

## Discovery of *Encheloclarias* (Teleostei: Clariidae) from Singapore, with notes on morphology and distribution

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**Abstract.** We report the discovery of several specimens of the genus *Encheloclarias* Herre & Myers, 1937, in Singapore, from Nee Soon Swamp Forest in the Central Catchment Nature Reserve. Morphological comparisons with type specimens of various *Encheloclarias* species revealed the Singapore specimens belong to *Encheloclarias kelioides* Ng & Lim, 1993. This discovery represents a range extension for the species, previously understood to be restricted to peat swamps in eastern Peninsular Malaysia and possibly central Sumatra. A redescription of *E. kelioides* and comparison against its congeners are provided. Its ecology and conservation status globally and locally are also discussed.

**Key words.** Siluriformes, freshwater swamp, peat swamps, black-water, critically endangered

### INTRODUCTION

The air-breathing catfish genus *Encheloclarias* (Clariidae) was established by Herre & Myers (1937), for a single species, *E. tapeinopterus* (as *Heterobranchus tapeinopterus* in Bleeker, 1852). Catfishes of the genus *Encheloclarias* are characterised by their relatively small size (for a clariid, SL under 200 mm), smallish head, anguilliform body, long anal fin, short dorsal fin, and the presence of an adipose fin. Other clariid catfish with adipose fins includes species of *Heterobranchus* Geoffroy Saint-Hilaire, 1809, and *Dinotopterus* Boulenger, 1906, both genera endemic to the African continent. *Encheloclarias* is clearly distinguished from its African counterparts by the adipose fin being unsupported by elongated neural spines (Fig. 1) (Teugels, 1983; Ng & Lim, 1993; Ng & Tan, 2000; Ng, 2012a). Species of *Encheloclarias* are thought to be restricted to the highly acidic, peat swamp habitats of Southeast Asia, where they are often found deep within the thick peat substratum (Ng, 1996). *Encheloclarias* was assumed to be monotypic until Ng & Lim (1993) revised the genus and described four new species. Ng & Tan (2000) and Ng (2012a) subsequently described a new species from Central Sumatra and another from southern Borneo, respectively. Currently, seven

species are recognised in this genus, viz., *E. tapeinopterus* (Bleeker, 1852) [Banka Island, Indonesia]; *E. baculum* Ng & Lim, 1993 [Sambas, Kalimantan Barat, Indonesia; Sarawak, East Malaysia]; *E. curtisoma* Ng & Lim, 1993 [Selangor, Peninsular Malaysia], *E. kelioides* Ng & Lim, 1993 [Pahang and Johor, Peninsular Malaysia], *E. prolatus* Ng & Lim, 1993 [Kuching, Sarawak, East Malaysia]; *E. velatus* Ng & Tan, 2000 [Jambi, Sumatra and Bintan Island, Riau Archipelago, Indonesia]; and *E. medialis* Ng, 2012a [Mentaya drainage, Kalimantan Tengah, Indonesia]. Due to the cryptic habits and difficulty in collecting specimens of *Encheloclarias*, the distribution of this group of catfishes is still poorly known (Ng & Lim, 1993; Ng, 1996). There are only a few specimens of *Encheloclarias* within museums and institutions around the world, with some species only known from a single specimen.

Early accounts of freshwater fishes of Singapore are mainly from the works of Cantor (1849), Duncker (1904), Regan (1909), Tweedie (1936, 1940, 1950, 1952), Herre & Myers (1937), Herre (1937, 1940), Fowler (1938), and Fraser-Brunner (1940). These studies mainly listed new species or incidental records, and provided an incomplete picture of the Singapore freshwater fish fauna. It was not until 1966 that the first comprehensive survey and record of the freshwater fish fauna of Singapore was published by Eric R. Alfred (Alfred, 1966). Since then, surveys specifically targeting the freshwater fishes of Singapore have been carried out more or less continuously to the present day and the freshwater fish fauna of the island is now relatively well understood (Johnson, 1973; Tham, 1973; Yang, 1984; Lim, 1989, 1991, 1995; Ng & Lim, 1989, 1997a, b; Lim & Ng, 1990, 1991, 1992; Munro, 1990; Ng, 1991; Ng et al., 1993; Larson & Lim, 2005; Baker & Lim, 2008, 2012; Larson et al., 2008, 2016; Tan & Lim, 2008, 2011; Ng et al., 2009; Ng, 2010, 2012b; Ng & Tan, 2010; Ng & Tan, 2010; Tan

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Fig. 1. Top two; *Encheloclarias kelioides* - ZRC 63056, 77.8 mm SL, Singapore. Bottom two; *Heterobranchus longifilis* - ZRC 38289, 119.4 mm SL, Africa. Composite images of lateral views of preserved fish and X-ray images. Specimens not to scale (THH).

et al., 2010; Yeo & Chia, 2010; Yeo & Lim, 2010, 2011; Yeo et al., 2010; Lim & Tan, 2011, 2012; Liew et al., 2012, 2013, 2018; Lim & Kwik, 2012; Low & Lim, 2012; Lim et al., 2013, 2016; Ng et al., 2013; Ng & Tan, 2013; Tan et al., 2013; Kwik & Yeo, 2015; Ho et al., 2016; Li et al., 2016; Tan et al., 2020). Among the intact natural freshwater habitats remaining in Singapore, the most significant by far is Nee Soon Swamp Forest in the Central Catchment Nature Reserve (CCNR). This habitat represents the last remaining fragment of primary freshwater swamp forest in Singapore, covering an approximate area of just 5 km<sup>2</sup> (Ho et al., 2016; Li et al., 2016). Belying its relatively small size, Nee Soon Swamp Forest harbours more than half of the native freshwater fish species in Singapore, with some species being restricted only to this forest (Ho et al., 2016; Li et al., 2016; Tan et al., 2020).

Recently, several specimens of *Encheloclarias* were collected from three locations in the Nee Soon Swamp Forest, as part of ongoing ecological and monitoring studies. Despite extensive past sampling efforts to document species of

freshwater fishes, there have been hitherto no known records of *Encheloclarias* in Singapore (Alfred, 1966; Ng & Lim, 1990; Baker & Lim, 2008, 2012; Ho et al., 2016; Li et al., 2016; Tan et al., 2020). The morphology of the present Singapore specimens, in comparison with type specimens of known congeners, agrees well with *Encheloclarias kelioides* Ng & Lim, 1993. This paper documents the discovery of the genus in Singapore, with a redescription of *E. kelioides* and comments on its distribution and ecology.

