho et al., 2016); Kent Ridge Park ponds (Tan, 2016b).

Remarks. Tham (1973) commented that *Poecilia reticulata* was used for mosquito control in fish ponds. This species is commonly sold as live feed in the ornamental fish trade (Tan HH, pers. obs.). See later account under “Species for biological control” for more details.

***Poecilia sphenops* Valenciennes, in Cuvier & Valenciennes**
(Fig. 68, CA[SPC])



Fig. 68. *Poecilia sphenops*, 50.2 mm SL male (top), 57.0 mm SL female (bottom); Pandan canal.

References. Johnson & Soong, 1963 (as *Mollienisia sphenops*); Alfred, 1966a (as *Mollienisia sphenops*); Johnson, 1973a (as *Mollienisia sphenops*); Johnson, 1973b (as *Mollienisia* spp.); Lim & Ng, 1990; Munro, 1990; Ng, 1991; Ng et al., 1993; Fernando & Phang, 1994; Subaraj, 1995; Lever, 1996; Ng & Lim, 1997a, 1997b; Ng & Sivasothi, 1999; Goh et al., 2002; National Parks Board, 2003; Ng

HH & Tan HH, 2010; Tan HH et al., 2010; Tan HTW et al., 2010; Jaafar et al., 2012; Leong, 2012; Ng HH & Tan HH, 2013; Tan, 2014d, 2016a; Ng et al., 2015; Ho et al., 2016; Li et al., 2016.

Distribution. MacRitchie Reservoir (Alfred, 1966a; Tan, 2016a); Pulau Ubin (Subaraj, 1995); Cluny Road drain (Ng & Lim, 1997a); Pandan Canal (Ng & Lim, 1997a); Sungei Sembawang — Senoko (Ng & Lim, 1997a); Mandai coastal streams (Tan HH, pers. obs., 2004); Sungei Buloh Wetland Reserve (National Parks Board, 2003); Bedok Reservoir (Ng HH & Tan HH, 2010); Lower Seletar Reservoir (Ng HH & Tan HH, 2010); Pandan canal (Tan HH, pers. obs., 2010); Jurong River (Ng HH, pers. obs., 2010); Kranji Reservoir (Tan HH, 2010); Marina Reservoir (comprising of Singapore River, Rochor canal, Kallang River, Geylang River and Marina Channel; Tan HH et al., 2010); Siglap canal (Leong, 2012); Punggol Reservoir (Ng HH & Tan HH, 2013); Serangoon Reservoir (Ng HH & Tan HH, 2013); Upper Seletar Reservoir (Tan, 2014d); Singapore Botanic Gardens (Tan HH, pers. obs., 2015); Central Catchment Nature Reserve — Nee Soon Swamp Forest (Ho et al., 2016; Li et al., 2016); Yew Tee canal (Tan HH, pers. obs., 2016); West Coast Park marsh pond (Tan HH, pers. obs., November 2016); Bishan Park (Liew JH, pers. obs., 2016).

Remarks. Fernando & Phang (1994) stated that this species had been very likely introduced as an escaped pet fish in the 1940s, and they easily hybridise with *P. latipinna*. This species is commonly sold as live feed in the ornamental fish trade (Tan HH, pers. obs.).

***Poecilia velifera* (Regan)**
(Fig. 69, CA)



Fig. 69. *Poecilia velifera*, 60 mm SL male, trade material.

References. Munro, 1990; Ng et al., 1993.

Distribution. Not known.

Remarks. The records of this species are probably escapees from the ornamental fish trade (Munro, 1990).

***Xiphophorus hellerii* Heckel**
(Fig. 70, CA[SPC])

References. Anonymous, 1989a; Ng et al., 1993; Fernando & Phang, 1994; Ng & Lim, 1997a, 1997b; Lim et al., 2016.



Fig. 70. *Xiphophorus hellerii*, 41.8 mm SL male (top), 39.1 mm SL female (bottom); trade material (wild type colour form).

Distribution. Recorded by Ng & Lim (1997a) from canals in Singapore, but no details provided; Woodlands Town Garden (Anonymous, 1989a); Pulau Tekong (Lim et al., 2016).

Remarks. Fernando & Phang (1994) noted that the introductions of *X. hellerii*, *X. maculatus* and *X. variatus* into Singapore for ornamental aquaculture probably started in the mid-1940s. This species is occasionally sold as live feed in the ornamental fish trade (Tan HH, pers. obs.).

***Xiphophorus maculatus* (Günther)**
(Fig. 71, CA[SPC])



Fig. 71. *Xiphophorus maculatus*, 27.3 mm SL, Mount Pleasant.

References. Lim & Ng, 1990; Ng et al., 1993; Fernando & Phang, 1994; Ng & Lim, 1997a, 1997b; Tan HH et al., 2010; Yeo & Lim, 2010; Tan et al., 2013; Kwik & Yeo, 2015.

Distribution. Cluny Road drain (Ng & Lim, 1997a); Kallang River (now part of Marina Reservoir; Tan HH et al., 2010); Bukit Batok Nature Park (Yeo & Lim, 2010); Bukit Brown (Tan et al., 2013).

Remarks. This species is commonly sold as live feed in the ornamental fish trade (Tan HH, pers. obs.).

***Xiphophorus variatus* (Meek)**
(Fig. 72, CA[SPC])



Fig. 72. *Xiphophorus variatus*, 28.3 mm SL, Bukit Brown (note deformed dorsal fin).

References. Ng et al., 1993; Fernando & Phang, 1994; Ng & Lim, 1997a; Tan et al., 2013.

Distribution. Bukit Brown (Tan et al., 2013).

Order Synbranchiformes

Family Mastacembelidae

***Macrogathus siamensis* (Günther)**
(Fig. 73, SEA)



Fig. 73. *Macrogathus siamensis*, 120.4 mm SL, trade material.

References. Ng & Lim, 1997a, 1997b.

Distribution. Recorded as an escapee in Seletar Reservoir (within Central Catchment Nature Reserve) and not an established species (Ng & Lim, 1997a).

***Macrogathus zebrinus* (Blyth)**
(Fig. 74, SEA[SPC])



Fig. 74. *Macrogathus zebrinus*, 195.9 mm SL, Lower Seletar Reservoir.

References. Baker & Lim, 2008, 2012; Ng, 2010; Ng HH & Tan HH, 2010; Baker & Leong, 2014; Ho et al., 2016; Tan et al., 2016; Tan & Teo, 2018.

Distribution. Kranji Reservoir (Ng, 2010; Ng HH & Tan HH, 2010); Lower Peirce Reservoir (Ng, 2010; Ng HH & Tan HH, 2010); Lower Seletar Reservoir (Ng, 2010; Ng HH & Tan HH, 2010); Tengah Reservoir (Ng, 2010; Ng HH & Tan HH, 2010); Banir (Baker & Leong, 2014; Ho et al., 2016); Kranji Marsh (Tan et al., 2016); Marina Reservoir (Tan & Teo, 2018).

Distribution. Originally found in the northern half of Singapore, recent records show it is now at Marina Reservoir (see Tan & Teo, 2018). The mode of transfer or spread is unknown.

Order Perciformes

Family Ambassidae

***Parambassis siamensis* (Fowler)**
(Fig. 75, SEA[SPC])

References. Anonymous, 1989b (as ?*Chanda nama*); Anonymous, 1990 (as *Parambassis punctulatus*); Lim & Ng, 1990 (as *Chanda* sp.); Munro, 1990 (as *Parambassis punctulatus*); Ng et al., 1993 (as *Parambassis punctulatus*);



Fig. 75. *Parambassis siamensis*, 39.9 mm SL, Serangoon Reservoir.

Lim et al., 1995; Subaraj et al., 1995; Ng & Lim, 1997a, 1997b; Baker & Lim, 2008, 2012; Ng HH & Tan HH, 2010; Kwik et al., 2013; Ng HH & Tan HH, 2013; Ho et al., 2016; Li et al., 2016; Tan, 2018.

Distribution. Lim & Ng (1990) observed this species in Central Catchment reservoirs; Kranji Reservoir (Ng & Lim, 1997a, 1997b; Ng HH & Tan HH, 2010); Upper Peirce Reservoir (Anonymous, 1989b; Ng & Lim, 1997a, 1997b; Ng HH & Tan HH, 2010); Lower Peirce Reservoir (Anonymous, 1990; Munro, 1990; Lim et al., 1995; Ng & Lim, 1997a, 1997b; Ng HH & Tan HH, 2010); Bukit Batok Nature Park (Tan, 2018); Jurong Lake (Ng HH & Tan HH, 2010); Upper Seletar Reservoir (Ng HH & Tan HH, 2010); Lower Seletar Reservoir (Ng HH & Tan HH, 2010); MacRitchie Reservoir (Subaraj et al., 1995; Ng HH & Tan HH, 2010); Murai Reservoir (Ng HH & Tan HH, 2010); Singapore Botanic Gardens, Swan Lake (Lim KKP, pers. obs., 2010); Pangsua pond (Kwik et al., 2013); Woodlands Town Park pond (Kwik et al., 2013); Punggol Reservoir (Ng HH & Tan HH, 2013); Serangoon Reservoir (Ng HH & Tan HH, 2013); Central Catchment Nature Reserve—Nee Soon Swamp Forest (Ho et al., 2016; Li et al., 2016); Sungei Seletar (Banir confluence; Tan HH, pers. obs., March 2017); Jurong Lake (unpublished data); Bishan Park (unpublished data); Pandan Reservoir (unpublished data); Serangoon Reservoir (unpublished data); Bedok Reservoir (unpublished data).

Remarks. This species was probably introduced into Singapore's reservoirs along with raw water transferred from Johor, Peninsular Malaysia (Ng HH & Tan HH, 2010). This species consumes zooplankton and insect larvae (Okutsu et al., 2011; Lim RHB, pers. obs.).

Family Datnioididae

***Datnioides microlepis* Bleeker**
(Fig. 76, SEA[SPC])

References. Ng HH & Tan HH, 2010.

Distribution. Pandan Reservoir (Ng HH & Tan HH, 2010); Bedok Reservoir (unpublished data).

Remarks. This species is probably from discarded pet fish, as this is a popular species in the ornamental fish trade. As



Fig. 76. *Datnioides microlepis*, 290 mm SL, Pandan Reservoir.

with other taxa commonly discarded, this species also grows to a large size not suitable for most home aquarists.

