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ARIUS VERRUCOSUS, A NEW SPECIES OF FRESHWATER ARIID
CATFISH (TELEOSTEI: ARIIDAE) FROM THE MEKONG RIVER

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ABSTRACT.—*Arius verrucosus* is a new species from the Mekong River drainage in mainland Southeast Asia. It can be distinguished from other ariids in the region (Sunda shelf) in having the following combination of autapomorphies: dorsal surface of exposed neurocranium ornamented with numerous small tubercles which never coalesce to form irregular radial ridges in adults, pectoral spine extending to a vertical posterior to last dorsal-fin ray (19.6–23.4 %SL) and ornamented with randomly distributed small tubercles. Together with *A. stormii*, it is distinguished from other ariids in the region by the following synapomorphies: laterosensory canal system forming a dense anastomosing network on dorsal surfaces of head and body with very long branches spanning at least middle third of flanks, and strongly flattened fin spines. Finally, a unique combination of the following characters further diagnoses it from other ariids in the region: strongly depressed head, strongly projecting shark-like snout partially exposing premaxillary teeth when mouth is closed, palatal teeth in four patches organized into two contiguous groups (separated by a wide medial gap) on each side of anterior part of palate, deeply notched posterior end of supraoccipital, lateral line curving dorsally at caudal-fin base, gill rakers absent on mesial aspect of first two gill arches, and head depth 15.5–16.7%SL.

Key words: *Arius verrucosus*, Teleostei, Ariidae, Mekong River, Cambodia, Laos, Vietnam

INTRODUCTION

Catfishes of the family Ariidae are predominantly found in inshore and brackish water habitats, although a few members are found exclusively in fresh water. The largest genus, *Arius* Valenciennes in Cuvier & Valenciennes, 1840, is now understood to be a polyphyletic assemblage

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(Kailola, 1999). Given the large number of species currently recognized within *Arius* and the cosmopolitan distribution of the group, the resolution of the phylogenetic relationships of its members is a project that will involve considerable time and effort. The discussion of character polarity in the taxa discussed below is therefore to be considered of a preliminary nature.

There are currently 24 species of *Arius* known from the rivers and coastal regions of mainland and Sundaic Southeast Asia (Kailola, 1999), viz. *A. argyropleuron* Valenciennes in Cuvier & Valenciennes, 1840, *A. arius* (Hamilton, 1822), *A. bilineatus* Valenciennes in Cuvier & Valenciennes, 1840, *A. bleekeri* Popta, 1900, *A. crossocheilus* Bleeker, 1846, *A. dispar* Herre, 1926, *A. dussumieri* Valenciennes in Cuvier & Valenciennes, 1840, *A. harmandi* (Sauvage, 1883), *A. intermedius* (Vinciguerra, 1880), *A. leptanotacanthus* Bleeker, 1849, *A. macronotacanthus* Bleeker, 1846, *A. maculatus* (Thünberg, 1792), *A. melanocheilus* Bleeker, 1852, *A. microcephalus* Bleeker, 1855, *A. nella* Valenciennes in Cuvier & Valenciennes, 1840, *A. nenga* (Hamilton, 1822), *A. polystaphylodon* Bleeker, 1846, *A. sagor* (Hamilton, 1822), *A. sona* (Hamilton, 1822), *A. stormii* (Bleeker, 1858), *A. thalassinus* (Rüppell, 1837), *A. truncatus* Valenciennes in Cuvier & Valenciennes, 1840, *A. utik* Bleeker, 1846, and *A. venosus* Valenciennes in Cuvier & Valenciennes, 1840. Of these, *Arius stormii* is a highly distinctive species with a strongly depressed head, strongly projecting, shark-like snout, premaxillary teeth partially exposed when the mouth is closed, laterosensory canal system forming a dense anastomosing network on the dorsal surfaces of the head and body, and long and broad dorsal and pectoral spines previously known from rivers in mainland and Sundaic Southeast Asia. *Arius stormii* has sometimes been placed in the genus *Hemiarius* Bleeker, 1862 (type species *Cephalocassis stormii* Bleeker, 1858), but until the phylogenetic relationships of the currently polyphyletic *Arius* are fully resolved, I follow Kailola (1999) in considering *Hemiarius* a junior synonym of *Arius*.

