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Boraras naevus, a new species of miniature and sexually dichromatic freshwater fish from peninsular Thailand (Ostariophysi: Cyprinidae)

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Abstract

Boraras naevus, new species, is described from peninsular Thailand. It is distinguished from other congeners by features of its sexually dimorphic colour pattern, principal caudal-fin, pelvic-fin and branched dorsal-fin ray counts, lateral scale row counts, and a number of osteological features.

Key words: Cypriniformes, Danioninae, Taxonomy, Southeast Asia

Introduction

Members of the cyprinid genus *Boraras* Kottelat & Vidthayanon are small, brightly coloured fishes that inhabit swamps and slow-flowing streams throughout much of Southeast Asia (Kottelat & Vidthayanon, 1993). Reaching maximum adult sizes less than 20 mm in standard length, all members of *Boraras* are considered miniature fishes (sensu Weitzman & Vari, 1988) and exhibit a number of reductive characteristics, including the absence of the body lateral line, reduced cephalic lateral line system, low numbers of scales, branched fin rays, gill rakers and pharyngeal tooth rows (Kottelat & Vidthayanon, 1993), and the complete absence of a number of skeletal elements (Conway, 2005; Britz & Conway, 2009). *Boraras* currently includes five species, most of which were formerly placed in *Rasbora* Bleeker: *B. brigittae* (Vogt), *B. maculatus* (Duncker), *B. merah* (Kottelat), *B. micros* Kottelat & Vidthayanon and *B. urophthalmoides* (Kottelat). Several phylogenetic investigations have recovered *Boraras* as a monophyletic group and suggest that the genus *Trigonopoma* Liao, Kullander & Fang (=*R. pauciperforata*-group of Kottelat & Vidthayanon, 1993) may represent the sister group to *Boraras* (Conway, 2005; Liao et al., 2009; Tang et al., 2010).

The relationships between the five species of *Boraras* are incompletely resolved (Conway, 2005). Amongst *Boraras*, two species (*B. maculatus* and *B. micros*) exhibit a distinctive blotched pattern, consisting of three blackish brown circular markings in similar positions on the body (one at base of caudal fin, one at base of anal fin and one situated at mid-height of flank, roughly midway between posterior margin of opercle and vertical through pelvic-fin origin). The other three species have a midlateral stripe and a small circular marking at the caudal-fin base (*B. urophthalmoides* and *B. brigittae*) or a very elongated blotch on the anterior third of the flank, and a narrow midlateral stripe from above the anal-fin origin to the middle of the caudal-fin base (*B. merah*). Ichthyological surveys conducted in peninsular Thailand uncovered an additional species of blotched *Boraras*, similar to *B. maculatus* and *B. micros* but differing in a number of characters. In this paper we provide its formal description.

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Material and methods

Counts and measurements follow those of Kottelat & Vidthayanon (1993) except for dorsal- and anal-fin ray counts. Measurements were taken on the left side of specimens using a Zeiss DRC Stereomicroscope equipped with an ocular micrometer to the nearest 0.1mm. Specimen photographs were obtained using a Zeiss SteREO Discovery V20 Stereomicroscope equipped with an axiocam MRc5. Selected specimens were cleared and double stained (c&s) following the protocol of Taylor & Van Dyke (1985). Counts of pharyngeal teeth, vertebrae, procurrent rays and hypurals were obtained from c&s specimens. Vertebrae counts include the four Weberian centra and the terminal compound centrum (Fink & Fink, 1981). Numbers in parentheses following a count indicate the frequency of that count when variation was encountered. Materials examined are housed in the following collections: BMNH, Natural History Museum, London; CMK, collection of the second author; NRM, Swedish Museum of Natural History, Stockholm; USNM, National Museum of Natural History, Smithsonian Institution, Washington; TCWC, Texas Cooperative Wildlife Collection, College Station; ZRC, Raffles Museum of Biodiversity Research, National University of Singapore, Singapore.

Results

Boraras naevus, new species

Figure 1

Holotype. ZRC 53120, male, 10.6 mm SL; Thailand: Surat Thani Province: swamp, East of road North of Amphoe Tha Chana, 83 km before Surat Thani on road from Lang Suan; M. Kottelat et al., 4 March 2001.

Paratypes. CMK 16459, 255; ZRC 53121, 50; BMNH 2011.8.3.1-20, 20; NRM 61765, 20; TCWC 15185.01, 4(c&s), 10.2–12.7 mm SL; same data as holotype.