Family Monodactylidae

Monodactylus sebae (Cuvier)
(Fig. 77, AF)

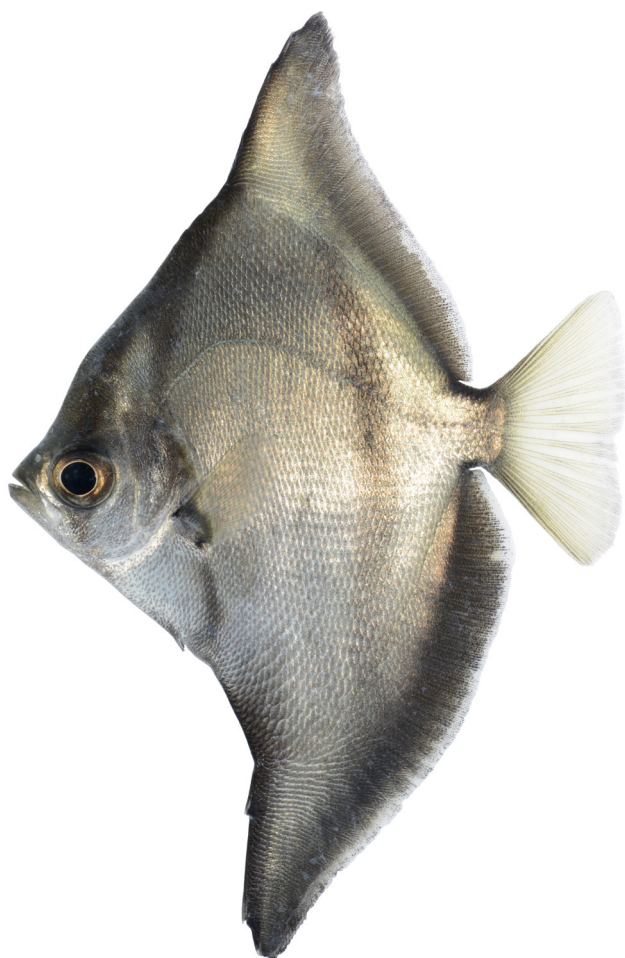


Fig. 77. *Monodactylus sebae*, 59.5 mm SL, trade material.

References. Tan & Soo, 2016.

Distribution. Marina Reservoir (Tan & Soo, 2016).

Remarks. This individual is probably a discarded pet fish, as this species is a popular fish species in the ornamental fish trade.

Family Cichlidae

Acarichthys heckelli (Müller & Troschel)
(Fig. 78, SA[SPC])



Fig. 78. *Acarichthys heckelli*, 96.0 mm SL male, Lower Peirce Reservoir.

References. Tan & Lim, 2008; Baker & Lim, 2008, 2012; Ng HH & Tan HH, 2010; Kwik et al., 2013; Liew et al., 2013; Tan, 2014d, 2016a; Ho et al., 2016.

Distribution. Central Catchment Nature Reserve — Nee Soon Swamp Forest (Tan & Lim, 2008; Ho et al., 2016); Upper Peirce Reservoir (Ng HH & Tan HH, 2010; Liew et al., 2013); Lower Peirce Reservoir (Ng HH & Tan HH, 2010; Liew et al., 2013); Lower Seletar Reservoir (Ng HH & Tan HH, 2010; Liew et al., 2013); Woodlands Town Park pond (Kwik et al., 2013); Sungei Seletar (Liew et al., 2013); Banir (Liew et al., 2013); Upper Seletar Reservoir (Tan, 2014d); MacRitchie Reservoir (Tan, 2016a); Bishan Park (unpublished data); Marina Reservoir (unpublished data); Punggol Reservoir (unpublished data).

Remarks. Autecology of this recently introduced species was documented by Liew et al. (2013).

Amphilophus citrinellus (Günther)
(Fig. 79A, B, CA[SPC])



Fig. 79A. *Amphilophus citrinellus*, 80.6 mm SL juvenile barred form, Pangsua Pond.

References. Ng HH & Tan HH, 2010; Kwik et al., 2013; Lim, 2013c; Yeo, 2013; Tan, 2014f, 2016c.

Distribution. Jurong Lake (Ng HH & Tan HH, 2010); Pandan Reservoir (Ng HH & Tan HH, 2010); Pangsua Pond (Kwik et al., 2013; Tan, 2014f); Woodlands Town Park



Fig. 79B. *Amphilophus citrinellus*, 219.3 mm SL adult male, Pandan Reservoir.

Pond (Kwik et al., 2013); Yishun Pond (Kwik et al., 2013; Lim, 2013c); Bishan Park (Yeo, 2013; Tan, 2016c); Marina South (Tan, 2014f); Pandan canal (Tan, 2014f); Sungei Buloh Wetland Reserve (Tan, 2014f); West Coast Park marsh pond (Tan, 2015a); Singapore Botanic Gardens (Tan HH, pers. obs., 2015); Marina Reservoir (Tan HH, pers. obs., 2016); Bedok Reservoir (unpublished data); Serangoon Reservoir (unpublished data).

Remarks. This is one of the parent species for the Louhan cichlid and Blood parrot hybrids.

***Amphilophus trimaculatus* (Günther)**
(Fig. 80, CA)



Fig. 80. *Amphilophus trimaculatus*, West Coast marsh pond.

References. Tan, 2014a (as *Cichlasoma trimaculatum*).

Distribution. West Coast Park marsh pond (Tan, 2014a).

Remarks. This is one of the parent species for the Louhan cichlid.

***Apistogramma borelli* (Regan)**
(Fig. 81, SA[SPC])

References. Tan HTW et al., 2010 (as *Apistogramma* sp.); Liew et al., 2012; Ho et al., 2016.

Distribution. Upper Seletar Reservoir Park stream (Liew et al., 2012); outskirts of Nee Soon Swamp Forest (Ho et al., 2016).



Fig. 81. *Apistogramma borelli*, 34.3 mm SL, Upper Seletar area (Lim KKP).

Remarks. An established population of this species exists in a stream along the outskirts of Nee Soon Swamp Forest (Liew et al., 2012; Ho et al., 2016). Its presence has been known since the 1990s.

***Astronotus ocellatus* (Agassiz, in Spix & Agassiz)**
(Fig. 82, SA)



Fig. 82. *Astronotus ocellatus*, 59.1 mm SL, trade material.

References. Lim & Ng, 1990; Ng et al., 1993; Ng & Lim, 1997b; Liew et al., 2012.

Distribution. Singapore Botanic Gardens (Liew et al., 2012), Bishan Park (Tan HH, pers. obs., March 2017).

Remarks. This is a popular species in the ornamental fish trade, available in several colour varieties.

***Cichla kelberi* Kullander & Ferreira**
(Fig. 83, SA[SPC])



Fig. 83. *Cichla kelberi*, 232 mm SL, Bedok Reservoir.

References. None. This is a new record for Singapore.

Distribution. Bedok Reservoir (unpublished data).

Remarks. Species of *Cichla* are large (more than 40 cm in length), highly territorial predatory fishes. Their presence in the water bodies will impact existing fish communities as this genus is highly piscivorous (Kovalenko et al., 2010). The four *Cichla* species could have been introduced by recreational anglers or/and released as unwanted ornamental pets (Ng HH & Tan HH, 2010).

***Cichla orinocensis* Humboldt, in Humboldt & Valenciennes**
(Fig. 84, SA[SPC])



Fig. 84. *Cichla orinocensis*, 217.5 mm SL, Pandan Reservoir.

References. Ng & Lim, 1997a (as *Cichla* cf. *monoculus*); Ng & Lim, 1997b (as *Cichla ocellaris*); Baker & Lim, 2008, 2012; Ng HH & Tan HH, 2010; Yeo & Chia, 2010; Kwik et al., 2013; Ng HH & Tan HH, 2013; Tan, 2013b, 2014d, 2014g; Ho et al., 2016.

Distribution. Lower Peirce Reservoir (Ng & Lim, 1997a; Ng HH & Tan HH, 2010); Bedok Reservoir (Ng HH & Tan HH, 2010); Jurong Lake (Ng HH & Tan HH, 2010); Kranji Reservoir (Ng HH & Tan HH, 2010); Upper Seletar Reservoir (Tan, 2013b, 2014d); Lower Seletar Reservoir (Ng HH & Tan HH, 2010); MacRitchie Reservoir (Ng HH & Tan HH, 2010); Pandan Reservoir (Ng HH & Tan HH, 2010); Woodlands Town Park pond (Kwik et al., 2013); Punggol Reservoir (Ng HH & Tan HH, 2013); Serangoon Reservoir (Ng HH & Tan HH, 2013); Banir (Tan, 2014g; Ho et al., 2016); Marina Reservoir (near Marina Bay Sands; Wozniak S, pers. obs., October 2016); Bishan Park (unpublished data).

Remarks. Juvenile individuals were recently obtained from a stream feeding into Lower Seletar Reservoir (Tan, 2014g), while adults were observed to be breeding in Upper Seletar Reservoir (Tan, 2013b); this is indicative that this species has established in Singapore.

***Cichla piquiti* Kullander & Ferreira**
(Fig. 85, SA[SPC])



Fig. 85. *Cichla piquiti*, 251.7 mm SL, Marina Reservoir.

References. None. This is a new record for Singapore.

Distribution. Marina Reservoir (unpublished data).

***Cichla temensis* Humboldt, in Humboldt & Valenciennes**
(Fig. 86, SA[SPC])



Fig. 86. *Cichla temensis*, 245 mm SL, Bedok Reservoir.

References. Liew et al., 2012; Lai, 2015; Ho et al., 2016; Tan, 2016a.

Distribution. Upper Seletar Reservoir (Liew et al., 2012); Lower Peirce Reservoir (Lai, 2015); MacRitchie Reservoir (Tan, 2016a); Bedok Reservoir (unpublished data); Upper Peirce Reservoir (unpublished data); Marina Reservoir (unpublished data).

Remarks. Juvenile individuals were obtained from Upper Seletar Reservoir (Liew et al., 2012), while adult pairs have been observed at MacRitchie Reservoir (Tan, 2016a); this is indicative of this species establishing breeding populations in Singapore.

***Coptodon zillii* (Gervais)**
(Fig. 87, AF)



Fig. 87. *Coptodon zillii*, 36.5 mm SL, Sumatra.

References. Burkill, 1963 (as *Tilapia zillii*); Alfred, 1968 (as *Tilapia zillii*); Munro, 1990 (as *Tilapia zillii*); Ng et al., 1993 (as *Tilapia zillii*); Ng & Lim, 1997a (as *Tilapia zillii*), 1997b (as *Tilapia zillii*).

Distribution. Singapore Botanic Gardens (Burkill, 1963; Alfred, 1968; Ng & Lim, 1997a, 1997b).

Remarks. There have been no recent records.

***Etroplus suratensis* (Bloch)**
(Fig. 88, SAs[SPC])



Fig. 88. *Etroplus suratensis*, 185 mm SL, Marina Reservoir (Kallang).

References. Lim et al., 1995; Ng & Sivasothi, 1999; Goh et al., 2002; Chua EK, 2010; Ng TH & Tan, 2010; Ng HH & Tan HH, 2010; Tan HH et al., 2010; Tan HTW et al., 2010; Jaafar et al., 2012; Leong, 2012; Kwik et al., 2013; Ng PX & Tan HH, 2013; Tan, 2013a; Ng et al., 2015; Tan, 2016c, 2017a; Tan & Ng, 2016; Theng et al., 2016; Toh et al., 2016.