While comparing material identified as *Arius stormii* from the Mekong River drainage in mainland Southeast Asia (Indochina) and river drainages in Sundaic Southeast Asia (Sumatra and Borneo), distinct and consistent differences were noted between fishes from the two areas. These differences have led to the conclusion that the mainland Southeast Asian population belongs to a previously undescribed species, which is described herein as *Arius verrucosus*, new species.

METHODS AND MATERIALS

Measurements were made point to point with dial calipers and data recorded to tenths of a millimeter. Counts and measurements were made on the left side of specimens whenever possible. Subunits of the head are presented as proportions of head length (HL). Head length itself and measurements of body parts are given as proportions of standard length (SL). Measurements and counts were made following Ng & Dodson (1999).

Fin rays were counted under a binocular dissecting microscope using transmitted light. Vertebral counts were taken from radiographs following the method of Roberts (1994). Numbers in parentheses following a particular fin-ray, branchiostegal-ray, gill-raker or vertebral count indicate the number of specimens with that count. Institutional codes follow Eschmeyer (1998).

SPECIES DESCRIPTIONS

Arius verrucosus new species

Fig. 1

Arius stormi (non Bleeker): Chau & Fang, 1949: 194; Rainboth, 1996: 165, Pl. 22, Fig. 175; Lim et al., 1999: 383.

Tachysurus stormi (non Bleeker): Suvatti, 1950: 281; Taki, 1978: 20.

Tachysurus stormii (non Bleeker): Suvatti, 1981: 80; Huong & Khoa, 1993: 243, Fig. 104a–c.

Arius stormii (non Bleeker): Roberts, 1993: 34, 45.

Hemiaris stormii (non Bleeker): Vidthayanon *et al.*, 1997: 49; Kottelat, 2001: 141, Fig. 401.

Arius (*Hemiaris*) *stormii*: Kailola, 1999: 1864 (in part).

Type material. Holotype: UMMZ 235408, 193.4 mm SL; Laos: Champasak, Mekong River at Ban Hang Khone, just downstream from Khone Falls; I. Baird, date unknown.

Paratypes: CAS 96570, 1 ex., 190.5 mm SL; Laos: Mekong River at Ban Hang Khone, just below Khone Falls; I. Baird, date unknown. UMMZ 214609, 1 ex., 267.5 mm SL; Vietnam: Can Tho fish market; W. J. Rainboth, 19 Jul 1974. UMMZ 214611, 1 ex., 136.2 mm SL; Vietnam: Chau Doc Province, Tan Chau District, Mekong River, east of Vinh Tha Id; R. E. Arden and O. K. Minh, 19 Oct 1974. UMMZ 214619, 1 ex., 98.7 mm SL; Vietnam: My Tho Province, Mekong River, channel west of Buddha Island; M. L. Smith *et al.*, 18 Jun 1974. UMMZ 232326, 2 ex.,

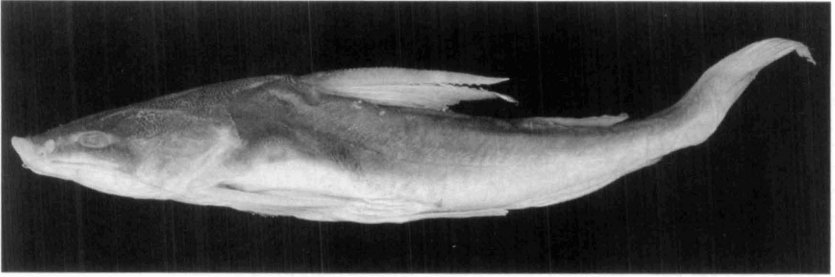


Fig. 1. *Arius verrucosus* UMMZ 232326, paratype, 214.2 mm SL; Cambodia: Stung Treng.

214.2–248.2 mm SL; Cambodia: Stung Treng morning market; W. J. Rainboth et al., 26 Jan 1995.