Diagnosis. *Boraras naevus* is distinguished from its congeners with a similar blotched color pattern (viz. *B. maculatus* and *B. micros*) by pronounced sexual dimorphism of the anteriormost blotch situated on the body side, which is a small circular marking of roughly orbit size or smaller in females and a large dorso-ventrally orientated oval-shaped marking larger than the orbit in males (vs. anteriormost blotch similar in size and shape in both sexes) and by its lower number of principal caudal-fin rays (9+8 vs. 9+9 in *B. micros*, 9–10+9 in *B. maculatus*). It is further distinguished from *B. maculatus* by its lower number of body scales in the midlateral row (24–26 vs. 26–29), and its lower number of pelvic-fin rays (i.5.i vs. i.6.i), and from *B. micros* by its higher number of body scales in the midlateral row (24–26 vs. 22–23), higher number of branched dorsal-fin rays (7 vs. 5–6), the presence of red and black pigment along the anterior edge of the dorsal and anal fins of males in life (vs. all fins transparent without red or black pigmentation in life in both sexes), the presence of infraorbital 4 (vs. infraorbital 4 absent), infraorbital 2 contacting both infraorbital 1 and infraorbital 3 (vs. infraorbital 2 greatly reduced in size, without contact with adjacent infraorbital bones), and the presence of the mesocoracoid (vs. mesocoracoid absent). *Boraras naevus* can be distinguished from the remaining species of *Boraras* (*B. brigittae*, *B. merah* and *B. urophthalmoides*) by the absence of a midlateral stripe (vs. broad, uninterrupted midlateral stripe from upper extremity of gill opening to middle of caudal-fin base in *B. brigittae* and *B. urophthalmoides*; or narrow, frequently interrupted midlateral stripe from above anal-fin origin to middle of caudal-fin base in *B. merah*).

Description. General body shape as in Figure 1. Morphometric and meristic data are listed in Table 1. Miniature species, largest specimen examined 12.7 mm SL (range 10.2–12.7 mm). Head and eye large, snout rounded, mouth small, terminal. Anterior nostril small, oval-shaped, separated from larger posterior nostril by a narrow, low strip of skin. Body compressed, deepest midway between occiput and dorsal-fin origin. Caudal peduncle slender. Dorsal fin origin situated roughly at mid-body, insertion of posteriormost dorsal-fin ray slightly anterior to vertical through anal-fin origin. Pelvic-fin origin situated anterior to vertical through dorsal-fin origin. Pectoral fin insertion situated low on flank. Caudal fin forked, upper and lower lobes rounded, upper lobe slightly longer than lower.

TABLE 1. Morphometric and meristic characters of *Boraras naevus*, *B. micros* and *B. maculatus*. Values for *B. naevus* obtained from holotype (ZRC 53120) and 10 paratypes (CMK 16459). Values for *B. maculatus* obtained from CMK 20696, BMNH 1985.12.18:10–18, 1995.5.17.112–126, USNM 101267 and 229241. Morphometric values for *B. micros* taken from Kottelat & Vidthayanon (1993) with additional meristic data obtained from BMNH 2004.4.29.1–3.