Distribution. Sungei Buloh Wetland Reserve (Lim et al., 1995; Ng TH & Tan, 2010; Tan, 2013a; Theng et al., 2016); Kallang (now part of Marina Reservoir; Ng TH & Tan, 2010); Kranji Reservoir (Ng HH & Tan HH, 2010); Lower Seletar Reservoir (Ng HH & Tan HH, 2010); Punggol Reservoir (Ng TH & Tan HH, 2010; Ng PX & Tan, 2013; Theng et al., 2016); Serangoon Reservoir (Ng TH & Tan HH, 2010; Ng PX & Tan HH, 2013; Theng et al., 2016); Pulau Ubin (Ng TH & Tan, 2010); Marina Reservoir — encompassing Singapore River, Rochor canal, Kallang River, Geylang River and Marina channel (Tan HH et al., 2010); Siglap canal (Leong, 2012); Yishun pond (Kwik et al., 2013); Tuas — Raffles Marina (Toh et al., 2016); Bishan Park (Tan, 2016c); Sentosa (Tan & Ng, 2016); West Coast Park (Tan, 2017a); Jurong Lake (unpublished data); Lower Peirce Reservoir (unpublished data); MacRitchie Reservoir (unpublished data); Bedok Reservoir (unpublished data); Upper Peirce Reservoir (unpublished data); Serangoon Reservoir (unpublished data).

Remarks. This euryhaline South Asian cichlid is well-established in Singapore (Ng TH & Tan, 2010) and besides being found in freshwater reservoirs, has also adapted to saline conditions of estuarine and coastal waters (Tan & Ng, 2016; Tan, 2017a).

***Geophagus altifrons* Heckel**
(Fig. 89, SA[SPC])

References. Baker & Lim, 2008, 2012; Ng HH & Tan HH, 2010; Tan HH et al., 2010 (as *G. surinamensis*); Tan HTW et al., 2010 (as *Geophagus* sp.); Kwik et al., 2013; Tan, 2014d, 2016a; Ho et al., 2016; Lim et al., 2016.

Distribution. Kallang River (now part of Marina Reservoir; Tan HH et al., 2010); Bedok Reservoir (Ng HH & Tan HH, 2010); Kranji Reservoir (Ng HH & Tan HH, 2010);



Fig. 89. *Geophagus altifrons*, 145.6 mm SL, Bedok Reservoir.

Upper Peirce Reservoir (Ng HH & Tan HH, 2010); Lower Peirce Reservoir (Ng HH & Tan HH, 2010); Upper Seletar Reservoir (Ng HH & Tan HH, 2010; Tan, 2014d); Lower Seletar Reservoir (Ng HH & Tan HH, 2010); MacRitchie Reservoir (Ng HH & Tan HH, 2010; Tan, 2016a); Tekong Reservoir (Ng HH & Tan HH, 2010); Woodlands Town Park pond (Kwik et al., 2013); Yishun pond (Kwik et al., 2013); outskirts of Nee Soon Swamp Forest (Ho et al., 2016); Pulau Tekong (Lim et al., 2016); Jurong Lake (unpublished data); Pandan Reservoir (unpublished data); Serangoon Reservoir (unpublished data).

Remarks. This is a common species in the ornamental fish trade.

***Herichthys carpintis* (Jordan & Snyder)**
(Fig. 90, CA[SPC])



Fig. 90. *Herichthys carpintis*, 210 mm SL, Sungei Buloh.

References. Jaafar et al., 2012; Liew et al., 2012.

Distribution. Sungei Buloh Wetland Reserve (Jaafar et al., 2012; Liew et al., 2012).

***Heros severus* Heckel**
(Fig. 91, SA[SPC])

References. Ng HH & Tan HH, 2010.

Distribution. Bedok Reservoir (Ng HH & Tan HH, 2010).

Remarks. Not established as this is regarded as a discarded aquarium fish.



Fig. 91. *Heros severus*, 70.2 mm SL, trade material.

***Heterotilapia buttikoferi* (Hubrecht)**
(Fig. 92, AF[SPC])



Fig. 92. *Heterotilapia buttikoferi*, 205 mm SL, Yishun Pond.

References. Baker & Lim, 2008, 2012 (as *Tilapia buttikoferi*); Ng HH & Tan HH, 2010 (as *Tilapia buttikoferi*); Tan HTW et al., 2010 (as *Tilapia buttikoferi*); Kwik et al., 2013 (as *Tilapia buttikoferi*); Tan, 2013d, 2014a (as *Tilapia buttikoferi*); Tan, 2016c.

Distribution. Bedok Reservoir (Ng HH & Tan HH, 2010); Jurong Lake (Ng HH & Tan HH, 2010); Upper Peirce Reservoir (Ng HH & Tan HH, 2010); Lower Peirce Reservoir (Ng HH & Tan HH, 2010); Upper Seletar Reservoir (Ng HH & Tan HH, 2010); Lower Seletar Reservoir (Ng HH & Tan HH, 2010); Pandan Reservoir (Ng HH & Tan HH, 2010); Pangsua pond (Kwik et al., 2013); Yishun pond (Kwik et al., 2013); Central Catchment Nature Reserve — Sime forest (Tan, 2013d); West Coast Park marsh pond (Tan, 2014a); Bishan Park (Tan, 2016c); Jurong Lake (Tan HH, pers. obs., 2018); Marina Reservoir (unpublished data); Pandan Reservoir (unpublished data); Serangoon Reservoir (unpublished data).

Remarks. This is a popular fish in the ornamental fish trade. Its introduction into Singapore is probably through pet fishes that are released into the water bodies.

***Mayaheros urophthalmus* (Günther)**
(Fig. 93, CA[SPC])



Fig. 93. *Mayaheros urophthalmus*, 151.1 mm SL, Japanese Garden.

References. National Parks Board, 2003 (as *Nandopsis festae* or *Cichlasoma urophthalmus*); Nico et al., 2007 (as “*Cichlasoma*” *urophthalmus*); Baker & Lim, 2008, 2012 (as *Cichlasoma urophthalmum*); Ng HH & Tan HH, 2010 (as *Cichlasoma urophthalmum*); Tan HTW et al., 2010 (as *Cichlasoma urophthalmus*); Yeo & Lim, 2010 (as *Cichlasoma urophthalmum*); Jaafar et al., 2012 (as *Cichlasoma urophthalmum*); Kwik et al., 2013 (as *Cichlasoma urophthalmus*); Ng HH & Tan HH, 2013 (as *Cichlasoma urophthalmum*); Tan, 2013a (as *Cichlasoma urophthalmum*); Yeo, 2013 (as *Cichlasoma urophthalmum*); Tan, 2014a, 2014f (as *Cichlasoma urophthalmum*); Ng et al., 2015 (as *Cichlasoma urophthalmum*); Tan, 2016c; Tan & Koh, 2016 (as *Cichlasoma urophthalmum*); Theng et al., 2016 (as *Cichlasoma urophthalmum*); Tan et al., 2017b.

Distribution. Sungei Buloh Wetland Reserve (National Parks Board, 2003; Tan, 2013a; Theng et al., 2016); Punggol River (now dammed as Punggol Reservoir; Nico et al., 2007); Bedok Reservoir (Ng HH & Tan HH, 2010); Sarimbun Reservoir (Ng HH & Tan HH, 2010); Upper Peirce Reservoir (Ng HH & Tan HH, 2010); Singapore Botanic Gardens (Yeo & Lim, 2010); Punggol Reservoir (Ng PX & Tan, 2013; Theng et al., 2016); Serangoon Reservoir (Ng PX & Tan, 2013; Theng et al., 2016); Bishan Park (Yeo, 2013; Tan, 2016c); West Coast Park marsh pond (Tan, 2014a); Pandan canal (Tan 2014f); Yishun Pond (Kwik et al., 2013; Tan, 2014f); Jurong Lake (Tan, 2014f); Marina South (Tan & Koh, 2016); Singapore Quarry (Tan et al., 2017b); Bishan Park (unpublished data).

Remarks. This species has adapted to brackish water and can be sighted in the waterways at Sungei Buloh Wetland Reserve (Tan, 2013a).

Mayaheros urophthalmus* × *Parachromis managuensis
(Fig. 94)

References. Jaafar et al., 2012.

Distribution. Sungei Buloh Wetland Reserve (Jaafar et al., 2012).



Fig. 94. *Mayaheros urophthalmus* × *Parachromis managuensis* hybrid, ca. 200 mm SL, Sungei Buloh.

***Maylandia estherae* (Konings)**
(Fig. 95, AF[SPC])



Fig. 95. *Maylandia estherae*, 115.0 mm SL, Pandan canal.

References. Liew et al., 2012.

Distribution. Pandan canal (Liew et al., 2012).

Remarks. This individual is probably a discarded pet fish.

***Oreochromis aureus* (Steindachner)**
(AF)

References. Welcomme, 1988; Lim & Ng, 1990; Ng et al., 1993; Lever, 1996; Ng & Lim, 1997b; Jaafar et al., 2012.

Distribution. Not known.

Remarks. This species is regarded as an escapee from aquaculture (Ng & Lim, 1997b).

***Oreochromis mossambicus* (Peters)**
(Fig. 96, AF[SPC])

References. Le Mare, 1949 (as *Tilapia mossambica*); Burkill, 1961 (as *Tilapia*); Johnson, 1964 (as *Tilapia mossambica*); Alfred, 1966a (as *Tilapia mossambicus*, as early as 1944); Johnson, 1973a, 1973b (as *Tilapia*); Tham, 1973 (as *Tilapia mossambica*); Yang, 1984 (as *Tilapia mossambicus*); Lim & Ng, 1990; Munro, 1990; Ng, 1991; Public Utilities Board, 1991 (as *Tilapia mossambicus*); Ng et al., 1993; Fernando & Phang, 1994; Lim et al., 1995; Subaraj, 1995; Subaraj et al., 1995; Lever, 1996; Ng & Lim, 1997a, 1997b; Ng & Sivasothi, 1999; Goh et al., 2002; National Parks Board, 2003; Baker & Lim, 2008, 2012; Ng HH & Tan HH, 2010; Tan HH et al., 2010; Tan HTW et al., 2010; Yeo & Chia, 2010; Yeo & Lim, 2010; Davison et al., 2012; Jaafar et al.,



Fig. 96. *Oreochromis mossambicus*, 150 mm SL male (top), 100 mm SL female (bottom); Pandan Reservoir.

2012; Leong, 2012; Kwik et al., 2013; Ng PX & Tan, 2013; Yeo, 2013; Tan, 2014a; Ng et al., 2015; Tan YK et al., 2015 (as *Oreochromis* sp.); Lim et al., 2016; Tan, 2016b, 2016c (as *Oreochromis* sp.); Tan & Koh, 2016; Theng et al., 2016; Tan et al., 2017b.

