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THE ARIID CATFISHES OF SINGAPORE

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***ABSTRACT.* —** This study verifies the presence of nine ariid catfish species from Singapore waters based on museum material. They are *Arius* cf. *gagora*, *Arius leptonotacanthus*, *Arius oetik*, *Hemiarius sona*, *Hexanematichthys sagor*, *Netuma bilineata*, *Osteogeneiosus militaris*, *Plicofollis argyropleuron*, and *Plicofollis nella*. *Arius* cf. *gagora* and *Netuma bilineata* are new records for Singapore, while *Hemiarius sona* is recorded for the first time in Singapore in more than a century. The occurrence of *Cryptarius truncatus* in Singapore waters is considered doubtful.

KEY WORDS. — Ariidae, Singapore, new records

INTRODUCTION

The Ariidae is one of two siluriform families with a strong representation in marine environments. Consisting of about 150 species in 29 genera (Betancur-R., 2009), this cosmopolitan group of marine fishes is predominantly restricted to the continental shelves of warm-temperate to tropical regions worldwide, although about 43 species are restricted to freshwater habitats (Betancur-R., 2010).

The monophyly of the Ariidae is strongly supported by morphological and molecular evidence (Diogo, 2005; Sullivan et al., 2006; Acero & Betancur-R., 2007), but there remains little consensus on the phylogenetic relationships at the intra-familial level, save for strong molecular and morphological evidence to support a basal dichotomy of the family into the subfamilies Ariinae and Galeichthyinae (Acero & Betancur-R., 2007). Studies attempting to elucidate the phylogenetic relationships within the Ariidae have been limited by geographical scope (Kailola, 2004; Betancur-R. et al., 2007), and a study that comprehensively samples global ariid diversity is still lacking. There have been two attempts (Kailola, 2004; Marceniuk & Menezes, 2007 and Marceniuk et al., 2012) to reclassify the Indo-Pacific species formerly assigned to *Arius* which is generally acknowledged to be a polyphyletic assemblage. Owing to the highly incongruent tree topologies on which the two classification schemes are based, the generic assignments of a number of Indo-Pacific ariids differ greatly in the taxonomy proposed. The taxonomy of Kailola (2004) is followed here primarily because it is more widely used in current literature on Indo-Pacific fishes, but the generic assignments for many of the species treated herein should be considered tentative.

Twelve species of ariid catfishes had been recorded from Singapore (Weber & de Beaufort, 1913; Fowler, 1938). These are *Arius venosus*, *Hemiarius sona*, *Hexanematichthys sagor*, *Ketengus typus*, *Nemapteryx macronotacantha*, *Nemapteryx nenga*, *Netuma thalassina*, *Osteogeneiosus militaris*, *Plicofollis argyropleuron*, *Plicofollis crossocheilos*, *Plicofollis nella*, and *Plicofollis polystaphylodon*. Many of these records were most likely based on specimens purchased in markets (each of whose true origin remains unknown), and the true diversity of ariid catfishes in Singapore waters remains uncertain.

There is a need to reappraise the status of ariid catfishes found in Singapore waters based on verified records (e.g., museum specimens with precise locality data). Such a study was conducted as part of the Comprehensive Marine Biodiversity Survey of Singapore, and its result is presented here as an annotated checklist.

MATERIAL AND METHODS

The present checklist is compiled from the examination of museum specimens from the Zoological Reference Collection (ZRC) of the Raffles Museum of Biodiversity Research (RMBR) at the National University of Singapore, and the California Academy of Sciences in San Francisco, USA (CAS). Institutional abbreviations follow Ferraris (2007). Unless stated otherwise, all material examined was collected from Singapore. Standard length (SL) is measured from the tip of the snout to the base of the caudal fin. Also included are authenticated sighting reports for the last decade (2003–2012) of specimens captured by anglers. These were obtained by searching the local internet fishing

forums and blogs, identifying fishes from photographs, as well as verifying the sites of capture whenever possible. Nomenclature and classification of the fishes follow Kailola (1999, 2004).

ANNOTATED CHECKLIST

Arius cf. ***gagora*** (Hamilton), Gagora sea catfish
Fig. 1

Material examined. — ZRC 53352, 9: 169.6–268.2 mm SL, Punggol Marina; ZRC 52389, 3: 238.7–248.2 mm SL, Pulau Ubin: Tanjong Tajam; ZRC 53332, 1: 156.1 mm SL, Pulau Tekong: south reclamation zone; ZRC 53351, 11: 159.0–238.3 mm SL, north of Merlin Rock off southeastern Pulau Tekong.

Distribution. — Eastern Straits of Johor (Fig. 2)

Fig. 1. *Arius* cf. *gagora*, ZRC 53351, 170.5 mm SL; Singapore: Pulau Tekong.