	Boraras naevus				*Boraras micros*	*Boraras maculatus*		
	Holotype	Range	Mean	St. Dev.	Range	Range	Mean	St. Dev.
Standard length	10.6	10.2–12.7			8.7–13.3	11.4–18.5		
In percentage of standard length								
Head length (HL)	28.3	27.3–30.1	28.9	0.9	26.0–32.0	23.6–30.0	27.8	1.6
Body depth	25.5	23.1–25.8	23.8	1	23.0–28.0	20.2–26.4	24.2	2.7
Predorsal length	61.3	55.5–61.2	58.2	1.5	53.0–60.0	53.7–60.1	56.3	2.8
Prepelvic length	50	49.1–50.8	49.8	0.6	46.0–52.0	48.3–50.4	49.9	1.1
Preanal length	66	63.0–66.0	64.6	1.2	60.0–68.0	63.2–64.8	64	0.8
Length of caudal peduncle	28.3	27.5–29.1	28	0.8	25.0–33.0	27.0–31.0	28.9	1.7
Depth of caudal peduncle	11.3	10.2–11.3	10.8	0.4	10.0–14.0	8.8–12.0	10.6	1.4
Eye diameter	10.4	9.4–11.1	10.4	0.6	10.0–12.0	8.8–9.7	9.2	0.4
Snout length	4.7	3.8–5.5	4.7	0.5	4.0–6.0	4.0–5.6	4.7	0.6
Length of dorsal fin	21.7	19.6–22.5	21.4	1	21.0–27.0	24.0–26.9	24.7	2.4
Length of anal fin	17.9	17.9–22.3	20.6	1.1	17.0–22.0	20.3–24.1	22.4	1.8
Length of pectoral fin	17.9	14.8–17.9	16.1	0.9	14.0–18.0	16.8–18.6	17.5	0.8
Length of pelvic fin	14.1	11.9–14.5	13.5	0.7	14.0–17.0	14.2–16.8	15.7	1.2
Length of upper caudal fin lobe	30.2	26.5–33.3	29.5	2.1	27.0–31.0	30.4–33.8	32.2	1.4
Length of lower caudal fin lobe	33	29.6–33.0	31.1	1.5	26.0–32.0	30.4–34.5	33.2	1.9
Length of median caudal rays	16	14.4–16.6	16	0.8	11.0–15.0	15.8–18.6	16.6	1.3
In percentage of head length								
Eye diameter	33.6	33.3–40.0	36.4	1.8	-	31.4–35.9	33.2	1.9
Snout length	16.6	13.3–20.0	16.3	1.9	-	15.4–17.9	17	2.4
Meristics								
Dorsal fin rays	ii.7.i	ii.7.i	-	-	ii.5–6.i	ii.7.i/ii.8	-	-
Anal fin rays	iii.5.i	iii.5.i	-	-	iii.5.i	iii.5.i/iii.6	-	-
Principal caudal fin rays	9+8	9+8	-	-	9+9	9–10+9	-	-
Dorsal procurrent rays	-	4–5	-	-	5	5	-	-
Ventral procurrent rays	-	5	-	-	5	5	-	-
Pelvic fin rays	i.5.i	i.5.i	-	-	i.5.i	i.6.i	-	-
Pectoral fin rays	i.6.ii	i.6.ii	-	-	i.6–8	i.8.i–ii	-	-
Abdominal vertebrae	-	14	-	-	13	14	-	-
Caudal vertebrae	-	15–16	-	-	14–15	15–17	-	-
Total vertebrae	-	29–30	-	-	28–29	29–31	-	-

Branchiostegal rays 3. Pharyngeal teeth arranged in two or three rows, formula 2,4–5,2,1(1) or 1,2,4–4,2,1(2). Infraorbital series composed of infraorbital 1 to infraorbital 4. Infraorbital 1 irregular in shape, its posterior edge rimming anterior margin of orbit. Infraorbital 2 smaller than infraorbital 1, rimming anteroventral margin of orbit ventral to posterior edge of infraorbital 1 and anterior edge of infraorbital 3. Infraorbital 3 largest of series, roughly

boomerang-shaped, its dorsal margin rimming much of posteroventral margin of orbit. Infraorbital 4 smallest of series, represented by poorly ossified sliver of dermal bone. Cephalic lateral line sensory system greatly reduced, composed only of short, open segment of canal ossification representing preopercular portion of preopercular-mandibular canal along ventral arm of preopercle. Otic, infraorbital, supraorbital, supratemporal and mandibular portion of preopercular-mandibular canal absent.

FIGURE 1. *Boraras naevus*, Thailand: Surat Thani Province. Above. ZRC 53120, holotype, male, 10.6 mm SL. Below. CMK 16459, paratype, female, 11.7 mm SL.

Dorsal-fin rays ii.7.i. Anal-fin rays iii.5.i. Principal caudal-fin rays 9+8. Pectoral-fin rays i.6.ii, pelvic-fin rays i.5.i. Dorsal procurrent rays 4(1) or 5(3), ventral procurrent rays 5(4). Total number of vertebrae 29–30, comprising 14 abdominal and 15(1) or 16(3) caudal vertebrae. Caudal-fin skeleton composed of 5 hypural elements, comprising fused parhypural+hypural 1 and hypurals 2–5. Free (second) uroneural absent. Three supraneurals posterior to supraneural 3, representing supraneurals 5–7.

Scales relatively large, cycloid, lacking radii. Scales in midlateral row from upper extremity of gill opening to caudal flexure 24–26. Predorsal scales 11 or 12. Transverse scale rows ½5½ or ½6½. Circumpeduncular scale rows 12.