Distribution. Upper Seletar Reservoir (previously known as Seletar Reservoir; Johnson, 1973a; Yang, 1984; Munro, 1990); Pulau Ubin (Subaraj, 1995); MacRitchie Reservoir (Subaraj et al., 1995); Lower Peirce Reservoir (Lim et al., 1995; Ng & Lim, 1997a); Central Catchment Nature Reserve — Nee Soon Swamp Forest (Ng & Lim, 1997a); Bedok Reservoir (Ng HH & Tan HH, 2010); Tekong Reservoir (Ng HH & Tan HH, 2010); Marina Reservoir — encompassing Singapore River, Rochor canal, Kallang River and Geylang River (Tan HH et al., 2010); Singapore Botanic Gardens (Yeo & Lim, 2010); Siglap canal (Leong, 2012); Pangsua pond (Kwik et al., 2013); Woodlands Town Park pond (Kwik et al., 2013); Yishun pond (Kwik et al., 2013); Punggol Reservoir (Ng PX & Tan HH, 2013; Theng et al., 2016); Serangoon Reservoir (Ng PX & Tan, 2013; Theng et al., 2016); Bishan Park (Yeo, 2013; Tan, 2016c); West Coast Park marsh pond (Tan, 2014a); Hindhede Quarry (Tan HH, pers. obs., July 2014); Marina Reservoir (Tan YK et al., 2015); Marina South (Tan & Koh, 2016); Sungei Buloh Wetland Reserve (National Parks Board, 2003; Theng et al., 2016); Kent Ridge Park ponds (Tan, 2016b); Tai Seng area (Tan HH, pers. obs., 2016); Pulau Tekong (Lim et al., 2016); Singapore Quarry (Tan et al., 2017b); Jurong Lake (unpublished data).

Remarks. This species was introduced as a source of food by the Japanese Army from Javan population during the Japanese Occupation of Singapore (1942–1945) (Alfred, 1966a; Tham, 1973; Lim & Ng, 1990; Yeo & Chia, 2010). It is now widespread in all Central Catchment reservoirs and other artificial water bodies and brackish water habitats (Ng & Lim, 1997b; Baker & Lim, 2008, 2012). The juveniles of this species are sometimes sold as live feed in the ornamental fish trade (Tan HH, pers. obs.).

***Oreochromis niloticus* (Linnaeus)**
(Fig. 97, AF[SPC])



Fig. 97. *Oreochromis niloticus*, 72.1 mm SL juvenile, Kranji Marsh.

References. Lim & Ng, 1990; Ng et al., 1993; Ng & Lim, 1997b; National Parks Board, 2003; Ng HH & Tan HH, 2010; Jaafar et al., 2012; Kwik et al., 2013; Ng PX & Tan HH, 2013; Tan, 2013a; Tan et al., 2016.

Distribution. Sungei Buloh Wetland Reserve (National Parks Board, 2003; Tan, 2013a); Jurong Lake (Ng HH & Tan HH, 2010); Murai Reservoir (Ng HH & Tan HH, 2010); Sarimbun Reservoir (Ng HH & Tan HH, 2010); Tengah Reservoir (Ng HH & Tan HH, 2010); Upper Peirce Reservoir (Ng HH & Tan HH, 2010); Lower Peirce Reservoir (Ng & Lim, 1997b); Yishun pond (Kwik et al., 2013); Punggol Reservoir (Ng PX & Tan, 2013); Serangoon Reservoir (Ng PX & Tan, 2013); Kranji Marsh (Tan et al., 2016); Bishan Park (unpublished data); Marina Reservoir (unpublished data).

Remarks. Both *O. niloticus* and *O. mossambicus* can adapt to saline conditions.

Oreochromis mossambicus* × *O. niloticus
(Fig. 98 [SPC])



Fig. 98. *Oreochromis mossambicus* × *O. niloticus* hybrid, 195 mm SL male (top), 170 mm SL female (bottom); Serangoon Reservoir.

References. Ng PX & Tan, 2013.

Distribution. Punggol Reservoir (Ng PX & Tan, 2013); Serangoon Reservoir (Ng PX & Tan, 2013).

Remarks. This hybrid has morphological characters of both parent species. Mature males tend to not exhibit the blackened body, but still having the multiple black bars and red margin over the caudal fin (Tan HH, pers. obs.).

***Parachromis managuensis* (Günther)**
(Fig. 99, CA[SPC])



Fig. 99. *Parachromis managuensis*, 130.0 mm SL, Pandan Reservoir.

References. Baker & Lim, 2008, 2012; Ng HH & Tan HH, 2010; Tan HTW et al., 2010; Kwik et al., 2013.

Distribution. Jurong Lake (Ng HH & Tan HH, 2010); Pandan canal (Tan HH, pers. obs., 2010); Pangsua pond (Kwik et al., 2013); Yishun pond (Kwik et al., 2013); Bishan Park (unpublished data), Pandan Reservoir (unpublished data).

Remarks. This species is common in the ornamental fish trade.

***Pterophyllum scalare* (Schultze, in Lichtenstein)**
(Fig. 100, SA[SPC])



Fig. 100. *Pterophyllum scalare*, 55.0 mm SL, Pangsua Pond.

References. Liew et al., 2012.

Distribution. Pangsua Pond (Liew et al., 2012).

Remarks. The specimens obtained from the listed site probably originated as discarded pets from the ornamental fish trade.

***Satanoperca jurupari* (Heckel)**
(Fig. 101, SA[SPC])



Fig. 101. *Satanoperca jurupari*, ca. 150 mm SL, Kranji Reservoir.

References. Ng HH & Tan HH, 2010; Baker & Lim, 2012.

Distribution. Kranji Reservoir (Ng HH & Tan HH, 2010).

***Thorichthys meeki* Brind**
(Fig. 102, CA)



Fig. 102. *Thorichthys meeki*, 63.9 mm SL, trade material.

References. Ng et al., 1993 (as *Cichlasoma meeki*); Ng & Lim, 1997a, 1997b.

Distribution. Cluny Road drain (Ng & Lim, 1997a, 1997b).

Remarks. This species is not established, and it is regarded as an escapee.

***Vieja melanura* (Günther)**
(Fig. 103, CA[SPC])



Fig. 103. *Vieja melanura*, 180 mm SL, Pandan canal.

References. Baker & Lim, 2008, 2012 (as *Paratheraps synspilus*); Ng HH & Tan HH, 2010 (as *Veija synspila*); Tan HTW et al., 2010 (as *Paratheraps synspila*); Kwik et al., 2013 (as *Paratheraps synspilum*); Ng et al., 2015 (as *Paraneetroplus melanurus*); Tan, 2015b, 2016c.

Distribution. Jurong Lake (Ng HH & Tan HH, 2010); Tengah Reservoir (Ng HH & Tan HH, 2010); Pandan canal (Tan HH, pers. obs., 2010); Pangsua Pond (Kwik et al., 2013); Yishun Pond (Kwik et al., 2013); Bishan Park (Tan, 2015b, 2016c); Marina Reservoir (near Marina Bay Sands; Wozniak S, pers. obs., October 2016); Singapore Botanic Gardens (Tan HH, pers. obs., 2002).

Remarks. This is likely one of the parent species for the Luohan cichlid.

Luohan/Flowerhorn cichlid
(Fig. 104 [SPC])



Fig. 104. Luohan/Flowerhorn cichlid hybrid, ca. 200 mm SL, Pandan Reservoir.

References. Baker & Lim, 2008, 2012 (as *Cichlasoma* hybrid [Luohan]); Ng HH & Tan HH, 2010 (as *Cichlasoma* hybrid); Jaafar et al., 2012 (as *Veija* spp.); Kwik et al., 2013 (as *Amphilophus* × *Paratheraps*); Ng PX & Tan, 2013 (as *Cichlasoma* sp. [Luohan]).

Distribution. Khatib Bongsu (Tan HH, pers. obs., 2004); Pandan river (Tan HH, pers. obs., 2004); Jurong Lake (Ng HH & Tan HH, 2010); Yishun Pond (Kwik et al., 2013); Punggol Reservoir (Ng PX & Tan, 2013); Serangoon Reservoir (Ng PX & Tan, 2013); Hindhede Quarry (Tan HH, pers. obs., 2014); Singapore Botanic Gardens (Tan HH, pers. obs., 2015).

Remarks. This multiple-genera hybrid fish was extremely popular in the mid-2000s but it has now fallen out of favour. At the height of the craze, lucrative sales prompted the opening of many boutique shops that sold only Luohan cichlids, as well as aquarium shops that opened 24 hours (Tan HH, pers. obs.).

Blood/Red Parrot hybrid
(Fig. 105 [SPC])



Fig. 105. Blood/Red Parrot hybrid, 88.0 mm SL, Pangsua Pond.

References. Liew et al., 2012 (as *Amphilophus citrinellus* × *Paraneotroplus melanurus*); Kwik et al., 2013 (as *Cichlasoma* hybrid).

Distribution. Pangsua Pond (Liew et al., 2012); Yishun Pond (Kwik et al., 2013).

Remarks. This mutated hybrid continues to be an extremely popular aquarium fish despite its artificially-induced physical defects (Tan HH, pers. obs.).

Red Tilapia
(Fig. 106 [SPC])



Fig. 106. Red Tilapia, 132.0 mm SL, Pangsua Pond.

References. Lim & Ng, 1990; Munro, 1990; Lim & Ng, 1992 (as *Oreochromis* spp. Hybrid); Goh et al., 2002 (as *Tilapia* hybrid); Tan, 2014a (as *Oreochromis* hybrid); Tan & Koh, 2017 (as *Oreochromis* sp.).

Distribution. Pulau Ubin HDB quarry (Lim & Ng, 1992); West Coast Park marsh pond (Tan, 2014a), Sungei Buloh Wetland Reserve (Tan & Koh, 2017); Yew Tee canal (Tan HH, pers. obs., 2016); Bishan Park (Andre, pers. obs., October 2016).

Remarks. This supposedly sterile hybrid of three species is brightly coloured (pink, orange or platinum) and frequently used for aquaculture (Lim & Ng, 1990; Tan & Koh, 2017). The juvenile individuals of this species are commonly sold as live feed in the ornamental fish trade (Tan HH, pers. obs.).

Family Gobiidae

***Brachygobius sabanus* Inger**
(Fig. 107, SEA[SPC])



Fig. 107. *Brachygobius sabanus*, 12.7 mm SL, Upper Seletar Reservoir inlet.

References. Baker & Lim, 2012; Lim & Tan, 2012; Tan et al., 2014; Kwik & Yeo, 2015 (as *Brachygobius doriae*); Ho et al., 2016; Larson et al., 2016; Tan et al., 2016.