Diagnosis. *Arius verrucosus* can be distinguished from other ariids in the region (Sunda shelf) in having the following combination of autapomorphies: dorsal surface of exposed neurocranium ornamented with numerous small tubercles which never coalesce to form irregular radial ridges in adults, pectoral spine extending to a vertical posterior to last dorsal-fin ray (19.6–23.4 %SL) and ornamented with randomly distributed small tubercles. Together with *A. stormii*, it is distinguished from other ariids in the region by the following synapomorphies: laterosensory canal system forming a dense anastomosing network on dorsal surfaces of head and body with very long branches spanning at least middle third of flanks, and strongly flattened fin spines. Finally, a unique combination of the following characters further diagnoses it from other ariids in the region: strongly depressed head, strongly projecting shark-like snout partially exposing premaxillary teeth when mouth is closed, palatal teeth in four patches organised into two contiguous groups (separated by a wide medial gap) on each side of anterior part of palate, deeply notched posterior end of supraoccipital, lateral line curving dorsally at caudal-fin base, gill rakers absent on mesial aspect of first two gill arches, and head depth 15.5–16.7%SL.

Description. Body moderately compressed. Dorsal profile rising evenly but not steeply from tip of snout to origin of dorsal fin, then sloping gently ventrally from there to end of caudal peduncle. Ventral profile flat to anal-fin base, then sloping gently dorsally from there to end of caudal peduncle. Anus and urogenital openings located at vertical through middle of appressed pelvic fin. Skin smooth. Lateral line complete and midlateral, and curving dorsally at caudal-fin base. Lateral line with a dense network of vertically-oriented anastomosing canals on

head and body; branches of lateral line system spanning at least middle of flanks. Canal system very prominent in large (>150 mm SL) specimens and less so in smaller (<150 mm SL) specimens.

Head depressed and broad, acutely triangular when viewed laterally and with acutely convex snout margin when viewed from above. Fleishy upper lip extending anteriorly beyond upper jaw. Gill openings wide, extending from exposed surface of posttemporal to isthmus. Mesial membranes fused to, and attached across, isthmus. Bony elements of dorsal surface of head exposed, granulose and ornamented with numerous small tubercles; tubercles never coalescing to form irregular radial ridges (Fig. 2a). In specimens smaller than 150 mm SL, dorsal surface of neurocranium ornamented with irregular radial ridges that break up to form tubercles in adults. Midline of cranium with fossa extending from midway between base of supraoccipital and posterior orbital margin to a point three-quarters between anterior orbital margin and tip of snout; middle of fossa occupied by fontanel. Supraoccipital spine moderately broad, with slightly converging sides and deeply notched posterior tip (Fig. 2). Cleithral process well-ossified anteroventrally, with oblique shaft and extending along proximal third of pectoral spine.

Barbels in three pairs. Maxillary barbel long and slender, extending to middle of pectoral-fin base. Inner mandibular-barbel origin close to midline; and extending to level of posterior edge of orbit. Outer mandibular barbel originates posterolateral of inner mandibular barbel, extending past pectoral-fin origin.

Eye ovoid, horizontal axis longest; located entirely in dorsal half of head. Orbit with free margin.

Mouth inferior, premaxillary tooth band partially exposed when mouth is closed. Oral teeth strong, sharp and depressible. Premaxillary tooth band strongly arched, of equal width throughout and with 4–5 irregular rows of teeth. Dentary tooth band narrower than premaxillary tooth band at symphysis, tapering laterally, and with 3–4 irregular rows of teeth. Palatal teeth in four patches on each side of the anterior part of the palate organised into two contiguous groups, with 2–3 irregular rows of teeth and separated by a wide medial gap; inner patches half as wide as outer patches. Palatal tooth patches partially coalesce in large individuals (greater than 260 mm SL; Fig. 3).

Gill rakers on first gill arch 15 (1), 16 (4) or 17 (1). Rakers long, slender and stiff; half as long as opposing filaments and becoming somewhat flattened in larger specimens (>250 mm SL). Rakers present on mesial aspect of all but first two arches.