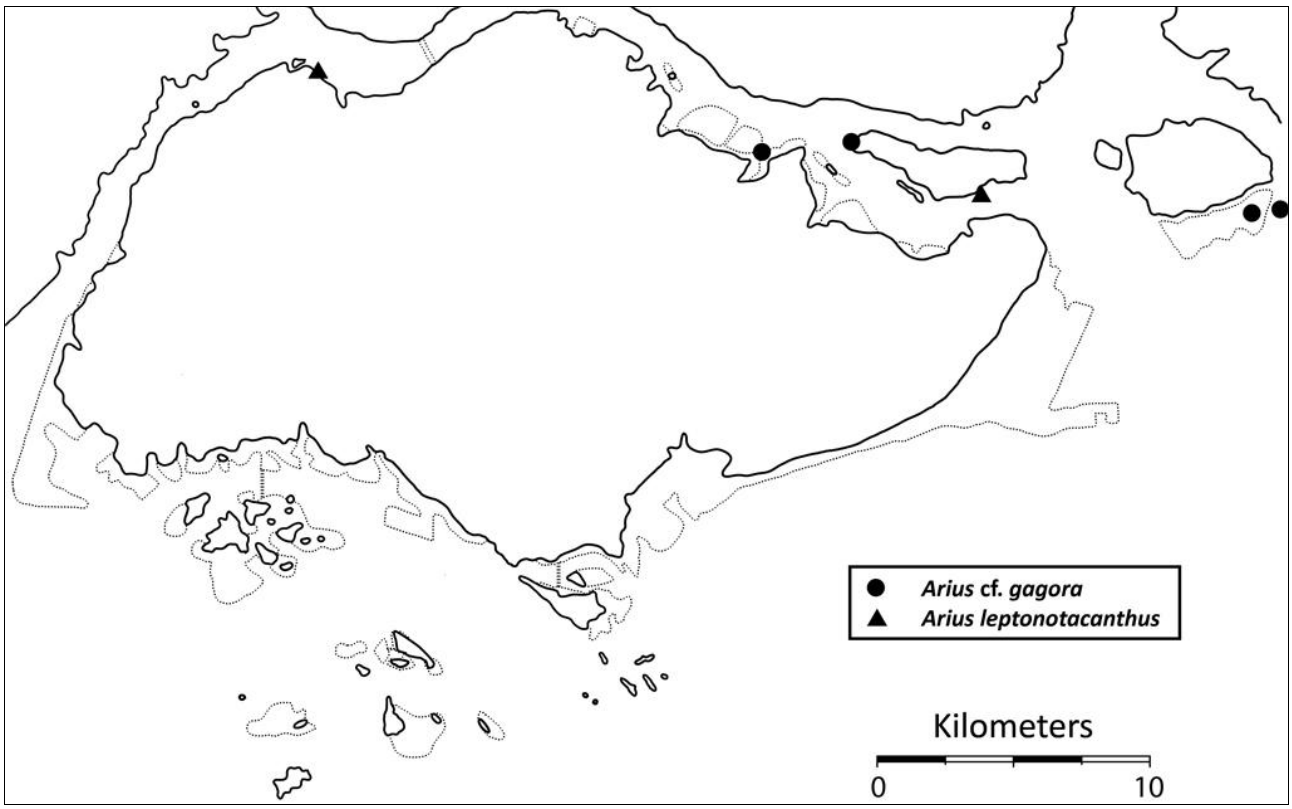

Fig. 2. Localities where *Arius* cf. *gagora* and *Arius leptonotacanthus* have been encountered. The solid outline of Singapore indicates original coastline, the dotted lines indicate reclaimed coastline circa 2010.

Remarks. — This species is distinguished from other Singapore ariids in having a combination of a broad snout, granular, palatal teeth in two ovoid patches on each side of the mouth arranged almost parallel to each other (Fig. 3), and its unusual barbel morphology. The barbels are extremely flattened, with extensions of skin along both lateral margins, particularly in the mandibular pairs (Fig. 4).

This species is tentatively identified as *Arius* cf. *gagora* on the basis of its dentition (Fig. 3) and overall similarity in shape to the illustration in the original description of *Arius gagora* (see Hamilton, 1822: pl. 10 Fig. 54). However, there is a need to confirm the identity of this species, which is here considered tentative pending comparison with Indian populations of *Arius gagora*.

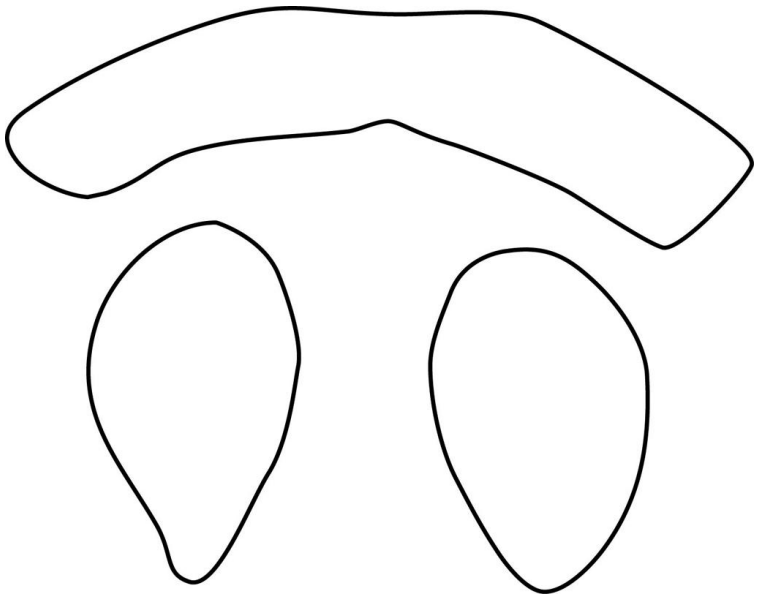

Fig. 3. Schematic illustration of upper jaw tooth patches of *Arius* cf. *gagora* (based on ZRC 53351, 216.8 mm SL).

Fig. 4. Ventral view of head of *Arius* cf. *gagora*, ZRC 53351, 159.0 mm SL, highlighting barbel morphology.