Distribution. Poyan Reservoir (Lim & Tan, 2012); Tengah Reservoir (Lim & Tan, 2012); Kranji Reservoir (Lim & Tan, 2012); Kranji Marsh (Lim & Tan, 2012; Tan et al., 2016); Sungei Buloh Wetland Reserve (Lim & Tan, 2012); Banir (Lim & Tan, 2012); Upper Seletar Reservoir (Tan et al., 2014); Sungei Seletar (Ho et al., 2016).

Remarks. This species is well-established in Singapore (Larson et al., 2016).

***Rhinogobius similis* Gill**
(Fig. 108, EAs[SPC])



Fig. 108. *Rhinogobius similis*, 34.8 mm SL male, Upper Seletar Reservoir spillway.

References. Alfred, 1966a (as *Stigmatogobius poecilosoma*); Johnson, 1973a, 1973b (as *Stigmatogobius poecilosoma*); Lim & Ng, 1990 (as *Stigmatogobius poecilosoma*); Munro, 1990 (as *Stigmatogobius poecilosoma*); Ng, 1991 (as *Stigmatogobius poecilosoma*); Lim et al., 1995 (as *Rhinogobius* cf. *giurinus*); Subaraj et al., 1995 (as *Rhinogobius* cf. *giurinus*); Ng & Lim, 1997a, 1997b (as *Rhinogobius giurinus*); Larson & Lim, 2005 (as *Rhinogobius giurinus*); Larson et al., 2008 (as *Rhinogobius giurinus*); Baker & Lim, 2008, 2012 (as *Rhinogobius giurinus*); Ng HH & Tan HH, 2010 (as *Rhinogobius giurinus*); Tan & Lim, 2011 (as *Rhinogobius giurinus*); Lim et al., 2013 (as *Rhinogobius giurinus*); Tan, 2014e, 2014g (as *Rhinogobius giurinus*); Kwik & Yeo, 2015 (as *Rhinogobius giurinus*); Ho et al., 2016 (as *Rhinogobius giurinus*); Larson et al., 2016 (as *Rhinogobius giurinus*); Li et al., 2016 (as *Rhinogobius giurinus*).

Distribution. MacRitchie Reservoir (Munro, 1990); Upper Seletar Reservoir (Munro, 1990; Larson & Lim, 2005; Ng &

Lim, 1997b; Ng HH & Tan HH, 2010; Tan, 2014e, 2014g); Banir (Munro, 1990; Tan, 2014g); MacRitchie Reservoir (Subaraj et al., 1995); Central Catchment Nature Reserve (Ng & Lim, 1997a); Jurong Road area (Ng & Lim, 1997a); Singapore Botanic Gardens (Ng & Lim, 1997a); Jurong Lake (Ng HH & Tan HH, 2010); Upper Peirce Reservoir (Ng HH & Tan HH, 2010); Lower Peirce Reservoir (Lim et al., 1995; Ng & Lim, 1997b; Ng HH & Tan HH, 2010); Lower Seletar Reservoir (Ng HH & Tan HH, 2010); Murai Reservoir (Ng HH & Tan HH, 2010); Poyan Reservoir (Ng HH & Tan HH, 2010); Tengah Reservoir (Ng HH & Tan HH, 2010); Banir (Tan & Lim, 2011); Kranji Marsh (Lim et al., 2013); Central Catchment Nature Reserve — Nee Soon Swamp Forest (Ho et al., 2016; Li et al., 2016); Bishan Park (unpublished data).

Remarks. Alfred's (1966a) material of *Stigmatogobius poecilosoma* consisted of three taxa, viz., *Eugnathogobius siamensis*, *Pseudogobiopsis oligactis* (recently rediscovered in Singapore; Tan & Lim, 2011) and *Rhinogobius similis* (Ng & Lim, 1997b; Larson et al., 2008, 2016). It is a well-established non-native species in Singapore that was accidentally introduced with fish fry imported from China (Larson et al., 2016).

The taxonomic status of *R. giurinus* was resolved recently and is considered junior to *R. similis* (Suzuki et al., 2015).

Family Helostomatidae

Helostoma temminckii Cuvier

(Fig. 109, SEA)



Fig. 109. *Helostoma temminckii*, ca. 80 mm SL, trade material.

References. Ng et al., 1993

Distribution. No detailed location provided.

Family Osphronemidae

Betta splendens Regan

(Fig. 110, SEA[SPC])

References. Cantor, 1849 (as *Macropodus pugnax*); Herre, 1940; Tweedie, 1952; Johnson, 1964; Johnson, 1973a; Lim & Ng, 1990; Munro, 1990; Ng et al., 1993 (as *B. imbellis*); Lever, 1996; Ng & Lim, 1997b; National Parks Board, 2003; Tan HH et al., 2010; Tan, 2016b.



Fig. 110. *Betta splendens*, ca. 30 mm SL male, trade material.

Distribution. This species had been sighted by Cantor (1849) and subsequently obtained by Herre in 1940 from Mandai area; Sembawang-Nee Soon area (Johnson, 1964, 1973a); Jurong Lake (Johnson, 1973a); Sungei Buloh Wetland Reserve (National Parks Board, 2003); Kallang River (now part of Marina Reservoir; Munro, 1990; Tan HH et al., 2010); Kent Ridge Park ponds (Tan, 2016b); Bukit Batok (Ng DJJ, pers. obs., 2018).

Remarks. This is a very popular ornamental fish species ubiquitous in aquarium shops, thus its presence in Singapore's water bodies is not surprising. Recently, this species is commonly sold as live feed in the ornamental fish trade, the culled fish being a by-product from selective breeding (Tan HH, pers. obs.).

Macropodus opercularis (Linnaeus)

(Fig. 111, EAs[SPC])



Fig. 111. *Macropodus opercularis*, 45.5 mm SL male, trade material.

References. Tan et al., 2013.

Distribution. Bukit Brown (Tan et al., 2013).

Remarks. This species is sometimes sold as live feed in the ornamental fish trade (Tan HH, pers. obs.).

Osphronemus goramy Lacepède

(Fig. 112, SEA[SPC])

References. Green, 1928 (as *Osphronemus olfax*); Smith, 1933 (introduced as early as 1898); Herre & Myers, 1937; Tweedie, 1940; Alfred, 1966a; Johnson, 1973a; Anonymous, 1988a; Lim & Ng, 1990; Munro, 1990; Ng et al., 1993; Ng & Lim, 1997a, 1997b; National Parks Board, 2003; Ng HH & Tan HH, 2010; Chua, 2015; Tan, 2017b.



Fig. 112. *Osphronemus goramy*, 142 mm SL, Serangoon Reservoir.

Distribution. Herre & Myers (1937) collected this species from Singapore but did not provide location details. MacRitchie Reservoir (Alfred, 1966a; Anonymous, 1988a; Ng & Lim, 1997a, 1997b; Ng HH & Tan HH, 2010); Sungei Buloh Wetland Reserve (National Parks Board, 2003); Bedok Reservoir (Ng HH & Tan HH, 2010); Kranji Reservoir (Ng HH & Tan HH, 2010); Upper Peirce Reservoir (Ng HH & Tan HH, 2010); Lower Peirce Reservoir (Ng HH & Tan HH, 2010); Lower Seletar Reservoir (Ng HH & Tan HH, 2010); Singapore Botanic Gardens (Tan HH, pers. obs., 2015); Sungei Seletar (Tan, 2017b); Jurong Lake (unpublished data); Bedok Reservoir (unpublished data); Serangoon Reservoir (unpublished data).

Remarks. This species is of economic importance as food fish in the Southeast Asian region, but not popular in Singapore. Xanthic and albinio varieties are popular in the ornamental fish trade; some individuals are even tattooed with numbers or coloured patterns on the bodies (Tan HH, pers. obs.).

***Osphronemus laticlavius* Roberts**
(Fig. 113, SEA)



Fig. 113. *Osphronemus laticlavius*, 72.9 mm SL, trade material.

References. Lim, 2013b.

Distribution. Singapore Quarry (Lim, 2013b).

Remarks. This is a popular species in the ornamental fish trade as it is considered lucky or good for “feng shui” (Lim & Ng, 1990).

***Sphaerichthys osphromenoides* Canestrini**
(Fig. 114, SEA)



Fig. 114. *Sphaerichthys osphromenoides*, 32.0 mm SL, Malaysia.

References. Boeseman, 1957; Ng & Lim, 1997b.

Distribution. Not known.

Remarks. These records are of individuals that are likely from the ornamental fish trade, not established (Lim & Ng, 1997b).

***Trichogaster lalius* (Hamilton)**
(Fig. 115, SAs)



Fig. 115. *Trichogaster lalius*, 43.1 mm SL male, trade material.

References. Lim & Ng, 1990 (as *Colisa lalia*); Ng et al., 1993 (as *Colisa lalia*).

Distribution. Not known.

Remarks. This species is probably from ornamental fish trade, and not established (Lim & Ng, 1990). The females of this species are sometimes sold as live feed in the ornamental fish trade (Tan HH, pers. obs.).

***Trichopodus microlepis* (Günther)**
(Fig. 116, SEA)

References. Anonymous, 1988a (as *Trichogaster microlepis*); Lim & Ng, 1990 (as *Trichogaster microlepis*); Ng et al., 1993 (as *Trichogaster microlepis*); Ng & Lim, 1997a (as *Trichogaster microlepis*); Ng & Lim, 1997b (as *Trichogaster microlepis*); Low & Lim, 2012.

Distribution. Mandai area (Anonymous, 1988a; Ng & Lim, 1997a); Jurong area (Ng & Lim, 1997a).

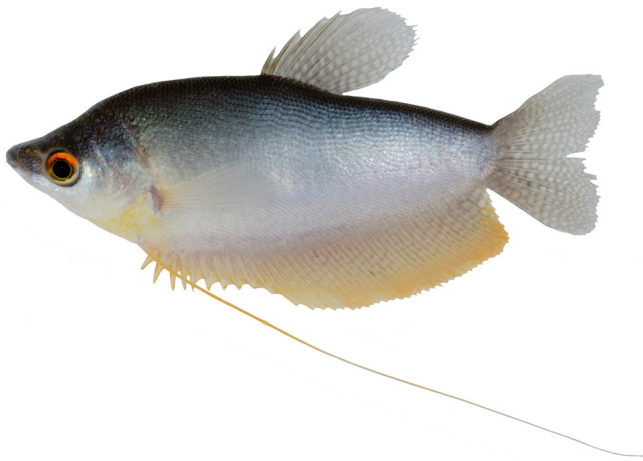


Fig. 116. *Trichopodus microlepis*, 92.6 mm SL, trade material.

***Trichopodus pectoralis* Regan**
(Fig. 117, SEA[SPC])



Fig. 117. *Trichopodus pectoralis*, 96.6 mm SL, Sungei Buloh.