## MATERIAL AND METHODS

Surveys in the present study were conducted at the upper reaches and feeder streams of the Nee Soon Swamp Forest drainage system (Nguyen et al., 2018). Water physicochemical parameters and flowrate were measured with a YSI Pro Plus Multiparameter Instrument (Xylem Analytics, Washington DC) and Flowwatch® flow meter (JDC Electronics, Switzerland), respectively. Three to five plastic minnow traps, placed five meters apart (diameter

160 mm, mesh size 2 mm), were used for trap sampling at the sites. Lead weights were used to ensure that the traps were submerged, with openings facing downstream. Traps were secured to bank vegetation with nylon cords. Pieces of chopped chicken sausage were placed in a tea strainer basket and left within the minnow traps as bait. The minnow traps were collected 24 hours later. Individuals captured were transported alive, back to the laboratory for documentation of live colouration. Specimens were subsequently euthanised (according to IACUC protocols), initially fixed in 10% formalin solution and then stored long term in 75% ethanol. Specimens were deposited in the Zoological Reference Collection (ZRC), Lee Kong Chian Natural History Museum (LKCNC), National University of Singapore.

The following abbreviations are used: HL, head length; TL, total length; SL, standard length. Measurements were made point-to-point using dial callipers and recorded to the nearest 0.1 mm. Counts and measurements were taken on the left side of the body, following Teugels (1986), Teugels et al. (1990), Ng & Lim (1993) and Ng (2012a). Paired-fin rays and gill rakers were counted under a dissecting microscope with transmitted light. Vertebrae and unpaired-fin rays were counted from radiographs. Photographs of living and dead specimens were obtained using a Nikon D800E or D850 digital single lens reflex (DSLR) camera, with AF-S Micro NIKKOR 105mm F2.8G ED lens.

## TAXONOMY

### INFRAClass TELEOSTEI

### ORDER SILURIFORMES

### FAMILY CLARIIDAE

#### Genus *Encheloclarias* Herre & Myers, 1937

#### *Encheloclarias kelioides* Ng & Lim, 1993

(Figs. 1–4)

*Encheloclarias kelioides* Ng & Lim, 1993: 30–31; Kottelat & Whitten, 1996: 4; Ng & Tan, 2000: 536; Ferraris, 2007: 149–150; Hārşan & Petrescu-Mag, 2008: 197 (list); Ng & Lim, 2008: 44–45; Chong et al., 2010: 2024, 2048; Chew & Zulkaffi, 2012: 283 (list); Sule et al., 2016: 429, 449, Table 3 (list); Ng et al., 2017: 15; Polgar & Jaafar, 2018: 137 (list); Vythalingam et al., 2022: 165 (list).

*Encheloclarias tapeinopterus* (non Bleeker) – Herre & Myers, 1937: 66 (Mawai, Johor); Hora & Gupta, 1941: 40 (key); Kottelat, 1989: 15 (list); Roberts, 1989: 128 (in part; no new record)

*Encheloclarias kelioides* (non Ng & Lim) – Tan & Tan, 1995: 355; Kottelat & Whitten, 1996: 4; Apriadi et al., 2018: 971–972.

**Material examined.** ZRC 29401, holotype, 64.8 mm SL; Peninsular Malaysia: Pahang, south of Pekan, blackwater stream across road, 69 km stone on road from Mersing to Pekan, near Kuantan; coll. M. Kottelat & P. K. L. Ng, 9 March 1992. --- ZRC 63056, 2 ex., 61.2–77.8 mm SL; Singapore: Central Catchment Nature Reserve, Nee Soon Swamp Forest; coll. E. X. P. Toh et al., 9 September 2022.

--- ZRC 63084, 3 ex., 68.6–92.0 mm SL; Singapore: Central Catchment Nature Reserve, Nee Soon Swamp Forest; coll. Cai Y. et al., 21 September 2022. --- ZRC 63406, 2 ex., 48.9–80.1 mm SL; Singapore: Central Catchment Nature Reserve, Nee Soon Swamp Forest; coll. Cai Y. et al., 23 November 2022. --- ZRC 63638, 4 ex., 78.2–102.4 mm SL; Singapore: Central Catchment Nature Reserve, Nee Soon Swamp Forest; coll. Cai Y. et al., 26 January 2023.

**Diagnosis.** Body (Figs. 2, 3) slender, moderately long, body depth 6–11% SL. Vertebrae 14–16 + 40–44 = 54–60 (n = 5). Anal fin and caudal fin fused only at base, completely disjunct beyond base. Head (Fig. 4) blunt, lateral edges with protuberance due to opercular muscles, proportionately short, about 15–17% SL. Pectoral fin spine with 4–8 distinct sharp serrae.

**Description.** Biometric data as in Table 1. Body moderately long, slender, cylindrical, gently tapering towards caudal peduncle. Dorsal profile rising gently from tip of snout to origin of dorsal fin, thereafter straight to end of caudal peduncle, except gently convex along base of adipose fin. Ventral profile of head slightly convex, thereafter almost horizontal to end of caudal peduncle. Skin smooth. Lateral line complete and midlateral in position. Vertebrae 14–16 + 40–44 = 54–60 (n = 5). Largest specimen examined is 102.4 mm SL (ZRC 63638).

Head gently depressed; predorsal profile slightly convex, ventral profile straight. Bony elements of dorsal surface of head covered with smooth, velvety skin; bones not readily visible. Front fontanelle longitudinally ovoid; located in interorbital region, with anterior tip reaching imaginary line connecting anterior orbital margins. Occipital fontanel ovoid, located at base of occipital process, slightly narrower than frontal fontanelle, posterior edge reaching imaginary line connecting bases of pectoral spines. Occipital process broad, with rounded tip. Eye ovoid, horizontal axis longest, subcutaneous, located dorsolaterally on head. Gill openings narrow, extending from dorsal-most point of pectoral-fin base to isthmus. Gill membranes free from each other, only united across isthmus, with 9 branchiostegal rays. First branchial arch with 7 gill rakers (from Ng & Lim, 1993).

Mouth subterminal, with fleshy, plicate lips. Premaxillary tooth band rectangular, length 35% HL, with villiform teeth. Vomerine tooth band subequal to premaxillary tooth band, length 32% HL, with subgranular teeth. Mandibular tooth band 51% HL, with villiform teeth (from Ng & Lim, 1993).

Barbels in four pairs; long, slender, with thick fleshy bases. Maxillary barbel typically longest and thickest at base, length 70.1–117.1% HL. Nasal barbel longer than mandibular and mental barbel, length 74.5–113.7% HL. Mental barbel origin close to midline, length 58.5–109.4% HL. Mandibular barbel originating posterolateral of mental barbel, longer than mental barbel, length 65.7–111.1% HL. Nostril tubes of anterior naris long, extending beyond edge of mouth when directed towards the front. Posterior naris just anterior to eye at base of nasal barbel, opening about eye diameter.