Arius leptonotacanthus Bleeker, smooth-spined sea catfish
Fig. 5

Material examined. — ZRC 5889, 1: 74.0 mm SL, Singapore; ZRC 31871, 1: 147.2 mm SL, Sungei Buloh; ZRC 51225, 3: 182.0–189.0 mm SL; ZRC 30560, 1: 174.9 mm SL, southern Pulau Ubin.

Distribution. — Straits of Johor (Fig. 2)

Remarks. — *Arius leptonotacanthus* is distinguished from other Singapore ariids in having a combination of a moderately prominent lateral ethmoid, short, supraoccipital process with a high keel, and palatal teeth in two elliptical or pear-shaped patches on each side of the mouth, with their long axes parallel or diverging posteriorly.

Fig. 5. *Arius leptonotacanthus*, ZRC 51225, 186.1 mm SL; Singapore: Pulau Ubin.

Arius oetik Bleeker, lowly sea catfish
Fig. 6

Material examined. — ZRC 30382, 1: 144.1 mm SL, prawn ponds in Sungei Buloh; ZRC 31872–31873, 2: 128.6–147.5 mm SL; ZRC 31911, 1: 143.6 mm SL, Sungei Buloh; ZRC 49725, 1: 204.1 mm SL, kelong E5 off the mouth of Sungei Simpang (1°27′19.00″N, 103°51′26.80″E); ZRC 53343, 3: 153.6–173.8 mm SL, vicinity of Pulau Seletar; ZRC 49702, 2: 200.6–210.0 mm SL, off the mouth of Sungei Seletar; ZRC 39679, 1: 196.2 mm SL, Sungei Punggol; ZRC 49675, 1: 192.0 mm SL, Straits of Johor off mouth of Sungei Punggol near Pulau Punggol Timor (1°25′19.6″N, 103°54′3.9″E); ZRC 3227, 1: 105.3 mm SL, Singapore; ZRC 30502–30503, 2: 104.8–122.1 mm SL, Punggol; ZRC 53342, 2: 126.7–184.8 mm SL, kelong E26 off Pulau Serangoon (1°25′10.2″N, 103°55′6.3″E); ZRC 53344, 2: 130.9–146.3 mm SL, kelong E63 off western tip of Pulau Ubin (1°25′39.1″N, 103°55′45.6″E); ZRC 53345, 1: 195.4 mm SL, Sungei Serangoon; ZRC 30556–30559, 4: 168.5–250.1 mm SL, southern Pulau Ubin; ZRC 40301, 2: 116.0–150.2 mm SL, Straits of Johor south of Pulau Tekong Besar at Malang Tiga.

Distribution. — Straits of Johor (Fig. 7)

Fig. 6. *Arius oetik*, ZRC 30556, 168.5 mm SL; Singapore: Pulau Ubin.