References. Hanitsch, 1901, 1904 (as *Osphromenus siamensis*); Regan, 1910 (described as *Trichogaster pectoralis*); Smith, 1933 (as *Trichogaster pectoralis*); Herre & Myers, 1937 (as *Trichogaster pectoralis*); Fowler, 1938; Tweedie, 1952 (as *Trichogaster pectoralis*); Alfred, 1961, 1966a (as *Trichogaster pectoralis*, introduced in 1898); Johnson, 1964 (as *Trichogaster pectoralis*); Johnson, 1973a (as *Trichogaster pectoralis*); Tan et al., 1987 (as *Trichogaster pectoralis*); Anonymous, 1988a, 1988b (as *Trichogaster pectoralis*); Chou & Lam, 1989 (as *Trichogaster pectoralis*); Lim & Ng, 1990, 1991, 1992 (as *Trichogaster pectoralis*); Munro, 1990 (as *Trichogaster pectoralis*); Lim, 1991 (as *Trichogaster pectoralis*); Ng & Lim, 1992 (as *Trichogaster pectoralis*); Ng et al., 1993 (as *Trichogaster pectoralis*); Lever, 1996 (as *Trichogaster pectoralis*); Ng & Lim, 1997a (as *Trichogaster pectoralis*); Ng & Lim, 1997b (as *Trichogaster pectoralis*); National Parks Board, 2003; Yeo & Chia, 2010 (as *Trichogaster pectoralis*); Tan HH et al., 2010; Low & Lim, 2012; Tan et al., 2016.

Distribution. Herre & Myers (1937) obtained 14 specimens from Singapore but did not provide location details; Jurong and Kranji Rivers (Alfred, 1961); Lower Peirce Reservoir (Alfred, 1966a); Singapore Botanic Gardens (Anonymous, 1988a); Seletar area (Munro, 1990); Central Catchment Nature Reserve — Nee Soon Swamp Forest (Lim, 1991;

Ng & Lim, 1992; Ng & Lim, 1997a, 1997b); Upper Seletar Reservoir (Anonymous, 1988a; Ng & Lim, 1997a, 1997b); Mandai area (Anonymous, 1988b; Ng & Lim, 1997a); Sungei Buloh Wetland Reserve (Lim & Ng, 1992; Ng & Lim, 1997a; National Parks Board, 2003); Kallang River (now part of Marina Reservoir; Tan HH et al., 2010); Kranji Marsh (Tan et al., 2016).

Remarks. Regan (1910) described *Trichopodus pectoralis* based on a series of six specimens from Thailand (Siam) and Singapore, but did not provide more precise locations. This species had apparently been introduced into Singapore in 1898 for aquaculture (Smith, 1933), and is presently sold in local markets, salted and without heads (Tan HH, pers. obs.).

***Trichopsis schalleri* Ladiges**
(Fig. 118, SEA[SPC])



Fig. 118. *Trichopsis schalleri*, ca. 35.0 mm SL, Thailand.

References. Ng HH & Tan HH, 2010.

Distribution. Lower Seletar Reservoir (Ng HH & Tan HH, 2010).

Remarks. The source of introduction is not known as this is a rarely-encountered species in the ornamental fish trade (Tan HH, pers. obs.).

Family Channidae

***Channa micropeltes* (Cuvier, in Cuvier & Valenciennes)**
(Fig. 119A, B, SEA[SPC])



Fig. 119. *Channa micropeltes*, ca. 30 mm SL juvenile (top), trade material; 435 mm SL adult (bottom), Bedok Reservoir.

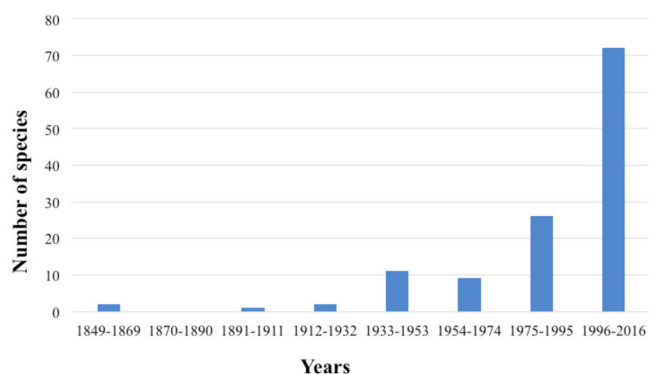


Fig. 120. Number of first records of non-native fish species from 1849 to 2016.

References. Burkill, 1961, 1963; Alfred, 1966a; Yang, 1984; Anonymous, 1988c, 1989a, 1989b; Lim & Ng, 1990; Munro, 1990; Lim, 1991; Ng, 1991; Public Utilities Board, 1991; Lim & Ng, 1992; Ng et al., 1993; Lim et al., 1995; Subaraj et al., 1995; Ng & Lim, 1997a, 1997b; National Parks Board, 2003; Baker & Lim, 2008, 2012; Ng HH & Tan HH, 2010; Ho et al., 2016; Tan, 2016b; Tan & Herder, 2016.

Distribution. Present in all reservoirs (Ng & Lim, 1997b) and widespread in ponds (Baker & Lim, 2008, 2012). Singapore Botanic Gardens (Burkill, 1963; Alfred, 1966a; Ng & Lim, 1997a); Sime Road forest stream (Anonymous, 1988c); Woodlands Town Garden (Anonymous, 1989a); Chestnut forest (Subaraj et al., 1995); Bedok Reservoir (Ng HH & Tan HH, 2010); Jurong Lake (Ng HH & Tan HH, 2010); Kranji Reservoir (Lim, 1991; Ng & Lim, 1997a, 1997b; Ng HH & Tan HH, 2010); Upper Peirce Reservoir (Anonymous, 1989b; Ng & Lim, 1997a, 1997b; Ng HH & Tan HH, 2010); Lower Peirce Reservoir (Lim et al., 1995; Ng & Lim, 1997a, 1997b; Ng HH & Tan HH, 2010); Upper Seletar Reservoir (Yang, 1984; Ng & Lim, 1997a, 1997b; Ng HH & Tan HH, 2010); Lower Seletar Reservoir (Ng & Lim, 1997a, 1997b; Ng HH & Tan HH, 2010); MacRitchie Reservoir (Subaraj et al., 1995; Ng & Lim, 1997a, 1997b; Ng HH & Tan HH, 2010); Kranji Reservoir (Ng & Lim, 1997a); Murai Reservoir (Ng HH & Tan HH, 2010); Pandan Reservoir (Ng HH & Tan HH, 2010); Poyan Reservoir (Ng HH & Tan HH, 2010); Sarimbun Reservoir (Ng HH & Tan HH, 2010); Tengah Reservoir (Ng & Lim, 1997a, 1997b; Ng HH & Tan HH, 2010); Sungei Buloh Wetland Reserve (Ng & Lim, 1997a; National Parks Board, 2003; Chua, 2015; Tan & Herder, 2016; Nee Soon Swamp Forest (Lim & Ng, 1992; Ho et al., 2016); Kent Ridge Park ponds (Tan, 2016b); Yew Tee canal (Tan HH, pers. obs., 2016).

Remarks. *Channa micropeltes* was first released into Seletar Reservoir (now known as Upper Seletar Reservoir) to control the abundant tilapia (*Oreochromis* sp.) population, and subsequently introduced into other reservoirs with large populations of tilapia (Yang, 1984). The juvenile individuals of this species are commonly sold as live feed in the ornamental fish trade (Tan HH, pers. obs.).

DISCUSSION

Non-native freshwater fish records over time. The first published records of non-native fish species in Singapore was in 1849. Since then, the number of non-native fish species recorded has increased exponentially in recent years (Fig. 120).

One of the main reasons for the recent increase in reports of non-native fishes is the increase in fish survey reports, and the growing popularity of citizen science, and readily-accessible online journals (e.g., Nature in Singapore: <http://lkcnhm.nus.edu.sg/nus/index.php/nhmpublications/nis>; Singapore Biodiversity Records: <http://lkcnhm.nus.edu.sg/nus/index.php/nhmpublications/singapore-biodiversity-records>), and nature blogs (e.g., Bird Ecology Study Group).

Reports of non-native fish species (established as well as non-established) were from throughout Singapore (Fig. 121). Notably, reservoirs were focal points of species reports. This is consistent with known associations between modified habitats and non-native fish establishment (Liew et al., 2016a; Liew et al., 2018a), especially where native species diversity is poor (Liew et al., 2016b). Recent findings suggest that non-native species form predator-prey interactions with native habitat generalists (e.g., *Channa striata*) in complex food webs (Liew et al., 2018b). In addition, some non-native species (e.g., cichlids, the dominant group of established freshwater fish) appear to be particularly well-suited or adaptable ecologically to Singapore's freshwater habitats (Kwik et al., in press).

Unsurprisingly, fish species from tropical regions form the majority of introductions (see Fig. 122; Central America [15] + South America [23] + Africa [9] + South Asia [8] + Southeast Asia [46] + Australasia [1] = 102 species; 82.9%). Of the regions, Southeast Asia is the main source of non-native fish (46 species, 37.3%). This somewhat reflects the primary sources of ornamental fish species traded in Singapore.

Species for biological control. Hanitsch (1912) reported on the feasibility of introducing *Poecilia reticulata* (listed as *Girardinus poeciloides*) as a vector control agent against the mosquito-borne disease malaria, which was prevalent in Singapore at that time. He also surveyed for potential local aquatic agents of vector control, and listed several species of freshwater fishes with potential — *Aplocheilus armatus* (listed as *Haplocheilus panchax*; presently the Sundaic population has been re-identified by Katwate et al., 2018), *Dermogenys collettei* (listed as *Heiramphus fluviatilis*), *Betta pugnax*, *Trichopodus trichopterus* (listed as *Osphronemus trichopterus*), *Anabas testudineus* (listed as *Anabas scandens*), *Channa striata* (listed as *Ophiocephalus striatus*) and *Clarias batrachus* (listed as *Clarias magur*). He cautioned about the risk of accidental introduction of other undesirable organisms. However, *Poecilia reticulata* was still introduced shortly after as a vector control against malaria (Lim & Ng, 1990: 75).