Table 1. Selected meristics and morphometrics for *Encheloclarias kelioides* (data for type material from Ng & Lim, 1993).

Catalogue number	ZRC 29401 holotype	CAS-SU 32004 paratype	ZRC 63056 (2), ZRC 63084 (3)
Location	Malaysia: Pahang, south of Pekan	Malaysia: Johor, Kota Tinggi	Singapore: CCNR
Standard Length (mm)	64.8	63.3	61.2–92.0
<b>MERISTICS</b>			
Dorsal-fin rays	25	25	23–26 (mode 25)
Anal-fin rays	51	53	47–52 (mode 47)
Pectoral-fin spine serrae	4	3	4– 8 (n = 5)
Gill raker	7	7	7 (n = 1)
Vertebral count	17 + 43 (total 60)	16 + 41 (total 57)	14–16 + 40–44 (total 54–60, mode 58)
<b>MORPHOMETRICS</b>			
<b>% Standard length</b>			
Head length	17	15	15–16
Head width	14	13	12–14
Occipital process to dorsal-fin origin	16	16	14–16
Body width	12	9	7–9
Body depth	11	7	6–9
Pre-dorsal fin length	31	28	28–31
Dorsal-fin length	32	31	30–32
Adipose-fin length	37	40	38–43
Pre-anal fin length	44	37	39–42
Anal-fin length	56	59	57–60
<b>% Head Length</b>			
Pre-dorsal fin length	190	189	184–202
Anal-fin length	365	400	359–402
Pre-anal fin length	262	270	254–276
Adipose-fin length	224	269	243–288
Nasal barbel length	110	-	75–114
Maxillary barbel length	163	-	70–117
Mandibular barbel length	128	-	66–111
Mental barbel length	108	-	59–109
<b>% Dorsal-fin length</b>			
Pre-dorsal fin length	100	105	87–100
Adipose-fin length	120	128	117–142
<b>% pre-anal fin length</b>			
Anal-fin length	152	158	136–153



Fig. 2. *Encheloclarias kelioides*, composite of dorsal, lateral and ventral views of freshly preserved fish - ZRC 63056, 77.8 mm SL, Singapore (THH).



Fig. 3. *Encheloclarias kelioides*, composite (laterally inverted) of dorsal, lateral and ventral views of freshly preserved fish - ZRC 63056, 61.2 mm SL, Singapore (THH).



Fig. 4. *Encheloclarias kelioides*, composite of dorsal, lateral and ventral close-up views of head - ZRC 63056, 77.8 mm SL, Singapore (THH).

Dorsal fin with moderately short base, spanning middle one-third of body; with 23–26 (mode 25) rays covered by thick layer of skin, without spine; pterygiophore insertion (origin) at vertebrae 9–10. Dorsal-fin margin approximately straight, parallel to dorsal edge of body. Adipose fin with gently convex dorsal margin; anterior point of origin contacting base of last dorsal-fin ray; gently curving posteriorly to fuse broadly with upper procurrent caudal fin rays. Anal-fin base long, with 47–52 (mode 47) rays, covered by thick layer of skin; margin straight, parallel to ventral edge of body, not confluent with caudal fin base. Anal-fin origin at vertical through tenth dorsal-fin ray, pterygiophore insertion at

vertebrae 16–17. Caudal fin long and rounded, with 19 principal rays, anterior-most lower procurrent caudal ray longer than last few anal-fin rays.

Pectoral fin broad, abruptly and sharply pointed at tip, with 1,8 rays. Anterior margin of spine smooth, posterior margin with 4–8 inward directed serrations ( $n = 6$ ). Pectoral-fin margin weakly convex anteriorly, gently convex posteriorly. Pelvic-fin origin at vertical through base of fifth dorsal-fin ray, pterygiophore insertion at vertebrae 13–14, with i,6 rays and convex margin; tip of fin reaching base of second anal-fin ray. Anus and urogenital openings located at vertical through middle of pelvic fin and anal-fin origin.

**Live colouration.** Dorsal surface of head, body and base of dorsal and caudal fin uniform brown, fading to a slightly paler colour on venter; adipose fin colouration similar to that of body, brown with hyaline margin; rays of all other fins dusky, with hyaline inter-radial membranes (Fig. 5). Barbels dirty white distally, fading to light brown proximally. Pectoral-fin spines very light brown dorsally, light grey ventrally (Fig. 5).

**Comparative notes.** Similar-sized specimens collected from Nee Soon Swamp Forest, Singapore, agree well in their characters with those of the holotype (ZRC 29401) and paratype (CAS-SU 32004) of *Encheloclarias kelioides* (Table 1). The specimens from Singapore are therefore regarded as conspecifics. The species can be distinguished from all other congeners by its habitus, fin morphology and vertebral count.

*Encheloclarias kelioides* can be immediately distinguished from *E. tapeinopterus* and *E. velatus* in the posteriormost part of the anal-fin and the ventral anteriormost part of the caudal-fin being fused only at the base, while remaining separated beyond the base (Figs. 3, 4) (vs. anal fin confluent with caudal fin along entire height of fins, cf. Ng & Lim, 1993: fig. 3; Ng & Tan, 2000: fig. 1); and from *E. curtisoma* by its proportionately longer, more shallow body: body depth 6–11% SL (Figs. 3, 4) (vs. proportionately shorter, stouter body: body depth 10.5–13.8% SL, cf. Ng & Lim, 1993: fig. 11). *Encheloclarias kelioides* can be distinguished from *E. prolatus* and *E. baculum* by its fewer vertebrae, and fewer dorsal and anal-fin rays (54–60, 23–26, 47–53, respectively, vs. 65–67, 26–29 and 54–65, respectively); and from *E. medialis* by the proportionately shorter head, 15–17% SL, with distinct lateral protuberance due to opercular muscle when viewed dorsally and ventrally (Figs. 2–4) (vs. relatively more rounded head shape without lateral protuberance when viewed dorsally, ventrally and proportionately longer head, 19.2% SL, cf. Ng, 2012a: fig. 3) and more numerous and distinct serrations on the posterior margin of the pectoral spine, 4–8 distinct sharp serrae (vs. 2 indistinct serrae on pectoral spine).