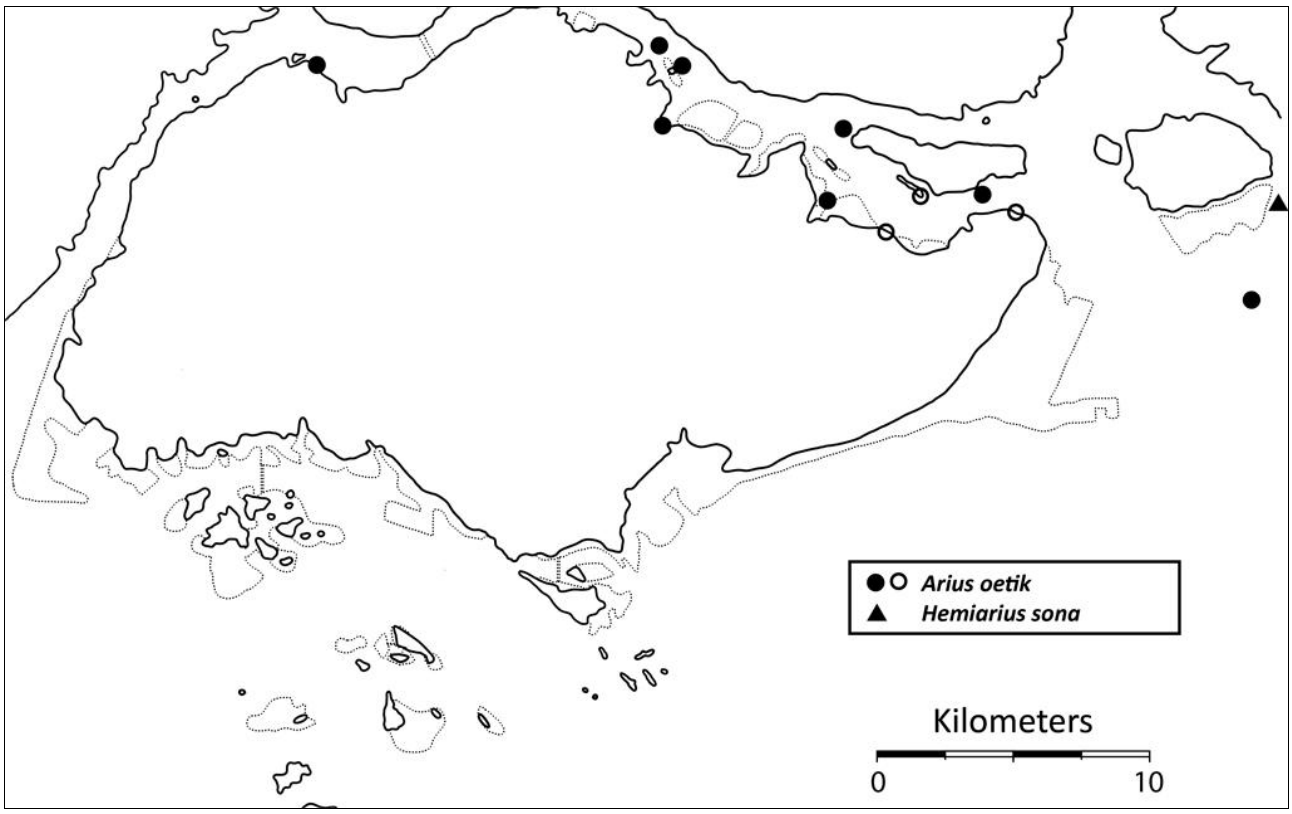

Fig. 7. Localities where *Arius oetik* and *Hemiarius sona* have been encountered. Open symbols indicate records from authenticated sightings (based on angling records), while closed symbols indicate records from specimens. The solid outline of Singapore indicates original coastline, while the dotted lines indicate reclaimed coastline circa 2010.

Remarks. — This species is distinguished from other Singapore ariids in having a combination of a strongly keeled, supraoccipital process, filament extending from the tip of the first soft ray of the dorsal fin, and palatal teeth in two triangular patches on each side of the mouth. *Arius oetik* has often been misidentified as *Arius venosus* in literature on Singapore fishes (e.g., Lim & Low, 1998). The identity of the material often identified as *Arius venosus* (e.g., fide Kailola, 1999) is itself problematic. This issue is being addressed in a separate study. *Arius oetik* differs from *Arius venosus* sensu Kailola (1999) in having (vs. lacking) a filamentous extension from the first soft ray of the dorsal fin.

Cryptarius truncatus (Valenciennes), spoon-snouted sea catfish
Fig. 8

Material examined. — CAS-SU 14174, 1: 313 mm SL, Singapore. Additional (non-Singapore) material examined: ZRC 39793, 3: 159.2–231.5 mm SL, Malaysia: Perak, Matang, Sungai Selinsing.

Distribution. — Collection locality of only specimen known from Singapore is likely to be in error (see below)

Remarks. — This species differs from other Singapore ariids in having a combination of a long, narrow head (head length 1.8–1.9 times in its width vs. 1.7 or less) with the latero-sensory canals arranged in a vein-like network on its sides, 8–9 rakers (vs. 10 or more) in the first gill arch, and palatal teeth in one small, oval patch on each side of the mouth that is widely separated from each other.

Given that *Cryptarius truncatus* has only been found in large rivers and their associated estuaries (it has been known to ascend a considerable distance upriver) and that Singapore has no rivers of significant length or width (the Kallang River, being the longest, is only 10 km), it is unlikely that suitable habitats for this species exist in Singapore. It is more likely that the only specimen recorded as coming from Singapore could have been caught outside the territory (the nearest known locality being the Muar River, about 150 km northwest of Singapore) and brought to a market in Singapore where it could have been purchased. Since ongoing ichthyological surveys have failed to record this species from Singapore, it seems unlikely that *Cryptarius truncatus* occurs in Singapore.

Fig. 8. *Cryptarius truncatus*, ZRC 39793, 159.2 mm SL; Malaysia: Perak, Matang.

Hemiarius sona (Hamilton), Sona sea catfish
Fig. 9

Material examined. — ZRC 50386, 3: 273.4–298.7 mm SL, Pulau Tekong near Merlin Rock (1°23′N, 104°5′E); ZRC 50390, 1: 539 mm SL, Pulau Tekong ca. 1 km N of Merlin Rock (1°23′N, 104°5′E).

Distribution. — Known only from the channel (Calder Harbour) off southeastern Pulau Tekong (Fig. 7)

Remarks. — This species was first recorded from Singapore (as *Arius gagorides*) by Duncker (1904). It has not been reported from there since and this is the first record in a century.

Hemiarius sona differs from all other Singapore ariids in having a sharply pointed (vs. gently rounded) snout, and the premaxillary tooth band partially exposed (vs. not exposed) when the mouth is closed. It is additionally distinguished in having a combination of strong, radiating granules on the head shield, and two patches of teeth on each side of the palate, with the outer triangular patch very much larger than the rounded inner patch. This species is golden yellow in life (H. H. Tan, pers. comm.).

Although Kailola (2004) assigned this species to *Hemiarius*, Marceniuk & Menezes (2007) placed this species within the genus *Sciades*. However, molecular data do not support either of these assignments (Betancur-R., 2009). As indicated previously, the classification of Kailola (2004) is followed here but assignment of this species to *Hemiarius* is tentative.

Fig. 9. *Hemiarius sona*, ZRC 50386, 273.4 mm SL; Singapore: Pulau Tekong.

Hexanematichthys sagor (Hamilton); Sagor sea catfish, belukang
Fig. 10

Material examined. — ZRC 53349, 1: 215.1 mm SL, vicinity of Pulau Seletar; ZRC 53340, 5: 131.3–150.4 mm SL, kelong E13 off Pulau Seletar (1°26′28.2″N, 103°52′12.7″E); ZRC 53348, 1: 183.8 mm SL, Seletar Wet Gap (1°24′53.56″N, 103°52′50.53″E); ZRC 51146, 2: 455–462 mm SL; ZRC 53341, 2: 75.1–76.8 mm SL; ZRC 53347, 1: 117.6 mm SL; ZRC 53341, 2: 71.2–104.3 mm SL, Sungei Serangoon; ZRC 46573, 1: 162.8 mm SL, Pulau Ubin at Sungei Besar; CAS-SU 32705, 1: 108.5 mm SL, Siglap.