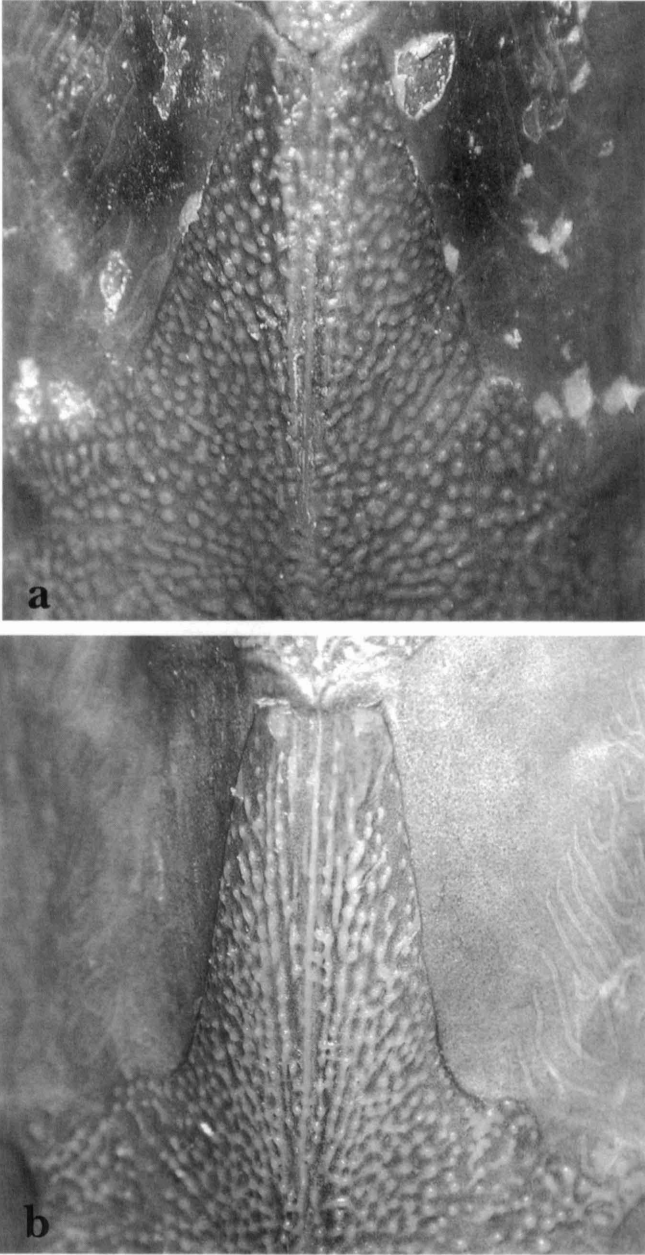


Fig. 2. Supraoccipital of: **a**, *Arius verrucosus*, UMMZ 214609, paratype, 267.5 mm SL; **b**, *A. stormii*, USNM 230312, 281.5 mm SL.

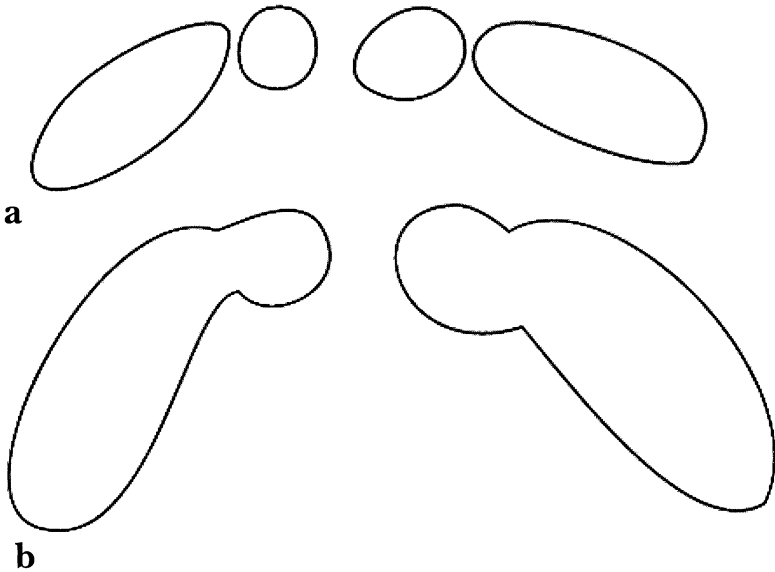


Fig. 3. Schematic illustration of the outline of the palatal tooth patches of *Arius verrucosus*, showing fusion with growth: a, UMMZ 214619, 98.7 mm SL; b, UMMZ 214609, 267.5 mm SL (not to scale).

Dorsal fin located above middle of body; origin nearer tip of snout than caudal flexure, with 7 (6) rays. Dorsal-fin margin convex, usually with anterior branch of fin-rays longer than other branches. Dorsal-fin spine long, straight and robust, with small retrorse serrations on anterior margin and 11–21 antorse serrations on posterior edge.

Adipose fin with margin convex or straight for entire length; posterior end deeply incised.