Within Singapore, *Encheloclarias kelioides* differs from all other clariid catfishes known, viz., *Clarias batrachus*, *C. leiakanthus*, *C. nieuhoftii* and *C. gariiepinus* (non-native), by its comparatively small adult size, SL up to 102.4 mm

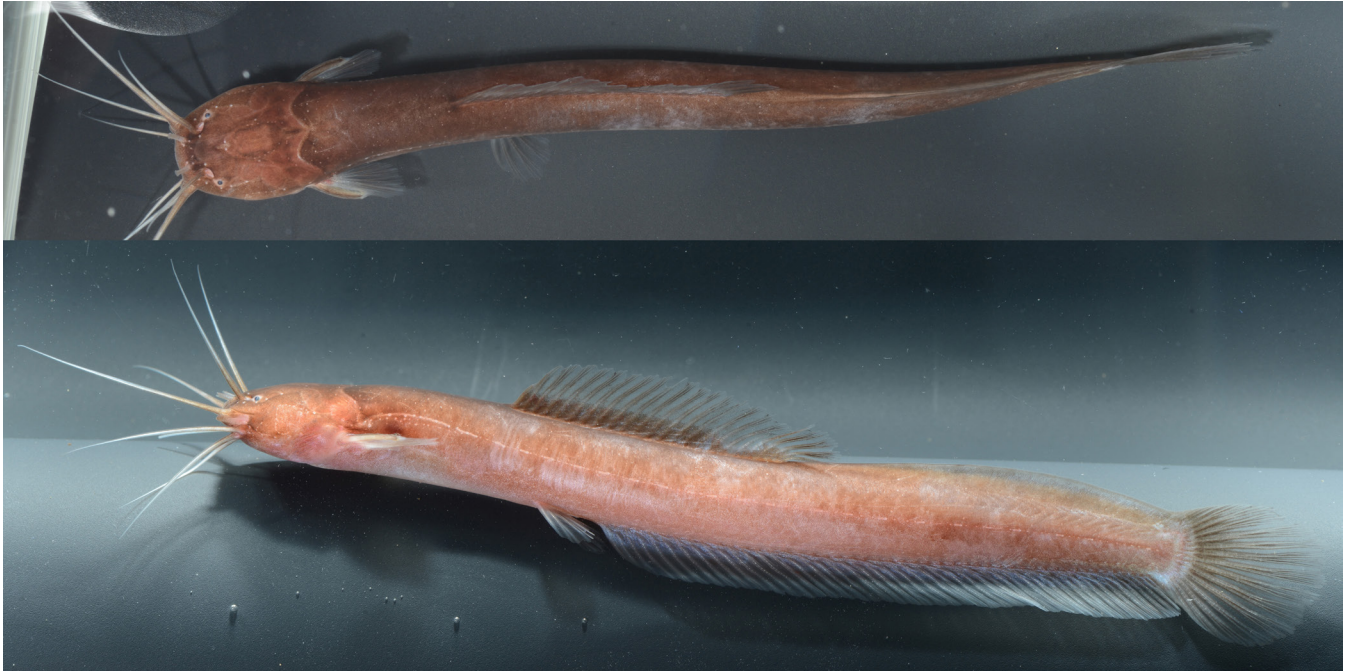


Fig. 5. *Encheloclarias kelioides*, composite of dorsal and lateral (laterally inverted) views of live fish - ZRC 63056, 77.8 mm SL, Singapore (THH).

recorded (vs. relatively larger size, SL up to 1700 mm for *C. gariepinus*); and short dorsal fin, which does not reach the caudal fin combined with the presence of a very low adipose fin (vs. long dorsal fin reaching caudal fin, and absence of adipose fin).

**Taxonomic significance.** *Encheloclarias kelioides* was originally described from two specimens (the holotype and a paratype: Ng & Lim, 1993), with no other specimens known to have been collected since. The two type specimens are similar in length, measuring 64.8 mm and 63.3 mm SL, respectively. The fresh specimens collected from Singapore in the present study range between 48.9–102.4 mm SL, providing new understanding with regard to the size and ontogenic variation of this species (e.g., the pectoral-fin spine serrae count). Irrespective of the size range, the meristic and morphometric data reported in the original description (Ng & Lim, 1993) still hold true, further supporting the validity of this species and its distinctiveness from other closely related and distributed species.

**Distribution.** Pahang, Johor, eastern Peninsular Malaysia and Nee Soon Swamp Forest, Singapore; and possibly central Sumatra (fide Ng & Tan, 2000).

## DISCUSSION

The present specimens were obtained from the Nee Soon Swamp Forest, which is the last significant fragment of freshwater swamp forest in Singapore. The fish were obtained during eight survey occasions conducted from September 2022 to January 2023 at three undisclosed locations, with a mean stream depth of 11 to 15 cm, and mean stream width of 110 to 200 cm. The substratum of the stream was largely



Fig. 6. View of stream where *Encheloclarias* was obtained from in Singapore, 6 September 2022 (THH).

characterised by mud and silt. No aquatic macrophytes were observed at the site of collection, but root mats of surrounding riparian plants and leaf litter were observed to cover a substantial extent of the stream (Fig. 6). Similar to previous accounts of aquatic habitats across the freshwater



Fig. 7. *Encheloclarias* cf. *kelioides*, composite (laterally inverted) of dorsal, lateral and ventral views of preserved fish - ZRC 44213, 147.9 mm SL, Sumatra (THH).

swamp forest, the stream water was characterised by relatively cool temperatures (25.36–25.78°C), low flow rates (0.55 ± 0.44 km/h), low dissolved oxygen (32.37–42.87%; 2.68–3.48 mg L<sup>-1</sup>), low conductivity (21.96–28.67 μS cm<sup>-1</sup>), low salinity (0.01 ppt), low total dissolved solids (0.0148 g L<sup>-1</sup>), low pH (pH 3.50–4.59) and clear but stained light brown (see Clews et al. 2018; Ho et al. 2018). This differs from descriptions of habitats *Encheloclarias* has been previously collected from, which were previously thought to be solely in the heavily tinted, acidic blackwaters of peat swamps (Ng & Lim, 1993; Ng, 1996). Collecting this cryptic and elusive species, however, was both difficult and fortuitous, with only baited traps left in the stream for 24 hours (as opposed to tray-net/kick-net sampling) being successful in capturing specimens. Syntopic fish species at the site of collection included *Silurichthys hasseltii* (Siluridae), *Betta pugnax* (Osphronemidae), and *Channa limbata* (Channidae); while other freshwater fauna recorded were *Macrobrachium malayanum* (Palaemonidae), *Parathelphusa maculata* (Gecarcinucidae), and the endemic *Irmengardia johnsoni* (Gecarcinucidae). Further downstream (ca. 20–100 m), additional syntopic fishes species encountered were: *Rasbora einthovenii* (Danionidae) and *Clarias leiacanthus* (Clariidae).

