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Validation of *Parabrachidontes*, a new genus of fresh- and brackish-water mussels (Bivalvia: Mytilidae) from Southeast Asia with a redescription of the type species and *P. amnicus* Tan et al., 2023

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Abstract. *Parabrachidontes*, new genus, and *P. amnicus* Tan et al., 2023 (Mollusca: Bivalvia: Mytilidae) were earlier described in the Supporting Information section of a paper published in the journal Zoologica Scripta. The description of the genus cannot be regarded as available for nomenclatural purposes, because it did not appear in the main text of the article, and therefore is not considered as published in the sense of ICZN Article 8. As such, a formal description is provided for the genus, and redescriptions of the type species *P. leucostictus* (von Martens, 1897) and *P. amnicus*, briefly described in that paper, are also presented.

Key words. nomenclature, freshwater mussels, supplementary material

INTRODUCTION

Tan et al. (2023) described a new genus and new species, *Parabrachidontes amnicus*, in the journal Zoologica Scripta, which is only available online. The paper was registered in ZooBank on 9 January 2023 as urn:lsid:zoobank.org:pub:EF5083D5-59BF-4693-A9D9-FF8E4790DE40, a registration which covers only the 16 pages of the main text. The new genus was registered as urn:lsid:zoobank.org:act:7DA9F849-ED7E-429E-A0C9-DAF3FFD9D7C8, and the new species as urn:lsid:zoobank.org:act:B92166DD-5FA0-4656-BDD1-DC2C4AA51A4D. These ZooBank registration numbers are also stated in the paper. The formal descriptions of both the new genus and new species (together with the ZooBank registration numbers), however, were only presented in a separate document in the Supporting (Supplementary) Information and not in the main paper. Here we report that, whereas the contents of the main paper fulfil the conditions for making available the specific name *amnicus* as of 21 February 2023, the generic name is not available.

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While the Supplementary Information document has the same title as the main paper, it was neither included in the ZooBank registration, nor formatted in the Zoological Scripta format, and it is just a Microsoft Word file saved as a pdf. Although its contents fulfil all the requirements to make the names available, it cannot be regarded as published in the current sense of the Code, as it does not appear to have the permanence needed to make it an available work by itself. There is also no assurance that the Supplementary Information document, which is accessed by a link in the main paper, will remain permanently archived (cf. ICZN 2012: Articles 8.1 and 8.5.3.1; see also Hayden et al., 2023). In the main paper (Tan et al. 2023: 305–310), the authors do contrast and compare the characters of allied genera with the new genus but unfortunately, they make no reference to a type species, and as such, the new genus name is not available (ICZN 1999: Article 13.3).

In view of this situation and to validate the new genus name, we provide herewith the formal descriptions of the new genus *Parabrachidontes* and reproduce the detailed description of *P. amnicus* contained in the Supplementary Information material of Tan et al. (2023). We also provide a redescription of the type species of *Parabrachidontes*. Detailed results of their phylogenetic placement and species delimitation were previously provided in the main text of Tan et al. (2023).

Nevertheless, we consider that the requirements for availability of the specific name *amnicus* in the main text of Tan et al. (2023) were all met with. The paper (Article 11.1) "must have been published, in the meaning of Article 8" which is fulfilled by the ZooBank registration. The new specific name (Article 11.9) "must be published in unambiguous combination with a generic name (Article 11.9.3.1.); "the generic name need not be valid or even available" (which

is the case, the generic name is unavailable). The new specific name (Article 13.1.1.) "…must be accompanied by a description or definition that states in words characters that are purported to differentiate the taxon" which is fulfilled on page 305, and must be (Article 16.1) "explicitly indicated as intentionally new" which is fulfilled by the use of "sp. n.". The requirement (Article 16.4) of "the explicit fixation of a holotype, or syntypes, for the nominal taxon" and "a statement of intent that they will be (or are) deposited in a collection and a statement indicating the name and location of that collection" are fulfilled by the caption of Figure 2 stating "Holotype, PMBC 30680... " with "PMBC" explained page 303 as "PMBC, Phuket Marine Biological Center Reference, Collection, Thailand".

We also take this opportunity to rectify paratype accession numbers of *P. amnicus* as given below.

Abbreviations used: ANSP, Academy of Natural Sciences of Philadelphia, USA; PMBC, Phuket Marine Biological Center, Thailand; MZBC, Museum Zoologicum Bogoriense Cibinong, Indonesia; NHMUK, The Natural History Museum, London, UK; PMBC, Phuket Marine Biological Center, Thailand; ZMA, Naturalis Biodiversity Center, Leiden; ZMB, Museum für Naturkunde, Berlin; ZRC, Zoological Reference Collection, Lee Kong Chian Natural History Museum, National University of Singapore.

NOMENCLATURAL ACTS

This work and the nomenclatural act herein, have been registered in ZooBank. The ZooBank Life Science Identifier (lsid) for this publication is urn:lsid:zoobank.org:pub:313B15C1-4865-4746-8186-CD8FF4EF1D50.

Parabrachidontes Tan, Tan, Sanpanich, Duangdee & Ambarwati, new genus

Type species: *Modiola leucosticta* von Martens, 1897: 86–88 (see below); by present designation.