Caudal fin deeply forked; upper and lower lobes pointed, with i,8,7,i (5) or i,8,8,i (1) principal rays. Procurrent rays symmetrical and extend only slightly anterior to fin base.

Anal-fin base ventral to posterior half of adipose fin, with iv,9 (1), v,9 (1) or v,10 (4) rays. Posterior fin margin concave.

Pelvic-fin origin at vertical through posterior end of dorsal-fin base, with i,5 (6) rays. Pelvic-fin margin slightly convex, tip of appressed fin not reaching anal-fin origin.

Pectoral fin with stout spine, sharply pointed at tip, extending to a vertical line beyond the last dorsal-fin ray. Anterior spine margin with small serrations along entire length; posterior spine margin with 14–21

Table 1. Morphometric data for *Arius stormii* (N=4) and *A. verrucosus* (N=7).

	<i>Arius stormii</i>	<i>Arius verrucosus</i>
Standard length (mm)	147.3–281.5	98.7–267.5
In % SL		
Head length	28.8–29.6	29.3–31.7
Head width	19.3–20.0	19.3–201.9
Head depth	14.5–15.1	15.5–16.7
Predorsal distance	38.7	39.6–42.0
Preanal length	72.0–72.3	68.8–72.3
Prepelvic length	53.9–55.0	51.0–56.8
Prepectoral length	24.7–26.0	26.1–28.5
Body depth at anus	12.5–13.1	10.8–13.4
Length of caudal peduncle	15.9–16.8	15.1–17.6
Depth of caudal peduncle	4.8–5.9	5.2–5.9
Pectoral-spine length	18.1–19.7	19.6–23.4
Pectoral-fin length	21.5–21.6	23.2–25.3
Dorsal-spine length	24.3–29.4	22.3–30.5
Length of dorsal-fin based	12.4–13.1	10.7–12.5
Pelvic-fin length	14.1–14.5	14.8–15.7
Length of anal-fin base	13.7–14.9	13.6–17.1
Caudal-fin length	21.2–22.6	22.4–24.3
Length of adipose-fin base	12.5–14.2	9.2–11.9
Adipose maximum height	3.2–3.6	3.3–4.9
Post-adipose distance	18.0–18.4	17.5–19.3
Dorsal to adipose distance	18.5–21.8	20.1–26.2
In % HL		
Snout length	37.0–39.8	35.2–41.7
Interorbital distance	38.3–39.9	26.6–39.7
Eye diameter	9.7–11.8	10.6–14.0
Maxillary barbel length	63.2–75.0	68.5–84.6
Inner mandibular barbel length	39.2–47.8	33.6–413.0
Outer mandibular barbel length	53.1–58.9	41.0–56.3

strong serrations along entire length. Spine ornamented with fine grooves, with small tubercles randomly scattered in middle (Fig. 4). Pectoral-fin margin straight anteriorly, convex posteriorly, with 11 (5) or 12 (1) rays.

Morphometric data as in Table 1.

Branchiostegal rays 4 (3) or 5 (3). Vertebrae 25+21=46 (1) or 25+22=47 (2), 25+23=48 (1) or 26+22=48 (1).

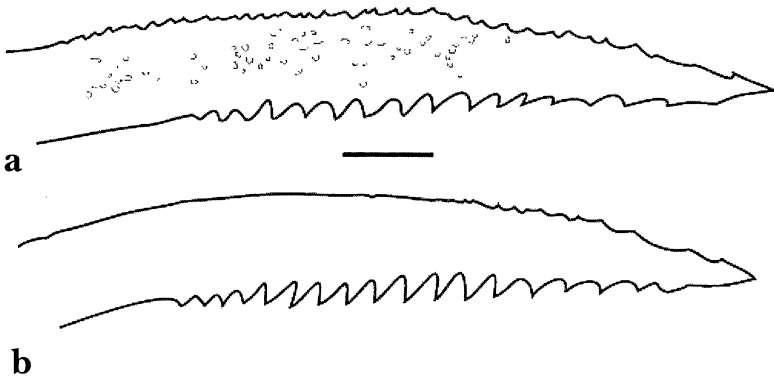


Fig. 4. Pectoral spines of: a, *Arius verrucosus*, UMMZ 232326, paratype, 214.2 mm SL; b, *A. stormii*, UMMZ 155676, 220.8 mm SL. Scale bar represents 5 mm.