Coloration in preservative. Body background colour ranging from light cream to light yellow. Body with three black blotches, one situated mid-height of body side, anterior to origin of pelvic fins, one situated at base of branched anal-fin rays (equivalent to the supraanal pigment of Brittan, 1954), and one at center of caudal-fin base. Black blotches made of pigments located in deeper layers of epidermis. Anteriormost blotch in males oval-shaped and larger than orbit, remaining blotches roughly circular in shape and smaller than orbit. All blotches of similar size and shape in females. Dorsal surface of body with weak reticulate pattern formed by heavy scattering of dark-brown pigment along posterior edge of scales. Dorsal reticulation more pronounced in males. Posterior edge of scales situated along body posterior to anteriormost blotch in males with weak scattering of dark-brown melanophores giving appearance of a weak reticulate pattern over posterior half of body side. Dense scattering of dark-

brown melanophores concentrated along body side below scales directly anterior and posterior to anteriormost blotch in males, separated from blotch by an area without pigment. Equivalent area in females with weak scattering of dark melanophores. Axial streak pronounced along posterior half of body, not visible on side anterior to dorsal fin origin. Occiput dark brown. All fins with light scattering of dark-brown melanophores across fin membranes between rays. Anterior edge of dorsal and anal fin and base of pelvic fin with intense scattering of dark brown-black melanophores in males. Anterior edge of dorsal fin weakly marked with dark brown-black melanophores in females.

Distribution and habitat. We have examined material from the type locality, in a swampy area north of Surat Thani. The species is reported to have a wider distribution in the lower Tapi drainage, on the Gulf of Thailand slope of peninsular Thailand. It is suspected that most of its natural habitats (swamps) has been transformed into paddy fields. Additional populations, or another, similar species is known from the Andaman Sea slope of the Malay Peninsula near Trang.

Etymology. From the Latin *naevus*, a spot, a mark on skin, a blemish, in allusion to the large sexually dichromatic blotch on the side of the body. A noun in apposition.

Discussion

The new species is assigned to *Boraras* because it possess all of the diagnostic characteristics of that genus (Kottelat & Vidthayanon, 1993) and exhibits all four of the osteological synapomorphies identified for *Boraras* by Conway (2005): (1) the absence of a supraorbital canal; (2) urohyal with a leaf-shaped appearance in ventral view; (3) outer arm of the os suspensorium (referred to as the 4th pleural rib by Conway, 2005) elongate, extending ventrally to a level parallel with or surpassing the ventralmost tip of the supracleithrum; and (4) the dorsalmost tip of the postcleithrum level with or higher than the distal end of the supracleithrum.

Within *Boraras*, *B. naevus* is most similar in terms of pigmentation pattern to *B. maculatus*, a species distributed throughout southern Thailand, Peninsular Malaysia and eastern Sumatra, and *B. micros* from the Mekong drainage of Thailand and Laos (Kottelat & Vidthayanon, 1993; Kottelat et al., 1993; Kottelat, 2001). All three exhibit a distinctive blotched pigment pattern, consisting of three black/brown circular markings (one at the base of the caudal fin, one at the base of the anal fin, and one situated at mid-height of flank, roughly midway between the posterior margin of the opercle and the vertical through the pelvic-fin origin). In *B. naevus*, the anteriormost blotch (which is the largest of the three) exhibits obvious sexual dimorphism, represented by a small circular marking of roughly orbit size or smaller in females compared to a large dorso-ventrally orientated oval-shaped marking much larger than the orbit in males (Fig. 1). In *B. maculatus* (Fig. 2) and *B. micros* (see Kottelat & Vidthayanon, 1993: figs. 7–8) the anteriormost blotch does not exhibit pronounced sexual dimorphism, being similar in size and shape in both sexes (there appears to be considerable variation in the size and shape of the blotch situated at the base of the anal fin in *B. maculatus*, not present in the two other blotched species, which may be shown to be the result of sexual dimorphism upon further investigation). In addition to this pigmentation feature, *B. naevus* is distinguished from *B. maculatus* and *B. micros* by a number of counts, including fewer principal caudal-fin rays (9+8 vs. 9–10+9 in *B. maculatus* and 9+9 in *B. micros*) and a different number of scales in midlateral row (24–26 vs. 22–23 in *B. micros* and 26–29 in *B. maculatus*). It is further distinguished from *B. maculatus* by a lower number of pelvic-fin rays (i.5.i vs. i.6.i) and from *B. micros* by a higher number of branched dorsal-fin rays (7 vs. 5–6). Males of *B. naevus* also exhibit prominent black markings along the anterior edge of the dorsal and anal fins, which are edged by red pigment in life, features that are absent in *B. micros* (all fins are hyaline in both sexes) but present in *B. maculatus* and the Bornean species of *Boraras*, viz. *B. brigittae* and *B. merah* (Kottelat, 1991). *Boraras naevus* is also distinguished from *B. micros* by a number of osteological features, including the presence of the mesocoracoid in the shoulder girdle (vs. absence), the presence of infraorbital 4 (vs. absence), and the size and shape of infraorbital 2 (infraorbital 2 in contact with both infraorbital 1 and infraorbital 3 vs. infraorbital 2 greatly reduced in size, without contact to adjacent infraorbital bones).