Prior to the present discovery, *Encheloclarias kelioides* had only been recorded at two localities in Peninsular Malaysia, with one specimen collected per locality; a blackwater stream south of Pekan, on the road towards Mersing, Pahang (type locality), and Sungei Sedili Besar area, Mawai, Johor, Malaysia. Both localities, however, have undergone extensive development since collection of the specimens in 1992 and

1934, respectively (see Gasim et al., 2007; Norhisyam et al., 2012). In particular, surveys conducted in Mawai in the 1990s did not obtain this species (Ng & Lim, 1993); and the IUCN has assessed *E. kelioides* in its Red List as “critically endangered (possibly extinct)” in the Peninsular Malaysia localities (Ahmad, 2019).

Tan & Tan (1995) reported a single specimen of *Encheloclarias* collected from Pulau Bintan, Indonesia, identified initially as *E. kelioides*. This material was later reidentified as *E. velatus* by Ng & Tan (2000), though without remark or discussion, and listed as non-type material. In the present study, we follow the identification provided by Ng & Tan (2000) for the Pulau Bintan population. Ng & Tan (2000) also obtained a series of clariid catfishes from a local market in Jambi, Central Sumatra. From these market specimens, they described *Encheloclarias velatus*, and identified one other specimen tentatively as *E. cf. kelioides* (ZRC 44213) (Fig. 7), hesitating to fully recognise it as *E. kelioides* due to its large size (147.9 mm SL) and difficulty in comparing it with the type material of *E. kelioides* due to the poor understanding of possible ontogenetic changes in morphology and/or morphometry. Even with the addition of the present series of specimens, we concur with their decision to identify the Sumatran specimen as *Encheloclarias* cf. *kelioides* until a larger series from Sumatra is available for verification.

The present discovery of *Encheloclarias kelioides* in Nee Soon Swamp Forest extends the distribution for the species southwards. Moreover, its distribution within Nee Soon Swamp Forest appears to be highly restricted; the species

has only been recorded at three localities at the upper reaches of the freshwater swamp forest drainage system despite additional sampling efforts at the lower reaches and other parts of the freshwater swamp forest. It remains possible, however, that this elusive and cryptic species is more widely distributed within Nee Soon Swamp Forest, and as such, more sampling efforts are required to ascertain its distribution. While the distribution of this species in Singapore is highly restricted, it is also well protected given that Nee Soon Swamp Forest lies within the Central Catchment Nature Reserve of Singapore, which is largely safeguarded from development and has limited public access (Ng & Lim, 1992). This legal protection could help assure the long-term survival of the species especially considering its possible extirpation/uncertain status in other, unprotected localities in Malaysia and Sumatra (for *E. cf. kelioides*), where peat swamp habitats have been largely converted to oil palm plantations (Gasim et al., 2007; Norhisyam et al., 2012; Miettinen et al., 2018; Ahmad, 2019). Given that species of the genus *Encheloclarias* are acid-water specialists, this discovery also highlights the significance of the Nee Soon Swamp Forest and the importance of conserving this habitat as a stronghold of uncommon and stenotopic freshwater fauna in Singapore (Ng & Lim, 1992; Cai et al., 2018; Clews et al., 2018;). In light of this new discovery, we recommend its IUCN Red List assessment status to be revised to Critically Endangered [B1ab (i,ii,iii,iv,v)] and consider its national conservation status in Singapore to be Critically Endangered.

**Comparative material.** *Encheloclarias curtisoma*: ZRC 14886, holotype, 79.4 mm SL; ZRC 14887–14888, 2 paratypes, 61.3–61.7 mm SL; Peninsular Malaysia: Selangor, north Selangor peat swamp forest, blackwater stream at 39 km milestone on road to Tanjung Malim from Sungei Besar; coll. P. K. L. Ng, T. Tan & K. K. P. Lim, 19 June 1991. ZRC 17356, 1 paratype, 45.1 mm SL; Peninsular Malaysia: Selangor, north Selangor peat swamp forest, blackwater stream at 50 km milestone on road to Tanjung Malim from Sungei Besar; coll. P. K. L. Ng, 14 September 1991. ZRC 29368–29369, 2 paratypes, 19.9–23.0 mm SL; Peninsular Malaysia: Selangor, north Selangor peat swamp forest, shallow blackwater stream, between 43 and 33 km milestone; coll. P. K. L. Ng & D. G. B. Chia, June 1992. ZRC 29367, 1 paratype, 57.9 mm SL; Peninsular Malaysia: Selangor, north Selangor peat swamp forest, blackwater stream at 39 km milestone on road to Tanjung Malim from Sungei Besar; coll. P. K. L. Ng et al., September 1992. ZRC 34553, 1, 33.4 mm SL; Peninsular Malaysia: Selangor, Sabak Bernam; coll. P. K. L. Ng, April 1993. ZRC 38259, 1, 121.6 mm SL; Peninsular Malaysia: Selangor, Sabak Bernam; coll. P. K. L. Ng, September 1993. ZRC 45671, 2, 109.6–124.9 mm SL; Peninsular Malaysia: Selangor, Sabak Bernam; Peninsular Malaysia: Selangor, Sabak Bernam; coll. P. K. L. Ng, 1993. *Encheloclarias baculum*: ZRC 39748, 1, 50.1 mm SL; Borneo: Sarawak, c. 200 m into peat swamp forest from left side of road towards Gedong, c. 11.0 km after turnoff towards Gedong from Serian-Sri Aman road (1°12'08.7" N 110°39'52.2" E); coll. H. H. Tan & S. H. Tan, 16 January 1996. ZRC 44215, 2, 105.5–109.7 mm SL; Borneo: Sarawak, Sibul, Sungai Kemayan; donated by D. Yong, 1998.

*Encheloclarias prolatus*: data from Ng & Lim (1993).  
*Encheloclarias tapeinopterus*: data from Ng & Lim (1993).  
*Encheloclarias velatus*: ZRC 44113, 3 paratypes, 142.0–169.2 mm SL; ZRC 49193, 1, 121.7 mm SL; Sumatra: Jambi, Angso Duo market; purchased by H. H. Tan et al., 26–27 October 1999. ZRC 32763, 1, 44.4 mm SL; Riau Archipelago: Pulau Bintan north, Tanjung Bintan, swamp forest; coll. P. K. L. Ng et al., 13 May 1993. Additional data from Ng & Tan (2000).  
*Encheloclarias cf. kelioides*: ZRC 44213, 1, 147.9 mm SL; Sumatra: Jambi, Angso Duo market; purchased by H. H. Tan et al., 26–27 October 1999.  
*Encheloclarias medialis*: data from Ng (2012a).