Coloration. Dorsal surface of head and body uniform gray (fading to brown in old preserved specimens), upper third of head and body darkest, gradually fading to a lighter color along middle third of head and body; lower third and ventral surfaces of head and body dirty white. Adipose fin gray; dorsal fin-rays gray, fin rays of all other fins with scattered gray melanophores; inter-radial membranes of all fins yellowish or dirty white. Posterior margins of dorsal and caudal fins sometimes edged with black.

Distribution. Known only from the middle and lower reaches of the Mekong River (as far upriver as Khone Falls in southern Laos; Fig. 5) and possibly the lower Bang Pakong (Roberts, 1993).

Habitat and biology. Although both *A. stormii* and *A. verrucosus* have only been recorded from rivers (Roberts, 1989; Rainboth, 1996), Kailola (1999) includes inshore coastal areas as part of the distribution of both species (as *A. stormii*). Since no material of *A. stormii* and *A. verrucosus* have been collected from inshore waters, this suggests that both species are restricted to freshwaters (although their occurrence near the mouths of rivers suggests that they are able to tolerate brackish water), a supposition supported by what little field data available (pers. obs. in Sumatra for *A. stormii* and Roberts, 1993 for *A. verrucosus*).

Arius verrucosus is only known from the Mekong River downstream of Khone Falls. This is a large, relatively slow flowing river with turbid water. It is a predatory species that feeds on invertebrates and fish (Lim et al., 1999).

Etymology. From the Latin *verruca*, meaning wart, in reference to the numerous small bumps on the pectoral spines and dorsal surface of the neurocranium. Used as a noun.

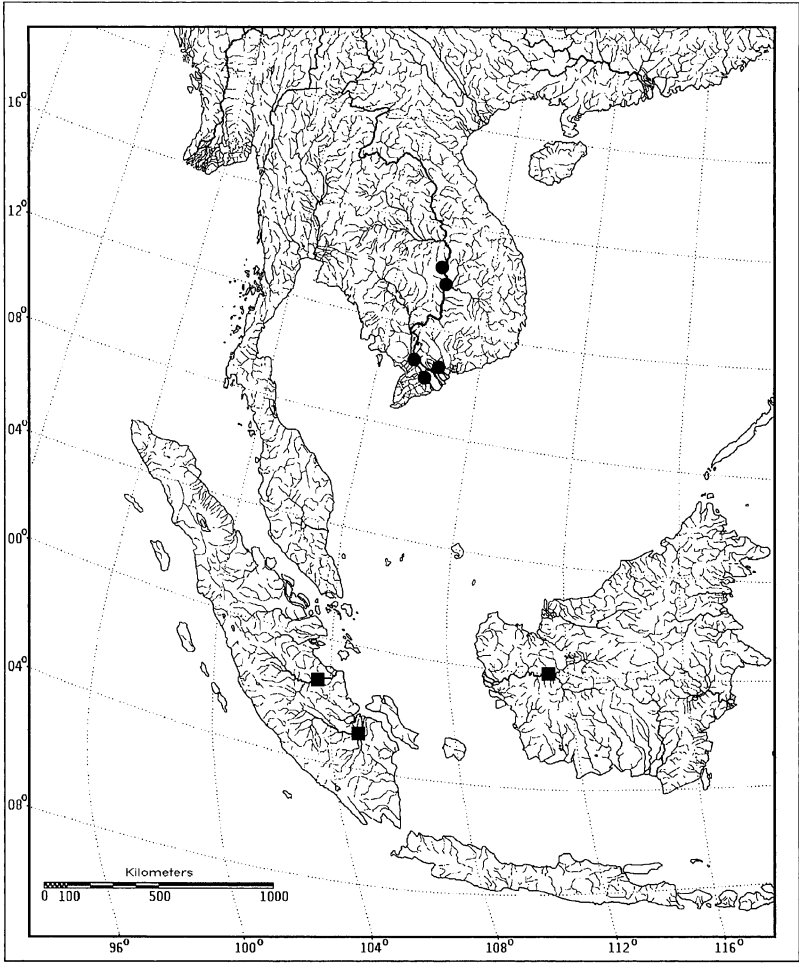


Fig. 5. Map showing the distribution of: a, *Arius verrucosus* (●); b, *A. stormii* (■).