Fig. 10. *Hexanematichthys sagor*, ZRC 53340, 131.3 mm SL; Singapore: off Pulau Seletar.

Distribution. — Eastern Straits of Johor and the Straits of Singapore (East Coast Park, Siglap, Tanah Merah; Fig. 11). This species is also found in canals draining to the sea, in areas under tidal influence (which explains the inland records indicated in Fig. 11).

Remarks. — This appears to be the most common ariid species in Singapore, being especially common in coastal and estuarine habitats with a muddy substrate. It is easily distinguished from other Singapore ariids in having a combination of a broadly rounded, almost hemispherical (vs. triangular or almost rectangular) supraoccipital spine and a pattern of alternating light and dark vertical bands on the flanks (vs. absent of such bands) in life. It is additionally distinguished in having four oval patches of palatal teeth (two on each side) with the inner patches smaller than the outer. *Hexanematichthys sagor* is also the only ariid catfish species in Singapore that can be found swimming up concrete canals that drain to the sea. As with the preceding species (*Hemiarius sona*), the generic assignment of this species between the studies of Kailola (2004), Marceniuk & Menezes (2007) and Marceniuk et al. (2012) differ considerably (*Hexanematichthys* in the former and *Sciades* in the latter two studies). Again, neither of these generic assignments is supported by molecular evidence; it is likely that the morphological characters used by Kailola (2004) to diagnose *Hexanematichthys* may be due to convergence (Betancur-R., 2009). Conversely, the synapomorphies that Menezes et al. (2012) use to diagnose *Sciades* are homoplasious. This species is here retained in *Hexanematichthys* only as a matter of convenience.

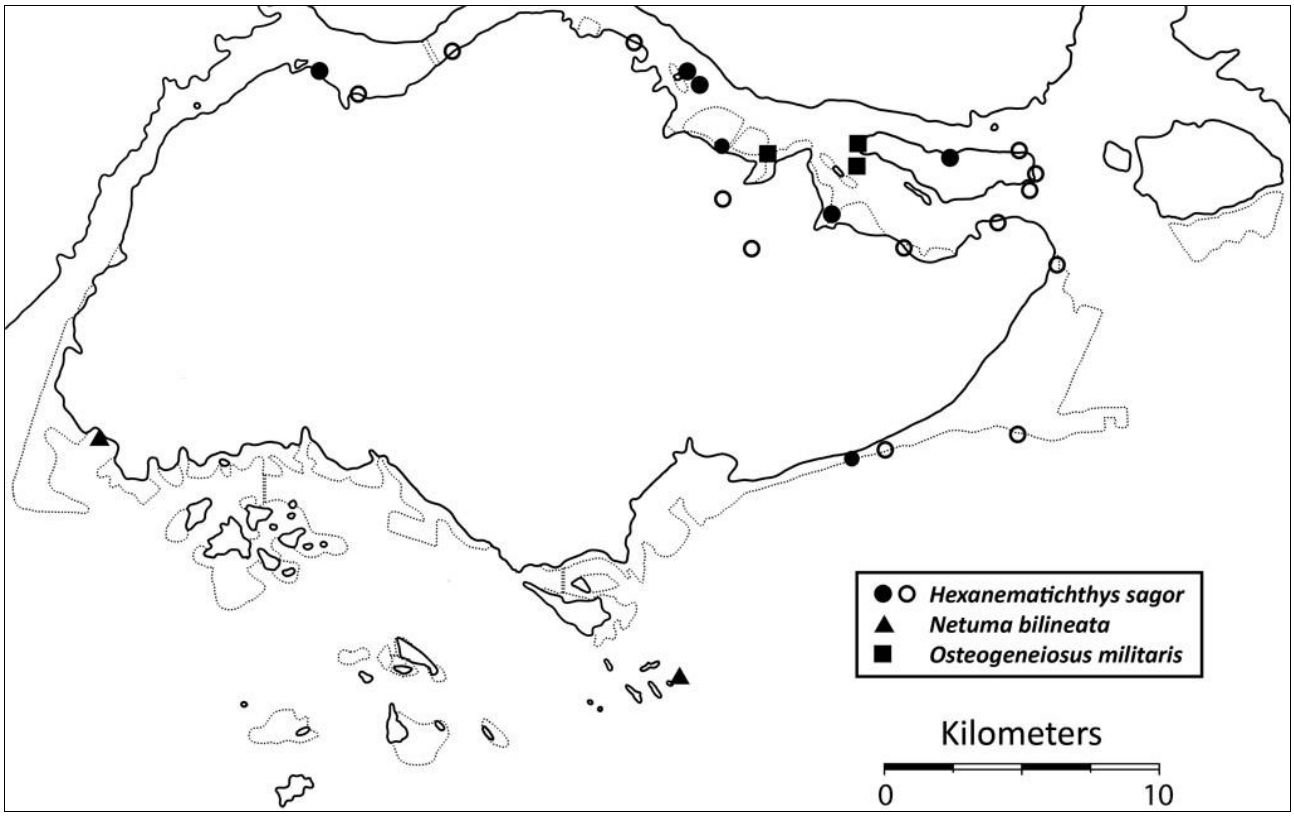

Fig. 11. Localities where *Hexanematichthys sagor*, *Netuma bilineata*, and *Osteogeneiosus militaris* have been encountered. Open symbols indicate records from authenticated sightings (based on angling records), while closed symbols indicate records from specimens. The solid outline of Singapore indicates original coastline, while the dotted lines indicate reclaimed coastline circa 2010.