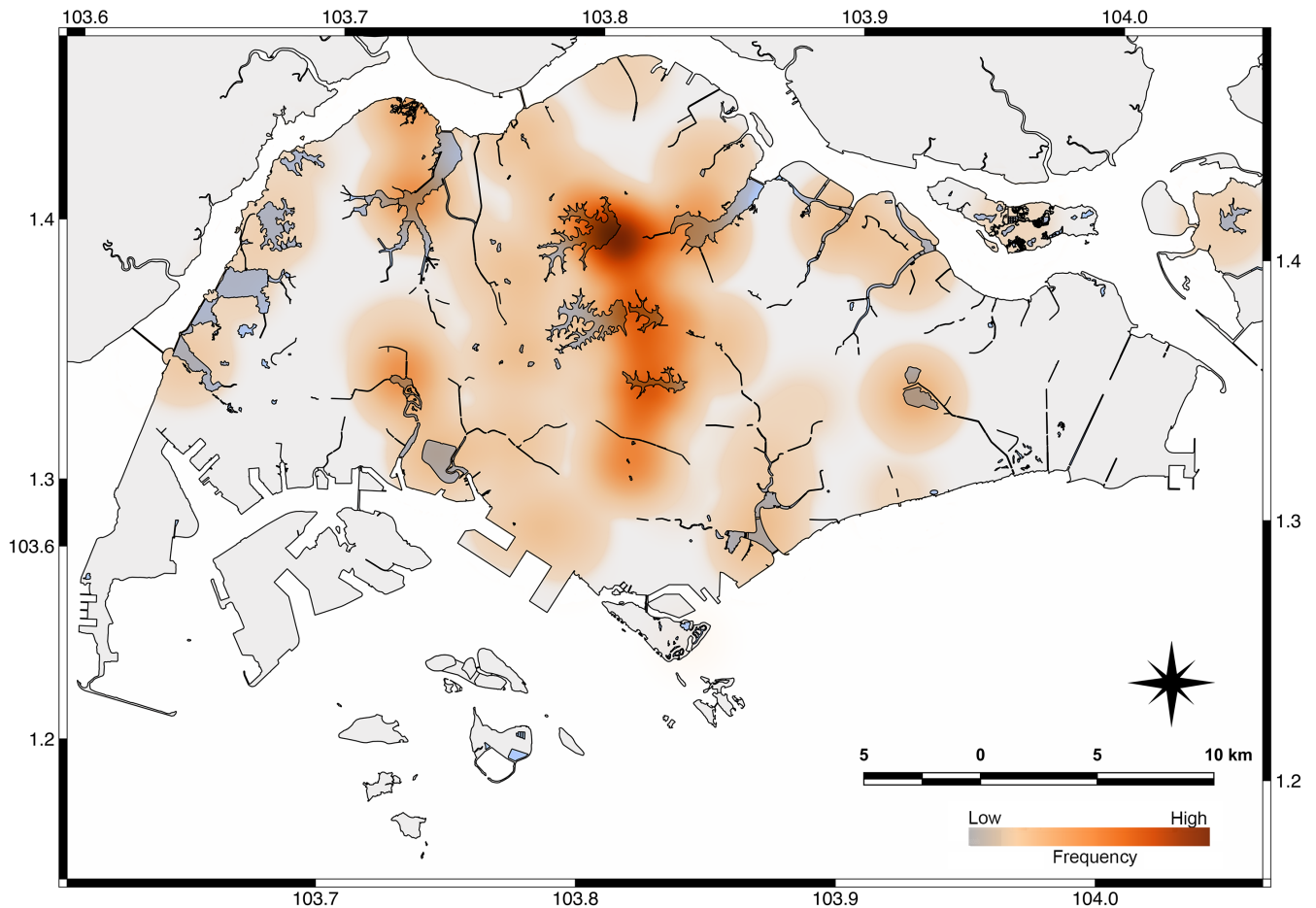


Fig. 121. Distribution of non-native fish species (established as well as non-established) records from 1849 to 2016 ($n = 648$). Intensity of orange hues represents species record frequency, in which darker shades correspond to higher occurrence records. Species records were location- and species-specific, which is to say that multiple reports of the same species from a single location is represented only once in the heat map.

This diminutive and very prolific species has since colonised many of Singapore's disturbed freshwater bodies (including at forest edges) since its introduction as a biological control; populations are present even in back mangrove habitats (Tan HH, pers. obs.). This species is very tolerant and can survive in polluted canals in industrial estates, and even sewerage tanks (Lim & Ng, 1990). This species has been an integral part of Singapore's ornamental fish trade, being part of the multi-million dollar aquarium/ornamental fish industry (Fernando & Phang, 1994). Fishes are subject to stringent selective breeding with numerous fancy and colourful variants. The rejected or culled fishes become a source of live feed (Lim & Ng, 1990) for large carnivorous ornamental fish species.

Gambusia affinis is another species introduced for biological control of mosquitoes (Lim & Ng, 1990). This small species is also ubiquitous and can also tolerate brackish conditions (Tan HH, pers. obs.).

Channa micropeltes was introduced into reservoirs to control the large populations of *Oreochromis* spp. present in the 1970s–1980s (Yang SL, pers. comm.; Ng HH & Tan HH, 2010). This species quickly established and became widely distributed in all artificial water bodies in Singapore. This is a highly coveted food fish, and is a sought-after target for

recreational angling, including illegal angling in prohibited areas.

Dubious records. One of the earliest lists of ornamental fishes imported from Singapore into Europe was documented by Boeseman (1957). In his list, he included species previously not recorded from Singapore, viz., *Kryptopterus vitreolus* (previously known as *K. bicirrhus*; a species known from southern and eastern Thailand; see Ng & Kottelat, 2013a), *Chromobotia macracanthus* (identified as *Botia macracanthus*; a species known only from Sumatra and Borneo; see Tan & Kottelat, 2009, and Kottelat et al., 1993), *Trigonopoma pauciperforatum* (identified as *Rasbora pauciperforata*; a species known from Peninsular Malaysia, Borneo and Sumatra; see Kottelat et al., 1993), *Trigonopoma gracile* (identified as *Rasbora taeniata*; a species known from Malaysia, Borneo and Sumatra; see Kottelat et al., 1993), *Puntigrus partipentazona* (identified as *Puntius partipentazona*; a species known from Peninsular Malaysia and Thailand; see Mohsin & Ambak, 1983), *Sphaerichthys osphromenoides* (a species known from peat swamps in Peninsular Malaysia, Sumatra and western Borneo; see Kottelat et al., 1993, and Tan & Ng, 2005) and *Gymnochanda filamentosa* (described as a new genus and new species, but later found to be a homonym of an earlier identical name given by Fraser-Brunner in 1955; apparently

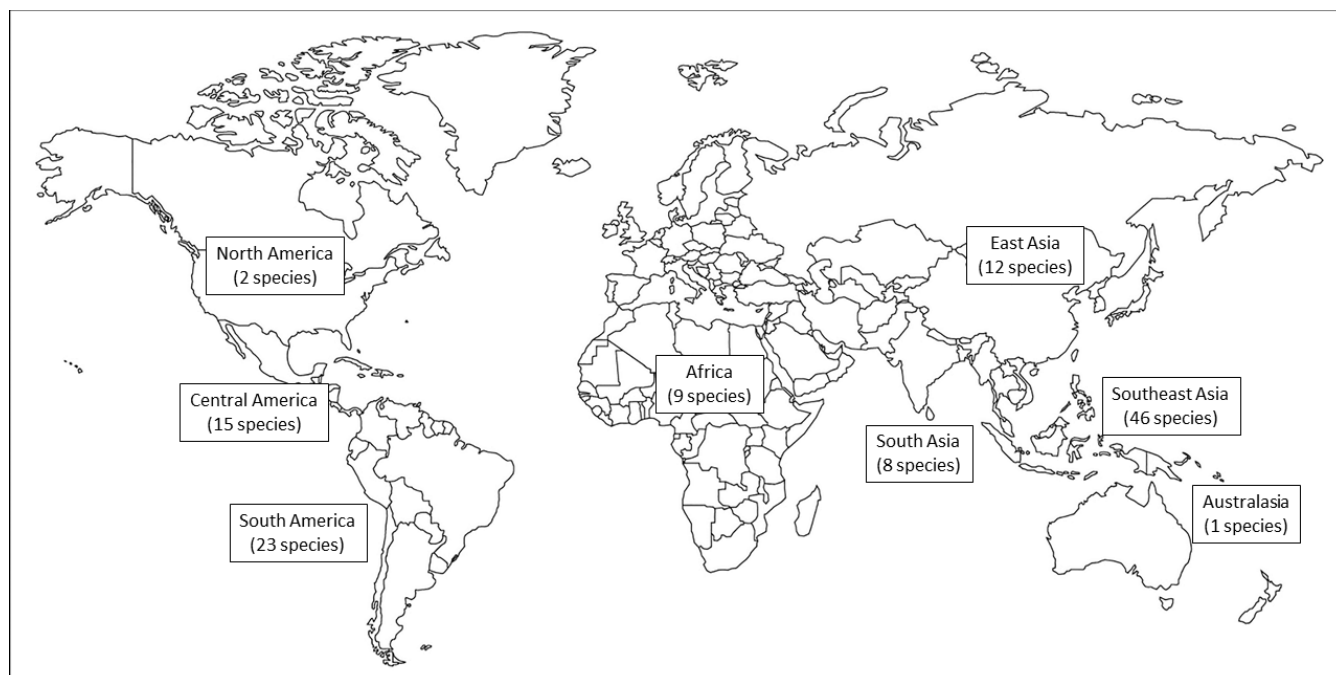


Fig. 122. World map showing region of origin for the 116 non-native freshwater fish species recorded in Singapore (excluding seven hybrids).

found only in Peninsular Malaysia and Sumatra; see Tan & Lim, 2014). In 1957, the ornamental fish trade was already an important industry in Singapore, and many of these species were imported from neighbouring countries and territories, including Peninsular Malaysia, southern Thailand and Sumatra. Alfred (1966a) commented that Boeseman's fish list is almost entirely based upon fish imports for the ornamental fish trade and thus was not used in his own checklist.

Native fish species. The number of extant native freshwater fish species recorded from Singapore is 42 (see Table 2). Of these, 22 species (52.4%) are restricted to forest streams within the Central Catchment and Bukit Timah Nature Reserves.

At least 11 native fish species are at present known to be extirpated; viz., Cyprinidae — *Barbodes dunckeri* (with known specimen deposition), *Osteochilus spilurus*, *Rasbora cephalotaenia*, *Rasbora paucisqualis*; Cobitidae — *Pangio semicineta* (with known specimen deposition); Siluridae — *Ompok leiacanthus*; Sisoridae — *Gyptothorax callopterus* (with known specimen deposition); Mastacembelidae — *Mastacembelus favus*; Pristolepididae — *Pristolepis fasciatus*; and Osphronemidae — *Belontia hasseltii*, *Betta tomi* (with known specimen deposition) (Alfred, 1966a; Lim & Ng, 1990). Some of these species are listed based on personal opinion (of the first author) and many years of ichthyological field work in Singapore and the Southeast Asian region.

Prior to the comprehensive list of freshwater fishes of Singapore by Alfred (1966a), there were very few published records from the island city state. Earlier records were based mainly on the works of Cantor (1849), Duncker (1904), Regan (1910), Tweedie (1936, 1940, 1950, 1952), Herre

& Myers (1937), Herre (1937, 1940), Fowler (1938), and Fraser-Brunner (1940). These works generally encompassed a larger geographic area which included sporadic collections made in Singapore.