DISCUSSION

Fourteen of the 24 other species of Southeast Asian *Arius* are known from mainland Southeast Asia (Kailola, 1999). These 14 species, *viz.* *A. argyropleuron*, *A. bilineatus*, *A. harmandi*, *A. leptotacanthus*, *A. macronotacanthus*, *A. maculatus*, *A. microcephalus*, *A. nella*, *A. nenga*, *A. sagor*, *A. thalassinus*, *A. truncatus*, *A. utik*, and *A. venosus*, are found in the Mekong

River, as well as the northern half of the South China Sea (into which the Mekong River debouches) and the adjacent coastal regions along the Gulf of Thailand.

Arius stormii and *A. verrucosus* can be distinguished from all of these species in having a combination of a strongly depressed head, strongly projecting, shark-like snout, premaxillary teeth partially exposed when the mouth is closed, laterosensory canal system forming a dense anastomosing network on the dorsal surfaces of the head and body with very long branches that span at least the middle third of the flanks, and long and broad dorsal and pectoral spines. The other Southeast Asian *Arius* (including the Sunda shelf species) lack one or more of these characters (particularly the shark-like snout and the prominent long branches of the laterosensory canal system), and can thus be easily distinguished from these two species.

The presence of a very prominent lateral line canal system that with very long branches spanning at least the middle third of the flanks and the strongly flattened fin spines are synapomorphies that unite *A. stormii* and *A. verrucosus* and are not seen in other *Arius*. The shark-like snout that exposes the maxillary teeth when the mouth is closed is also a distinctive feature of these two species that distinguish them from other *Arius* in the region. A shark-like snout is also present in *Arius dioctes* Kailola, 2000, and may be indicative of a phylogenetic relationship between *A. dioctes* and the *A. stormii*+*A. verrucosus* lineage.

Arius verrucosus further differs from all Southeast Asian *Arius* (except *A. stormii*) in having the lateral line curving dorsally at the caudal-fin base (*vs.* bifurcating in *A. arius*, *A. macronotacanthus*, *A. maculatus*, *A. microcephalus*, *A. nenga*, *A. truncatus*, *A. utik*, and *A. venosus*) and the absence of gill rakers on the hind aspect of the first two gill arches (*vs.* presence in all arches in *A. dispar*, *A. harmandi*, *A. leptonotacanthus*, *A. macronotacanthus*, *A. maculatus*, *A. microcephalus*, *A. nenga*, *A. sona*, *A. utik*, and *A. venosus*).

The shape of the palatal tooth patches also clearly distinguishes *A. stormii* and *A. verrucosus* from other Sunda shelf ariiids. The only other Southeast Asian *Arius* to possess palatal tooth patches in four patches organised into two contiguous groups (separated by a wide medial gap) on each side of anterior part of palate are *A. harmandi*, *A. sagor* and *A. sona*. However, *A. harmandi* has the premaxillary toothband not (*vs.* partially) exposed when the mouth is closed, a smooth (*vs.* denticulate) anterior margin of the pectoral spine, gill rakers on the hind aspect of all of the gill arches (*vs.* absent in the first two arches), and more anal-fin rays (19–20 *vs.* 13–15), *A. sagor* has a broader, shorter snout (snout length