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## LITERATURE CITED

- Ahmad AB (2019) *Encheloclarias kelioides*. The IUCN Red List of Threatened Species: e.T7726A91227276. <https://dx.doi.org/10.2305/IUCN.UK.2019-3.RLTS.T7726A91227276.en>. Accessed 22 February 2023.
- Alfred ER (1966) The fresh-water fishes of Singapore. *Zoologische Verhandelingen*, 78: 3–67, 8 pls.
- Apriadi T, Pratama G, Putra RD, Jumsurizal J, Jaya YV, Firdaus M, Arpas HD, Suryanti A (2018) Comparative study on the fish diversity from natural and bauxite post-mining in wetland system of Bintan Island, Indonesia. *Biodiversitas Journal of Biological Diversity*, 19(3): 967–973.
- Baker N & Lim KKP (2008) *Wild Animals of Singapore: a photographic guide to mammals, reptiles, amphibians and freshwater fishes*. First Edition. Nature Society (Singapore), Singapore, 180 pp.
- Baker N & Lim KKP (2012) *Wild Animals of Singapore: a photographic guide to mammals, reptiles, amphibians and freshwater fishes*. Second Edition. Nature Society (Singapore), Singapore, 180 pp.
- Bleeker P (1852) Nieuwe bijdrage tot de kennis der ichthyologische fauna van het eiland Banka. *Natuurkundig Tijdschrift voor Nederlandsch Indië*, 3: 715–738.
- Boulenger GA (1906) Fourth contribution to the ichthyology of Lake Tanganyika. *Transactions of the Zoological Society of London*, 17(5): 537–600.
- Cai, Y, Davison GWH, Chan L & Liang SY (2018) Conservation outputs and recommendations for Nee Soon freshwater swamp forest, Singapore. *Gardens' Bulletin Singapore*, 70(Supplement 1): 191–217.

- Cantor T (1849) Catalogue of Malayan fishes. Journal of the Asiatic Society of Bengal, 18(2): 983–1426, pls. 1–14.
- Chew PC & Zulkaffli AR (2012) Sperm cryopreservation of some freshwater fish species in Malaysia. In: Katkov I (ed.) Current Frontiers in Cryopreservation. InTechOpen, London, pp. 269–292.
- Chong VC, Lee PKY & Lau CM (2010) Diversity, extinction risk and conservation of Malaysian fishes. Journal of Fish Biology, 76(9): 2009–2066.
- Clews E, Corlett RT, Ho JKI, Kim DE, Koh CY, Liong SY, Meier R, Memory A, Ramchunder SJ, Sin TM, Siow HJMP, Sun Y, Tan HH, Tan SY, Tan HTW, Theng MTY, Wasson RJ, Yeo DCJ & Ziegler AD (2018) The biological, ecological and conservation significance of freshwater swamp forest in Singapore. Gardens' Bulletin Singapore, 70(Supplement 1): 9–31.
- Duncker G (1904) Die fische de Malayische halbinsel. Mitteilungen aus dem Naturhistorischen Museum, Hamburg, 21: 133–207.
- Ferraris CJ (2007) Checklist of catfishes, recent and fossil (Osteichthyes: Siluriformes), and catalogue of siluriform primary types. Zootaxa, 1418: 1–628.
- Fowler HW (1938) A list of the fishes known from Malaya. Fisheries Bulletin of Singapore, 1: 1–268.
- Fraser-Brunner A (1940) XIV—On some species of the genus *Acanthopthalmus*, with description of a new species. Annals and Magazine of Natural History, Series 11, 6(32): 170–175.
- Gasim MB, Ismail BS, Toriman E, Mir SI & Chek TC (2007) A physico-chemical assessment of the Bebar River, Pahang, Malaysia. Global Journal of Environmental Research, 1(1): 7–11.
- Geoffroy Saint-Hilaire E (1809) Poissons du Nil, de la mer Rouge et de la Méditerranée. Description de l'Égypte. Muséum national d'Histoire naturelle, Paris, Volume 1 (Part 1), pp. 1–52.
- Hârşan R & Petrescu-Mag IV (2008) Endangered fish species of the world—a review. Aquaculture, Aquarium, Conservation & Legislation, 1(2): 193–216.
- Herre AWCT (1937) A contribution to the ichthyology of the Malay Peninsula. Part I. Marine fishes. Bulletin of the Raffles Museum, 13: 5–53.
- Herre AWCT (1940) Additions to the fish fauna of Malaya and notes on rare or little known Malayan and Bornean fishes. Bulletin of the Raffles Museum, 16: 27–61.
- Herre AWCT & Myers GS (1937) A contribution to the ichthyology of the Malay Peninsula. Part II. Fresh-water fishes. Bulletin of the Raffles Museum, 13: 53–74, pls. 5–7.
- Ho JKI, Quek RF, Ramchunder SJ, Memory A, Theng MTY, Yeo DCJ & Clews E (2018) Aquatic macroinvertebrate richness, abundance and distribution in the Nee Soon freshwater swamp forest, Singapore. Gardens' Bulletin Singapore, 70 (Supplement 1): 71–108.
- Ho JKI, Ramchunder SJ, Memory A, Theng M, Li T, Clews E, Cai Y, Tan HH & Yeo DCJ (2016) A Guide to the Freshwater Fauna of Nee Soon Swamp Forest. Tropical Marine Science Institute, National University of Singapore, Singapore, 139 pp.