Netuma bilineata (Valenciennes), round-snout sea catfish
Fig. 12

Material examined. — ZRC 31392–31394, 3: 119.7–158.2 mm SL, Tuas Basin; ZRC 53446, 1: 172.2 mm SL, Straits of Singapore off Kusu Island.

Distribution. — Straits of Singapore (Fig. 11)

Remarks. — This species has been misidentified as *Netuma thalassina*, but is reidentified here as *Netuma bilineata* following Kailola (1986). This is made on the basis of the following characters: narrow occipital process with gently concave sides (vs. broad occipital process with convex sides in *Netuma thalassina*) and rounded, blunt snout (vs. prominent and broadly pointed snout in *Netuma thalassina*). *Netuma bilineata* is also more likely to be encountered in shallower waters (Kailola, 1986).

Netuma bilineata differs from all other Singapore ariids in having a combination of the palatal teeth arranged in three patches on each side of palate and generally forming a large triangle, a short-based adipose fin and slender and tapering caudal-fin lobes.

Fig. 12. *Netuma bilineata*, ZRC 31394, 158.2 mm SL; Singapore: Tuas Basin.

Osteogeneiosus militaris (Linnaeus), soldier catfish
Fig. 13

Material examined. — ZRC 49822, 1: 261.3 mm SL, Straits of Johor at mouth of Sungei Punggol near Punggol Marina; ZRC 50233, 1: 288.6 mm SL, Pulau Ubin at Tanjong Tajam; ZRC 52388, 2: 284.8–284.9 mm SL, Pulau Ubin at western tip off Outward Bound School.

Distribution. — Eastern Straits of Johor (Fig. 11)

Remarks. — This species differs from all other Singapore ariids in having only the maxillary (vs. with maxillary and two pairs of mandibular) barbels. It is additionally distinguished by a combination of thin skin covering the head shield, palatal teeth grouped into two large longitudinal, semi-oval or elliptical patches with concave inner margins (one on each side), thin dorsal- and pectoral-fin spines, and bluish colouration in life.

Plicofollis argyropleuron (Valenciennes), long-snouted sea catfish
Fig. 14

Material examined. — ZRC 53388, 1: 220.3 mm SL, Sungei Buloh at sluice gate near bridge; ZRC 3683, 1: 295.3 mm SL, Changi; ZRC 53334, 9: 197.8–288.5 mm SL, Pulau Tekong south reclamation zone; ZRC 50389, 1: 284.4 mm SL, Pulau Tekong near Merlin Rock (1°23′N, 104°5′E).

Distribution. — Straits of Johor and the eastern Straits of Singapore (East Coast Park; Fig. 15)

Remarks. — This species differs from all other Singapore ariids in having a combination of a long head (27–36% SL), long snout (44–48% HL), lateral ethmoid not prominent, supraoccipital process narrowly triangular with straight sides,and granular palatal teeth in two patches on either side of the mouth that are arranged in a longitudinal series: the anterior patch is much smaller than the posterior patch and somewhat circular, the posterior patch is ovate, and are parallel to each other or converging towards the midline posteriorly.

Fig. 13. *Osteogeneiosus militaris*, ZRC 50233, 288.6 mm SL; Singapore: Pulau Ubin.

Fig. 14. *Plicofollis argyropleuron*, ZRC 53334, 200.0 mm SL; Singapore: Pulau Tekong.