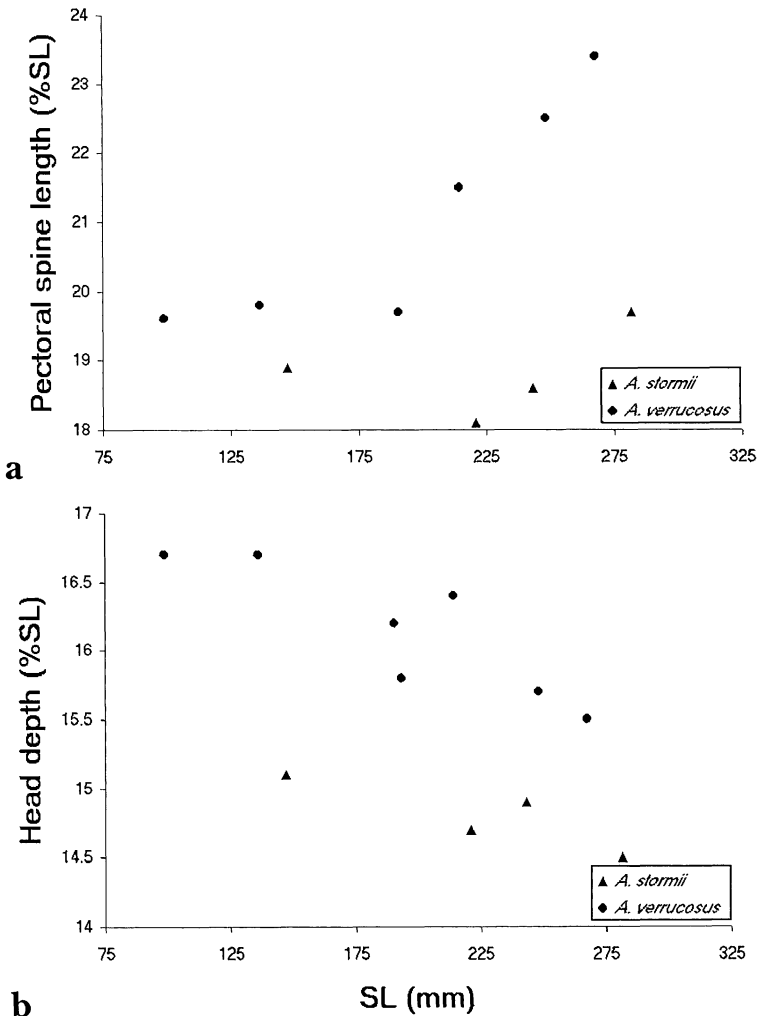


Fig. 6. a, Pectoral-spine length plotted against SL for *A. stormii* and *A. verrucosus*; b, Head depth plotted against SL for *A. stormii* and *A. verrucosus*.

30.8–35.3 %SL vs. 35.2–41.7), more anal-fin rays (16–19 vs. 13–15) and vertebrae (53–55 vs. 46–48), and *A. sona* possesses gill rakers on the hind aspect of all of the gill arches (vs. absent in the first two arches) and has a bigger eye (20.8 %SL vs. 10.6–14.0).

The posterior end of the supraoccipital in *A. verrucosus* is more deeply notched than that of *A. stormii* (Fig. 2). The pattern of ornamentation

on the dorsal surface of the exposed neurocranium in *A. verrucosus* consists of numerous small tubercles which almost never coalesce to form irregular radial ridges (Fig. 2a), while that in *A. stormii* consist of irregular radial ridges formed from the coalescence of elongate tubercles (Fig. 2b). The pectoral spine of *A. verrucosus* is also longer than that of *A. stormii* (extending to a vertical posterior to the last dorsal-fin ray vs. to a vertical through the middle of the dorsal fin; 19.6–23.4 %SL vs. 18.1–19.7; Fig. 6a). This difference in pectoral spine length is unlikely to be due to ontogeny, as the line through the pectoral spine length plotted against SL as a single series for both species has a low r-squared value (0.1387). The middle portion of the spine is ornamented with randomly distributed small tubercles in *A. verrucosus*, which are absent in *A. stormii* (Fig. 4). The two species further differ in *A. verrucosus* having a deeper head (15.5–16.7 %SL vs. 14.5–15.1; Fig. 6b), but it should be noted that the possibility that this difference could be due to ontogeny alone has not been entirely ruled out, as the line through the head depth plotted against SL as a single series for both species has a moderate r-squared value (0.4196).

Arius stormii and *A. verrucosus* is another example of a species formerly thought to be widespread throughout Southeast Asia and now found to consist of one Sundaic and one mainland species. A model of the historical biogeography of species with this pattern of distribution has been proposed by Bornbusch & Lundberg (1989), who hypothesized that the post-Pleistocene isolation of the North Sunda River system resulted in speciation.

Comparative material.

Arius sagor: UMMZ 214982, 4 ex., 133.1–192.8 mm SL; Malaysia: Penang, Georgetown market, from Andaman Sea. UMMZ 233704, 3 ex., 103.9–119.0 mm SL; Thailand: Songkhla Lake.

Arius sona: MCZ 159231, 1 ex., 126.9 mm SL; Malaysia: Penang.

Arius stormii: UMMZ 155676, 1 ex., 220.8 mm SL; Sumatra: Palembang. USNM 230312, 1 ex., 281.5 mm SL; Borneo: Kalimantan Barat, fish market at Sintang. ZRC 38706, 2 ex., 147.3–243.0 mm SL; Sumatra: Jambi.

Data for other species from Kailola (1999).

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