- Hora SL & Gupta JC (1941) Notes on Malayan fishes in the collection of the Raffles Museum, Singapore. I. Catfishes of the families Siluridae, Bagridae, Amblycepidae, Akysidae, Sisoridae, Chacidae, Schilbeidae and Clariidae. Bulletin of the Raffles Museum, 17: 12–43, 2 pls.
- Johnson DS (1973) Freshwater life. In: Chuang SH (ed.) Animal Life and Nature in Singapore. Singapore University Press, Singapore, pp. 103–127.
- Kottelat M (1989) Zoogeography of the fishes from Indochinese inland waters with an annotated check-list. Bulletin Zoologisch Museum, 12(1): 1–55.
- Kottelat M & Whitten T (1996) Freshwater fishes of Western Indonesia and Sulawesi: additions and corrections. Hong Kong: Periplus editions, 8 pp.
- Kwik JTB & Yeo DCJ (2015) Difference in fish assemblages in protected and non-protected freshwater streams in a tropical urbanized country. Hydrobiologia, 762: 143–156.
- Larson HK & Lim KKP (2005) A guide to gobies of Singapore. Singapore Science Centre, Singapore, 164 pp.
- Larson HK, Jaafar Z & Lim KKP (2008) An annotated checklist of the gobioid fishes of Singapore. Raffles Bulletin of Zoology, 56(1): 135–155.
- Larson HK, Jaafar Z & Lim KKP (2016) An updated checklist of the gobioid fishes of Singapore. Raffles Bulletin of Zoology, Supplement 34: 744–757.
- Li T, Chay CK, Lim WH & Cai Y (2016) The fish fauna of Nee Soon swamp forest, Singapore. Raffles Bulletin of Zoology, Supplement 32: 56–84.
- Liew JH, Giam X, Clews E, Tan KYW, Tan HH, Kho ZY & Yeo DCJ (2018) Contrasting changes in freshwater fish assemblages and food webs follow modification of tropical waterways. Ecology of Freshwater Fish, 27(4): 1114–1125.
- Liew JH, Tan HH & Yeo DCJ (2012) Some cichlid fishes recorded in Singapore. Nature in Singapore, 5: 229–236.
- Liew JH, Tan HH, Yi Y & Yeo DCJ (2013) [issued 2014] Ecology and origin of the introduced cichlid *Acarichthys heckelii* in Singapore's fresh waters – first instance of establishment. Environmental Biology of Fish, 97: 1109–1118.
- Lim KKP (1989) Recent reports: reptiles, amphibians & freshwater fish (Singapore). The Pangolin, Malayan Nature Society (Singapore Branch), 2(4): 63–68.
- Lim KKP (1991) Records for the second quarter, 1991: freshwater fishes. The Pangolin, Malayan Nature Society (Singapore Branch), 4(2): 8–10.
- Lim KKP (1995) Fishes. In: Chung CS, Corlett RT, Wee YC & Geh SY (eds.) Rainforest in the city: Bukit Timah Nature Reserve, Singapore. Gardens' Bulletin Singapore, Supplement 3: 159–163.
- Lim KKP & Kwik JTB (2012) New record of the Chinese cyprinid fish *Toxobramis houdemeri* in Singapore. Nature in Singapore, 5: 271–273.
- Lim KKP & Ng PKL (1990) A guide to the freshwater fishes of Singapore. Singapore Science Centre, Singapore, 160 pp.
- Lim KKP & Ng PKL (1991) Records for the third quarter, 1991: freshwater fishes. The Pangolin, Malayan Nature Society (Singapore Branch), 4(3): 5–8.
- Lim KKP & Ng PKL (1992) [issued 1993] Current records: fishes. The Pangolin, The Nature Society (Singapore), 5(1–4): 11–15.
- Lim KKP & Tan HH (2011) Addition of three cyprinid fishes to the alien fauna of Singapore. Nature in Singapore, 4: 377–382.
- Lim KKP & Tan HH (2012) Additions of fish species to the established alien fauna of Singapore: *Amblypharyngodon chulabhornae* and *Brachyogobius sabanus*. Nature in Singapore, 5: 69–72.
- Lim KKP, Baker N & Yeo SH (2013) Fishes of Kranji Marsh. Singapore Biodiversity Records, 2013: 60–61.
- Lim KKP, Chua MAH & Lim NT-L (2016) Freshwater fishes, terrestrial herpetofauna and mammals of Pulau Tekong, Singapore. Nature in Singapore, 9: 165–198.
- Low BW & Lim KKP (2012) Gouramies of the genus *Trichopodus* in Singapore (Actinopterygii: Perciformes: Osphronemidae). Nature in Singapore, 5: 83–93.
- Miettinen J, Liew SC & Kwok LK (2018) Decline of Sumatran peat swamp forests since 1990. In: 34th International Symposium on Remote Sensing of Environment — The GEOSS Era: Towards Operational Environmental Monitoring. Sydney, Australia, 4 pp.
- Munro AD (1990) Singapore freshwater fishes. In: Chou LM & Ng PKL (eds.) Essays in Zoology. Department of Zoology, National University of Singapore, Singapore, pp. 97–125.
- Ng C, Ooi P, Wong WL & Khoo G (2017). An overview of the status, trends and challenges of freshwater fish research and conservation in Malaysia. Survey in Fisheries Sciences, 3(2): 7–21.