Like the blotched species of *Boraras*, *B. merah* (a species from southern Borneo; Kottelat, 2001) also exhibits a large blotch, surrounded by a depigmented area, on the anterior third of the flank. The anterior blotch of *B. merah* differs in shape from the anteriormost blotch of *B. maculatus*, *B. micros* and *B. naevus* (longitudinally elongate oval-shaped marking vs. circular, dorso-ventrally orientated marking) and does not appear to exhibit pronounced

sexual dimorphism (vs. anteriormost blotch exhibiting sexual dimorphism in *B. naevus*). In addition, *Boraras merah* also exhibits a narrow, frequently interrupted or faint midlateral stripe, extending from above the anal-fin origin to the middle of the caudal-fin base. This feature is unique to *B. merah* and appears "intermediate" between that of the blotched species of *Boraras* (*B. maculatus*, *B. micros* and *B. naevus*) and the two striped species (*B. brigittae* from southern Borneo and *B. urophthalmoides* from mainland southeast Asia; Kottelat, 2001).

FIGURE 2. *Boraras maculatus*, BMNH 1985.12.18:8-9, Malaysia: Kelantan: Ayer Hitam. Above. Male, 12.9 mm SL. Below. Female, 15.0 mm SL.

In a recent morphological phylogenetic investigation of *Boraras* (Conway, 2005), the blotched species (*B. maculatus* and *B. micros*) and striped species (*B. brigittae* and *B. urophthalmoides*) were recovered in different clades and not each other's closest relatives. This was due to the recovery of a sister group relationship between the two smallest members of the genus, the blotched *B. micros* and striped *B. urophthalmoides*. The results of a recent molecular phylogenetic investigation on danionines (Tang et al., 2010) also suggested that the blotched and striped species of *Boraras* are not monophyletic groups. Contrary to Conway (2005), Tang et al. (2010) recovered the striped species *B. urophthalmoides* as the sister group to all remaining species of *Boraras* and the blotched species *B. maculatus* as the sister group to a clade composed of *B.* cf. *micros* (actually *B. naevus*; K. W. Conway pers. obs), *B. brigittae* and *B. merah*. Given these conflicting results and the discovery of additional blotched *Boraras* diversity, the intrarelationships of *Boraras* may be worth revisiting.

Comparative material

Boraras maculatus. BMNH 1913.5.24.15-17, paralectotypes, 3; Malaysia: Johor: Bukit Tray, Bandar Maharani [Muar]. BMNH 1960.3.8.11-12, 2; Malaysia: Johor: Sungei Sendai. BMNH 1970.9.3:53-54, 2; Singapore: Nee Soon. BMNH 1985.12.18:8-9, 3; Malaysia: Kelantan: Ayer Hitam. BMNH 1985.12.18:10-18, 9; Malaysia: Johor: "Johor Bahru, 7km

South of Kuantan" [erroneous ?]. BMNH 1985.12.18:6-7, 2; BMNH 1995.5.17.112-126, 15 (6c&s); Malaysia: Johor; 6km South of Kluang on Road to Renggam. CMK 18398, 30; Indonesia: Sumatra; Jambi (aquarium trade). CMK 20696, 2; Indonesia: Sumatra: Jambi, blackwater ditch at about km 18 on road Muara Sabak–Jambi. USNM 101267, 1; Malaysia: Melaka: outlet of Lake Chin Chin, Jasin, Malacca. USNM 229241, 2; Malaysia: Johor: blackwater forest tributary of Muar River, 0.5 miles North of Kampong Bukit Kepong.

Boraras micros. BMNH 2004.4.29.1-3, 3(2c&s); Thailand (aquarium-fish trade).

Boraras urophthalmoides. CMK 16507, 94; Thailand: Nakhorn Sri Thammarat Prov.: heath forest swamp near Ban Bo Lo. CMK 18734, 20; Thailand: Chantaburi Prov.: heath forest west of Tha Mai.

Boraras brigittae. CMK 7437, 4; Indonesia: Borneo: Kalimantan Selatan: Banjarmasin (aquarium bred).

Boraras merah. CMK 16317, 56; Indonesia: Borneo: Kalimantan Barat: Anjungan (aquarium-fish trade). CMK 20318, 7; Indonesia: Borneo: Kalimantan Tengah: Mentaya drainage.

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