Alfred's (1966a) publication was based on his earlier works conducted from 1960. However, even by then, much of Singapore's natural landscape and habitats had been altered, due to urbanisation and cultivation of cash crops (e.g., gambier). Corner (1978) documented the demise of many swamp forest habitats in southern Johor and Singapore in pre-Second World War era, although the account was only published much later. For Singapore, Corner (1978) documented the clear felling of swamp forest habitats mainly from Mandai (present day Upper and Lower Seletar Reservoirs and residential estates), Jurong (present day Jurong Lake, Chinese and Japanese Gardens, industrial and residential estates), and Ang Mo Kio (present day industrial and residential areas). No documentation of the then aquatic inhabitants was made. Thus, many indigenous species, and knowledge of these species, were lost. Some of the earlier records by Herre & Myers (1937) and Herre (1940) included some of these localities, however these reports were not comprehensive but gave positive correlations with acid-water swamp forest habitats (e.g., *Silurichthys hasseltii*).

Ornamental fish trade. Prior to 1950s, Singapore was already a hub for the ornamental fish trade (Boeseman, 1957). To date, more than 760 species from 89 families have been recorded from the ornamental fish trade based in Singapore; these are imported from all over the world (Lee, 2008, unpublished thesis). Many of the tropical fishes are potentially invasive species. Many species in cultivation were inadvertently introduced into the water bodies of Singapore, either as escapees or intentional releases (Fernando & Phang, 1994). There is an ongoing trend for keeping monster or

Table 2. Extant native inland freshwater fishes of Singapore. This is a current listing, which comprises 42 species from 19 families and 8 orders (data from Baker & Lim, 2012; and unpublished data). Names in bold represent species restricted to forest streams within protected areas like the Central Catchment Nature Reserve.

Family	Species	Family	Species
MEGALOPIDAE	<i>Megalops cyprinoides</i>	ADRIANICHTHYIDAE	<i>Oryzias javanicus</i>
CYPRINIDAE	<i>Barbodes banksi</i> <i>Barbodes lateristriga</i> <i>Boraras maculatus</i> <i>Cyclocheilichthys apogon</i> <i>Desmopuntius hexazona</i> <i>Rasbora einthovenii</i> <i>Rasbora elegans</i> <i>Trigonostigma heteromorpha</i>	APLOCHEILIDAE	<i>Aplocheilus armatus</i>
		ZENARCHOPTERIDAE	<i>Dermogenys collettei</i> <i>Hemirhamphodon pogonognathus</i>
		ELEOTRIDAE	<i>Oxyeleotris marmorata</i> <i>Oxyeleotris urophthalmus</i>
		GOBINELLIDAE	<i>Eugnathogobius siamensis</i> <i>Glossogobius aureus</i> <i>Gobiopterus brachypterus</i> <i>Mugilogobius chulae</i> <i>Pseudogobiopsis oligactis</i>
COBITIDAE	<i>Pangio muraeniformis</i>		
NEMACHEILIDAE	<i>Nemacheilus selangoricus</i>	NANDIDAE	<i>Nandus nebulosus</i>
BAGRIDAE	<i>Mystus gulio</i> <i>Pseudomystus leiacanthus</i>	ANABANTIDAE	<i>Anabas testudineus</i>
SILURIDAE	<i>Silurichthys hasseltii</i>	OSPHRONEMIDAE	<i>Betta imbellis</i> <i>Betta pugnax</i> <i>Luciocephalus pulcher</i> <i>Trichopodus trichopterus</i> <i>Trichopsis vittata</i>
AKYSIDAE	<i>Parakysis longirostris</i>		
CLARIIDAE	<i>Clarias batrachus</i> <i>Clarias leiacanthus</i> <i>Clarias nieuhofii</i>	CHANNIDAE	<i>Channa gachua</i> <i>Channa lucius</i> <i>Channa melasoma</i> <i>Channa striata</i>
SYNBRANCHIDAE	<i>Monopterus javanensis</i>		
MASTACEMBELIDAE	<i>Macroglyphus maculatus</i>		

tank-buster fish species (INJAF, 2018); these species can potentially grow to large adult sizes, some even larger than humans. These species are usually obtained during the juvenile stage, but rapidly outgrow hobbyists' limited tank sizes. This trend is a cause for concern as these monster species are high-potential candidates for release. Disposal of adult or sub-adult fishes will eventually become an issue because there are limited options for adoption or public displays due to their large adult size. Some of these fishes have been recorded in this present study and include *Potamotrygon motoro*, *Atractosteus spatula*, *Chitala ornata*, *Arapaima gigas*, *Osteoglossum bicirrhosum*, *Scleropages* spp., *Hampala macrolepidota*, *Leptobarbus rubripinna*, *Morulius chrysophekadion*, *Chromobotia macracanthus*, *Piaractus brachypomus*, *Hemibagrus capitulum*, *Clarias gariepinus*, *Pterygoplichthys* spp., *Pangasionodon hypophthalmus*, *Pangasius sanitwongsei*, *Phractocephalus hemioliopus*, *Danioideus microlepis*, *Cichla* spp., *Osphronemus goramy*, and *Channa micropeltes*. Some of these species are known to be harmful to humans due to venomous spines, e.g., *Potamotrygon motoro* (Ng et al., 2009); or aggressive nature, and large adult sizes, e.g., *Channa micropeltes* (Ng & Lim, 1990).

Currently, not many freshwater fish species are commercially bred in Singapore due to space constraints and cost. The few

which are mainly consisting of fast growing and easily bred species, e.g., Poeciliidae (see Fernando & Phang, 1994).

Food fish aquaculture. Alfred (1966b) provided a bibliography of 291 entries pertaining to Malayan freshwater fisheries; this work provided insights to the range of publications and resources available during Singapore's colonial history (1849–1964).

Birtwistle (1931a) provided a detailed account on the cultivation of five species of Chinese carps (*Cirrhinus molitorella*, *Ctenopharyngodon idella*, *Cyprinus carpio*, *Hypophthalmichthys molitrix* and *H. nobilis*) in mud ponds in Malaya (which then included Singapore). The fry of the abovementioned species was imported from overseas (China, Hong Kong and Taiwan) and subsequently placed into mud ponds for the growing-out phase. Maxwell (1921), Stead (1923) and Birtwistle (1931b) gave interesting accounts on how fertilised ova and fish fry were shipped from China in large jars of freshwater, and how the water and contents were vigorously stirred for aeration. Le Mare (1949) provided an additional mode of transportation of fry in tin cans during the North-East monsoon by air freight. Tham (1973) also provided a brief account of the above practice, while noting that *H. molitrix* and *H. nobilis* were subsequently artificially bred in Malaysia and the fry then exported to Singapore.

Barbonymus gonionotus (Lampam jawa) was also introduced into Malaya from Indonesia during the Japanese Occupation (1942–1945) (Mohsin & Ambak, 1983). It was a very popular food fish with the local Malay community and was widely cultivated.

Tilapia (*Oreochromis* sp.) was introduced into Malaya from Indonesia by the Japanese army during the latter part of the Japanese Occupation, ca. 1941–1945 (Le Mare, 1949; Tham, 1973; Mohsin & Ambak, 1983). However, Costa-Pierce (2003) indicates that the introduction could date earlier to 1938. During the 1950s, it was a very popular food fish cultured in ponds and mining pools throughout Malaya. At present, tilapia remains a staple food fish in Singapore; available live mainly from Peninsular Malaysia, as fresh whole fish, or as pre-packed fillets.

A recent import for the live food fish trade is *Monopterus cuchia* (Synbranchidae) from India, which is usually sold in some supermarkets (Tan HH, pers. obs.). Each individual can weigh over a kilogram and is an esteemed food fish in northern Chinese cuisine restaurants. There is a possibility that this species has already been introduced into Singapore's water bodies, but this suspicion remains unverified. *Monopterus cuchia* is superficially similar to the native species *Monopterus javanensis*, and can only be distinguished with the aid of the microscope; *M. cuchia* possesses body scales which are absent in the native species; and morphology of the gill opening and buccal chambers (Nico et al., 2019).

At present, the bulk of fish aquaculture in Singapore focuses on marine species, usually set in netted cages in the open system along the Straits of Johor and Straits of Singapore. Very few freshwater fish species are actively used in aquaculture. The aquacultured freshwater fish species are mainly imported from Malaysia.

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ADDENDUM

This section includes three new records post-2017 and one overlooked record. We feel strongly these should be included to illustrate the complexity and fluidity of monitoring the presence of non-native fish situation in Singapore; and the ease of overlooking elusive records.

Order Siluriformes

Family Bagridae

Horabagrus brachysoma (Günther)
(Fig. 123, SAs)



Fig. 123. *Horabagrus brachysoma*, length not recorded, 700 g, Kranji Reservoir (Looh CW).

References. None. This is a new record for Singapore.

Distribution. Kranji Reservoir.

Remarks. This is an overlooked record which was brought to our attention recently (Raghavan R, pers. comm., February 2020). This species is common in the ornamental fish trade (Tan HH, pers. obs.).

Family Claroteidae

Chrysichthys auratus (Geoffroy St. Hilaire)
(Fig. 124, AF[SPC])



Fig. 124. *Chrysichthys auratus*, 242.0 mm SL, Bishan (Lim RHB).

References. Tan, 2019.

Distribution. Kallang River (Tan, 2019); Bishan Park (unpublished record).

Remarks. This is based on observations (Tan, 2019; Tan & Tay, 2019) and actual specimens. The source of introduction of the specimens is a mystery (Tan, 2019).

Order Characiformes

Family Anostomidae

Leporinus fasciatus (Bloch)
(Fig. 125, SA)



Fig. 125. *Leporinus fasciatus*, 67.0 mm SL, trade material.

References. Tan & Tay, 2019.

Distribution. Kallang River (Tan & Tay, 2019).

Remarks. This is a common ornamental fish, and most likely a discarded pet fish.

Order Perciformes

Family Cichlidae

Veija × *Mayaheros* (?) hybrid
(Fig. 126, [SPC])

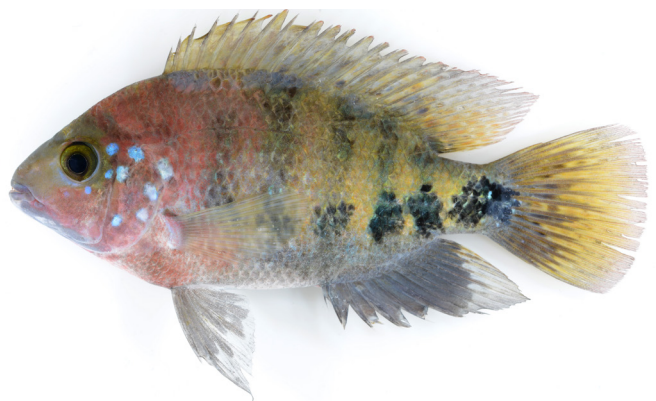


Fig. 126. *Veija* × *Mayaheros* (?) hybrid, 115.9 mm SL, Jurong Lake.

References. None. This is a new record for Singapore.

Distribution. Jurong Lake area (Tan HH, pers. obs.).

Remarks. This is most likely a hybrid, as all *Veija* specimens lack the blue iridescent spots on the head.