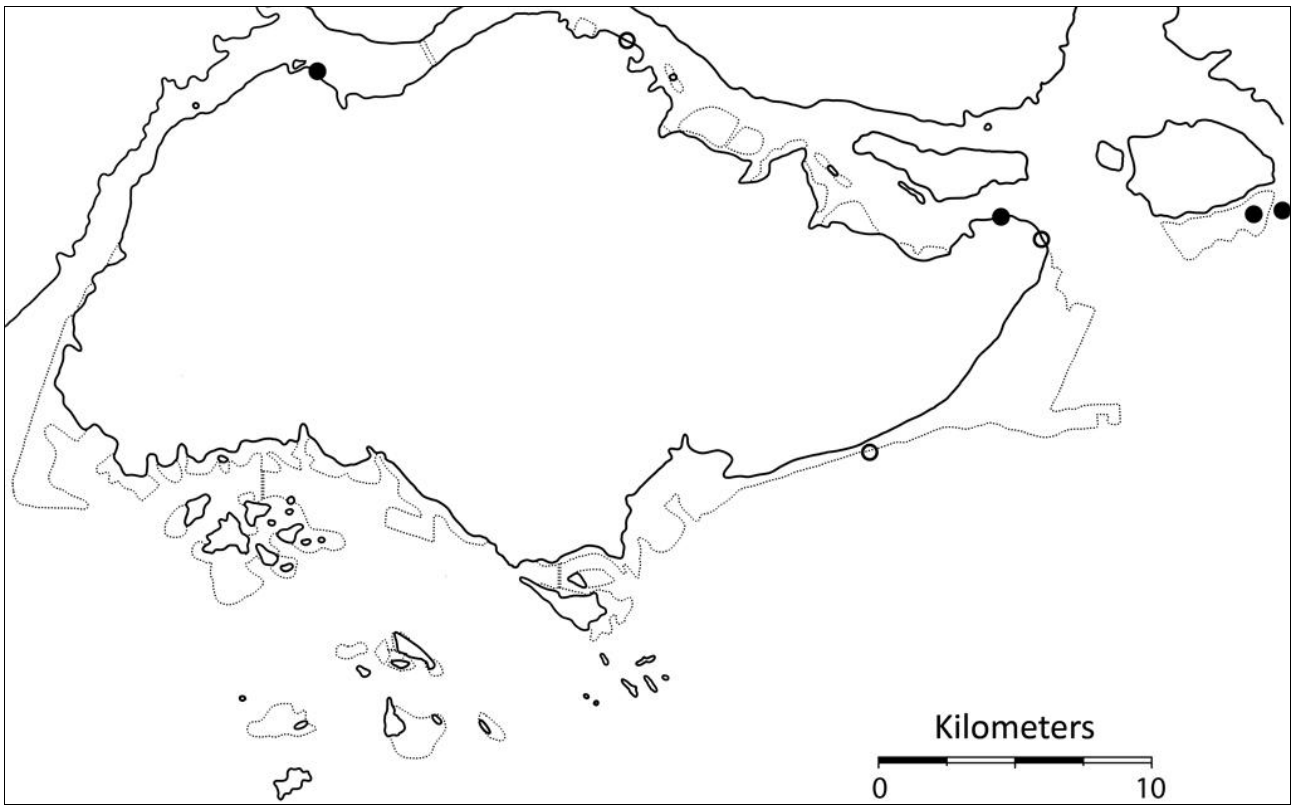

Fig. 15. Localities where *Plicofollis argyropleuron* individuals have been encountered. Open symbols indicate records from authenticated sightings (based on angling records), while closed symbols indicate records from specimens. The solid outline of Singapore indicates original coastline, the dotted lines indicate reclaimed coastline circa 2010.

Plicofollis argyropleuron is morphologically very similar to *Plicofollis nella*, but they can be distinguished by the snout lengths (44–48% HL in *Plicofollis argyropleuron* vs. 41–44 in *Plicofollis nella*), the shape of the lateral ethmoid (not prominent in *Plicofollis argyropleuron* vs. prominent in *Plicofollis nella*), the shape of the dorsal head profile (straight in *Plicofollis argyropleuron* vs. slightly convex in *Plicofollis nella*), the shape of the supraoccipital process (with straight sides in *Plicofollis argyropleuron* vs. with convex sides in *Plicofollis nella*), and the shapes of the caudal fin lobes (broader and with curved posterior margins of the lobes in *Plicofollis argyropleuron* vs. slender and with straight posterior margins in *Plicofollis nella*).

Plicofollis nella (Valenciennes), shield-headed sea catfish
Fig. 16

Material examined. — ZRC 49726, 1: 209.0 mm SL, kelong E5 off the mouth of Sungei Simpang (1°27′19.00″N, 103°51′26.80″E); ZRC 53339, 9: 152.1–181.6 mm SL, Punggol Marina; ZRC 53350, 1: 170.7 mm SL, kelong E26 off Pulau Serangoon (1°25′10.2″N, 103°55′6.3″E); ZRC 53333, 2: 305–350 mm SL, Pulau Tekong south reclamation zone; ZRC 50387, 1: 199.6 mm SL, Pulau Tekong near Merlin Rock (1°23′N, 104°5′E).

Distribution. — This species inhabits habitats with sandy substrate, and is known from the eastern Straits of Johor and the Straits of Singapore (East Coast Park, Marina South, Labrador, Jurong Island; Fig. 17).

Remarks. — *Plicofollis nella* differs from all other Singapore ariids in having a combination of a long head (29–33% SL), long snout (41–44% HL), prominent lateral ethmoid, supraoccipital process ovate with convex sides, and granular palatal teeth in two patches on either side of the mouth that are arranged in a longitudinal series: the anterior patch is much smaller than the posterior patch and somewhat circular, the posterior patch is elongate and diverging away from the midline posteriorly. Subadults of this species frequently have orange/reddish fins in life.

Fig. 16. *Plicofollis nella*, ZRC 53339, 159.6 mm SL; Singapore: Punggol Marina.

DISCUSSION

Based on museum specimens, nine species of ariid catfishes are definitively known from Singapore waters: *Arius* cf. *gagora*, *Arius leptonotacanthus*, *Arius oetik*, *Hemiarius sona*, *Hexanematichthys sagor*, *Netuma bilineata*, *Osteogeneiosus militaris*, *Plicofollis argyropleuron*, and *Plicofollis nella*. The discoveries of *Arius* cf. *gagora* and *Netuma bilineata* locally represent new records for Singapore, while *Hemiarius sona* is recorded for the first time from Singapore in more than a hundred years; the occurrence of *Cryptarius truncatus* in Singapore waters is considered doubtful.

Seven species previously recorded as being from Singapore were not encountered in the preparation of this checklist. They are *Arius venosus*, *Ketengus typus*, *Nemapteryx macronotacantha*, *Nemapteryx nenga*, *Netuma thalassina*, *Plicofollis crossocheilus*, and *Plicofollis polystaphylodon*. The problem of the identity of *Arius venosus* has been briefly highlighted in the account for *Arius oetik*; all of the material from Singapore identified as *Arius venosus* examined in this study have turned out to be *Arius oetik*, although Bleeker's record of this species (sensu Kailola, 2004) needs to be verified with freshly collected material. The record of *Ketengus typus* and *Nemapteryx nenga* (as *Arius caelatus*) from Singapore by Bleeker (1861) is based on specimens seen in markets, making it likely that these species may have been caught outside Singapore. The record of *Nemapteryx macronotacantha* from Singapore by Weber & de Beaufort (1913) is not based on specimens, but on the record of *Arius arius* from Penang by Cantor (1849) (refer to the subsequent paragraph for a more detailed discussion). The records of *Netuma thalassina* from Singapore waters are most likely owed to misidentifications of *Netuma bilineata* (see remarks for the latter species). The records of *Plicofollis crossocheilus* and *Plicofollis polystaphylodon* are most likely owed to misidentifications of *Plicofollis argyropleuron* and/or *Plicofollis nella*.