- Ng HH (2010) The zebra spiny eel (*Macrogathus zebrinus*) – a non-native species in Singapore (Synbranchiformes: Mastacembelidae). *COSMOS*, 6(1): 91–93.
- Ng HH (2012a) *Encheloclarias medialis*, a new catfish from southern Borneo (Teleostei: Clariidae). *Ichthyological Exploration of Freshwaters*, 23(2): 111–116.
- Ng HH (2012b) The status of the catfish *Mystus wolffii* Bleeker, 1851 (Actinopterygii: Siluriformes: Bagridae) in Singapore, with notes on its taxonomy. *Nature in Singapore*, 5: 73–77.
- Ng HH & Lim KKP (2008) Catalogue of the Siluriform (Teleostei, Ostariophysi) Types in the Raffles Museum of Biodiversity Research, National University of Singapore. Raffles Museum of Biodiversity Research, National University of Singapore, 74 pp.
- Ng HH & Tan HH (2000) A new species of *Encheloclarias* from Sumatra. *Journal of Fish Biology*, 57: 536–539.
- Ng HH & Tan HH (2010) An annotated checklist of the non-native freshwater fish species in the reservoirs of Singapore. *COSMOS*, 6(1): 95–116.
- Ng HH, Low BW, Kwik JTB & Yeo DCJ (2013) [issued 2014] The tables are turned: an invasive species under potential threat. *Biological Invasions*, 16: 1567–1571.
- Ng HH, Tan HH, Yeo DCJ & Ng PKL (2009) [issued 2010] Stingers in a strange land: South American freshwater stingrays (Potamotrygonidae) in Singapore. *Biological Invasions*, 12(8): 2385–2388.
- Ng PKL (1996) The rediscovery of the rare bladefin catfish, *Encheloclarias*. *Nature Malaysiana*, 21: 52–58.
- Ng PKL (ed.) (1991) *Freshwater life in Singapore*. Singapore Science Centre, Singapore, 162 pp.
- Ng PKL & Lim KKP (1989) A preliminary report of a South American loricariid catfish, *Pterygoplichthys* sp., in Singapore freshwaters. *The Pangolin, Malayan Nature Society (Singapore Branch)*, 2(4): 69–71.
- Ng PKL & Lim KKP (1992) The conservation status of the Nee Soon freshwater swamp forest of Singapore. *Aquatic Conservation: Marine and Freshwater Ecosystems*, 2(3): 255–266.
- Ng PKL & Lim KKP (1993) The Southeast Asian catfish genus *Encheloclarias* (Teleostei: Clariidae), with descriptions of four new species. *Ichthyological Exploration of Freshwaters* 4: 21–37.
- Ng PKL & Lim KKP (1997a) The freshwater fishes of Singapore. *Journal of the Singapore National Academy of Science*, 22–24: 109–124.
- Ng PKL & Lim KKP (1997b) The diversity and conservation status of fishes in the Nature Reserves of Singapore. *Gardens' Bulletin Singapore*, 49(2): 245–265.
- Ng PKL, Chou LM & Lam TJ (1993) The status and impact of introduced freshwater animals in Singapore. *Biological Conservation*, 64: 19–24.
- Ng PX & Tan HH (2013) Fish diversity before and after construction of the Punggol and Serangoon Reservoirs, Singapore. *Nature in Singapore*, 6: 19–24.
- Ng TH & Tan HH (2010) The introduction, origin and life history attributes of the non-native cichlid, *Etroplus suratensis* (Bloch, 1790) in the coastal waters of Singapore. *Journal of Fish Biology*, 76: 2238–2260.
- Nguyen CTT, Wasson RJ & Zeigler AD (2018) The hydro-geomorphic status of Nee Soon freshwater swamp forest catchment of Singapore. *Gardens' Bulletin Singapore*, 70(Supplement 1): 33–48.
- Norhisyam MS, Roshani O, Zuhairi AN, Akmal SN, Syahril MM, Hawa SA, Wahidah MN & Harmin SA (2012) Water quality, diversity and distribution of blackwater fishes in selected locations of Raja Musa Peat Swamp Forest Reserve. In: *Malaysian Sciences and Technology Congress 2012, Malaysia*, pp. 1–10.
- Polgar G & Jaafar Z (2018) *Endangered Forested Wetlands of Sundaland*. Springer, Berlin, pp. 89–93.
- Regan CT (1909) The Asiatic fishes of the family Anabantidae. *Proceedings of the Zoological Society of London*, 79(4): 767–787, pls. 77–79.
- Roberts TR (1989) The freshwater fishes of western Borneo (Kalimantan Barat, Indonesia). *Memoirs of the California Academy of Sciences*, 14: 1–210.
- Sule HA, Ismail A & Amal MNA (2016) A review of the ichthyofauna of Malaysian peat swamp forest. *Pertanika Journal of Tropical Agricultural Science*, 39(4): 421–458.
- Tan HH & Lim KKP (2008) *Acarichthys heckelii* (Müller & Troschel), an introduced cichlid fish in Singapore. *Nature in Singapore*, 1: 129–133.
- Tan HH & Lim KKP (2011) Rediscovery of the bigmouth stream goby, *Pseudogobiopsis oligactis* (Actinopterygii: Gobiiformes: Gobiinellidae) in Singapore. *Nature in Singapore*, 4: 363–367.
- Tan HH, Low MEY & Lim KKP (2010) Fishes of the Marina basin, Singapore, before the erection of the Marina Barrage. *Raffles Bulletin of Zoology*, 58(1): 137–144.
- Tan HH, Lim KKP, Liew JH, Low BW, Lim RHB, Kwik JTB & Yeo DCJ (2020) The non-native freshwater fishes of Singapore: an annotated compilation. *Raffles Bulletin of Zoology*, 68: 150–195.
- Tan JYH, Tan LHC, Quek G, Lim VSF & Tan HH (2013) The fish fauna of Bukit Brown, Singapore. *Nature in Singapore*, 6: 229–237.
- Tan SH & Tan HH (1995) The freshwater fishes of Pulau Bintan, Riau archipelago, Sumatera, Indonesia. *Tropical Biodiversity* 2(3): 351–367.
- Teugels GG (1983) La structure de la nageoire adipeuse dans les genres *Dinotopterus*, *Heterobranchus* et *Clarias* (Pisces: Siluriformes: Clariidae). *Cybiurn*, 7: 11–14.
- Teugels GG (1986) A systematic revision of the African species of the genus *Clarias* (Pisces: Clariidae). *Annales-Musee Royal de l'Afrique Centrale*, 247: 1–199.
- Teugels GG, Denayer B & Legendre M (1990) A systematic revision of the African catfish genus *Heterobranchus* Geoffroy-Saint-Hilaire, 1809 (Pisces: Clariidae). *Zoological Journal of the Linnean Society*, 98: 237–257.
- Tham AK (1973) Fish and prawn ponds. In: *Chuang SH (ed.) Animal Life and Nature in Singapore*. Singapore University Press, Singapore, pp. 260–268.
- Tweedie MWF (1936) A list of the fishes in the collection of the Raffles Museum. *Bulletin of the Raffles Museum*, 12: 16–28.
- Tweedie MWF (1940) Additions to the collection of fishes in the collection of the Raffles Museum. *Bulletin of the Raffles Museum*, 27: 93–146, pls. 13–26.
- Tweedie MWF (1950) Notes on Malayan freshwater fishes. *Bulletin of the Raffles Museum*, 21: 97–105.
- Tweedie MWF (1952) Notes on Malayan fresh-water fishes. No. 3–5. *Bulletin of the Raffles Museum*, 24: 63–95, figs. 1–4.
- Vythalingam LM, Raghavan R, Hossain M & Bhassu S (2022) Predicting aquatic invasions in a megadiverse region: Maximum entropy based modelling of six alien fish species in Malaysia. *Aquatic Conservation: Marine and Freshwater Ecosystems*, 32(1): 157–170.
- Yang SL (1984) Fishes in our reservoirs. In: *PUB Digest 97/5/84*. Public Utilities Board, Singapore, pp. 10–17.
- Yeo DCJ & Chia CSW (2010) Introduced species in Singapore: an overview. *COSMOS*, 6: 23–37.
- Yeo DCJ & Lim KKP (2010) *Aplocheilus lineatus*, a non-native killifish (Actinopterygii: Cyprinodontiformes: Aplocheilidae) in Singapore. *Nature in Singapore*, 3: 327–332.
- Yeo DCJ & Lim KKP (2011) Freshwater ecosystems. In: *Ng PKL, Corlett RT & Tan HTW (eds.) Singapore Biodiversity: An Encyclopedia of the Natural Environment and Sustainable Development*. Editions Didier Millet, Singapore, pp. 52–63.
- Yeo DCJ, Wang LK & Lim KKP (2010) *Private Lives. An Exposé of Singapore's Freshwaters*. The Raffles Museum of Biodiversity Research, National University of Singapore, Singapore, 258 pp.