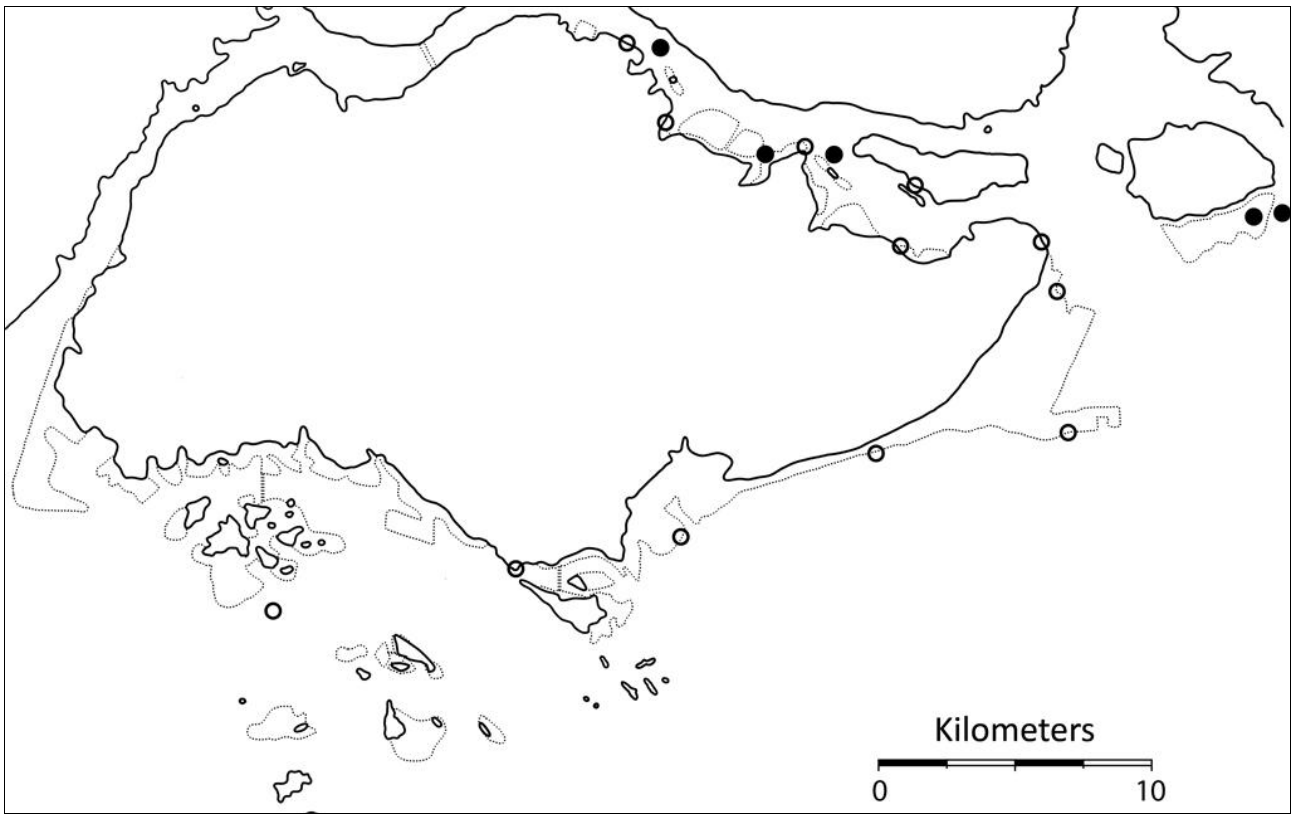

Fig. 17. Localities where *Plicofollis nella* have been encountered. The open symbols indicate records from authenticated sightings (based on angling records), while closed symbols indicate records from specimens. The solid outline of Singapore indicates original coastline, while the dotted lines indicate reclaimed coastline circa 2010.

Bleeker (1858) also recorded the presence of *Arius arius* from Singapore (this is the basis on which the record of this species by Kailola [1999] is made). This record is based on that of Cantor (1849), who recorded this species from Penang, Peninsular Malaysia, and Singapore (for which only material from Penang was preserved). Günther (1864) subsequently reidentified Cantor's material as *Nemapteryx macronotacantha*. Thus it is very likely that neither *Arius arius* nor *Nemapteryx macronotacantha* is found in Singapore waters, since no specimens have been obtained.

Although there are 24 marine and brackish water species of ariid catfishes in the Sunda Shelf (Kailola, 1999), only about one-third of this diversity is found in Singapore waters. This is in part due to the absence of suitable habitats in Singapore for some of the species (e.g., the absence of large rivers and their estuaries for species such as *Cryptarius truncatus*). Although it is questionable if some of the 19th century records refer to fishes caught in Singapore waters, it cannot be ruled out that some of these ariid species were indeed caught locally and may have been extirpated, given that these catfishes have been shown to be vulnerable to overfishing and anthropogenic disturbance (Vidthayanon & Premcharoen, 2002; Menon, 2003).

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