ZooBank registration: urn:lsid:zoobank.org:act:EB33F9A1-3627-4E3D-A639-7D1A921CF36F and urn:lsid:zoobank.org:act:7DA9F849-ED7E-429E-A0C9-DAF3FFD9D7C8

Diagnosis. Adult shell up to 30 mm in length, mytiliform to modioliform in outline, equivalve; shell surface generally either greenish-brown or dark brown to black, entirely smooth or bearing weak to strong radial ribs, often with closely set commarginal lines. Umbones generally subterminal. Shell interior iridescent; linear series of small teeth are present on the inside edge of shell margins anterior (about 12 elongate, closely-set teeth) and posterior (about 7 papillate crenules) to the ligament. Ligament internal, narrow, resilial pits absent. Posterior adductor muscle scar confluent with single, narrow posterior byssal retractor muscle scar. Ascending lamella of outer demibranch on either side of animal is shorter than descending lamella; terminal (upper) edge of the ascending lamella fused to the adjacent mantle lobe surface. Ascending lamella of inner demibranch may also be fused to the mantle surface of the visceral mass. Plicate glands are absent. The pericardium is located between the anterior and posterior sets of the posterior byssal retractor muscle complex (Category 3 of Morton, 2015). Currently, the new genus comprises three species distributed variously in India, peninsular Thailand, Singapore, Sarawak (east Malaysia) and Sulawesi (Indonesia). Two of the three species occur in salinities below 3 psu.

Parabrachidontes leucostictus (von Martens, 1897), new combination

Modiolus leucostictus von Martens, 1897: 86–88, plate X, figs. 18–21.
Modiola evansi Smith, 1903: 368, figure.
Modiola evansi—Lynge, 1909: 132; Annandale, 1916: 93; Suvatti, 1939: 102
Brachidontes arcuatulus—Brandt, 1974: 257 pl. 18 fig. 21 (not *Arcuatula arcuatula* (Hanley, 1843))
Limnoperna siamensis—Swennen et al., 2001: 62 and figure 008 [not *Limnoperna siamensis* (Morelet, 1866)]
Arcuatula leucosticta—Huber, 2010: 107 and 110 (not figured)
Brachidontes evansi—Huber, 2010: 116, figure.
Brachidontes setiger—Ngo et al., 2018: 176, fig. 4C (not *Brachidontes setiger* Dunker, 1857)
Parabrachidontes leucostictus—Tan et al., 2023: 304–308 and figs. 1, 3, 4, 6B, 7, S1B, S2B, C

Diagnosis. Shell surface faintly corrugated radially, with corresponding dark brown to black bands over a dark green background. Umbones subterminal. Dorsally directed edges of ascending lamellae of both outer and inner demibranchs are attached by tissue fusion to mantle surface.

Material examined. *Modiolus leucostictus* holotype (ZMA 135170) and paratypes (ZMB 108.841), Maros River, Makassar, South Sulawesi (MZBC Pel.2214); *Modiola evansi*: 10 syntypes from Tale Noi, Songkhla Lake, Thailand (NHMUK 1901.2.4.140-149; ANSP 98099); 20 specimens from Thale Noi and Thale Luang, Songkhla Lake, Thailand (PMBC 30687-88; ZRC.MOL.24971-72); 8 specimens from Santubong & Buntal, Sarawak, East Malaysia (NHMUK 94.7.14.27–33); 20 specimens from Sarawak River, Kuching, East Malaysia (ZRC.MOL. 24958); 10 specimens from Maros River, Makassar, South Sulawesi, Indonesia (ZRC. MOL. 24959).

Description. Shell up to 30 mm in length, thin, elongate, mytiliform, somewhat flattened laterally but with a moderately strong keel. Valve surfaces dominated by fine, closely spaced commarginal lines over a faintly corrugated surface. The raised regions correspond to the dark brown to black radial pigment bands present across the posterior region of the valves, while the furrows between the dark pigment bands are greenish yellow. A few of these dark bands bifurcate towards the shell margin. These bands are narrower and closer together along and ventral to the keel but become progressively wider dorsally where the bands are also farther apart. The region ventral to the keel is brownish yellow, where the radial bands are obsolete or absent altogether. At the anteriormost region, 4–6 faint radial furrows are present. Umbones are subterminal. Byssal hairs

absent. Interior of shell is tinged iridescent light purple. Inside edges of dorsal and anterior regions of shell are weakly crenulate. The ligament is narrow, devoid of resilial pits. Shell under ligament has no crenules, while posterior to the ligament, there are 10–12 crenules on the inside edge of the shell. The region anterior to the ligament and ventral to the umbones has about 15 denticles. The posterior shell margin is faintly crenulate, corresponding to the termination of the radial bands on the shell surface. The anterior adductor muscle scar traces a shallow arc just inside the antero-ventral edge of the shell. The posterior adductor muscle is oval and elongate antero-posteriorly (3.5 mm x 2 mm) and merges with the posterior byssal retractor muscle scar, which is unusually long and extends anteriorly beyond a quarter way from the posterior end of the ligament. Shell microstructure comprising a thin (10-15µm) subperiostracal homogeneous layer (likely of calcite) and thicker 250-300 µm nacreous aragonitic layer. A simple prismatic myostracum occurs as the innermost layer. Shell is thus mostly aragonitic (97–98% w/w) with a small amount of calcite that is likely associated with the uppermost shell layer just under the periostracum. Animal. Labial palps small (about 48 folds), short, about ⅕ length of ctenidium (3 mm vs 16 mm). Edges of ascending lamellae of outer and inner demibranchs attached along its entire length to inner surface of adjacent mantle along its mid-region. Inner demibranchs about half width of outer demibranchs (outer: inner demibranch width 2.8 mm: 1.4 mm). Plicate organs absent. Foot elongate, muscular. Midgut and style separate. The intestine makes a loop along the left side of the animal. The pericardial complex is located dorsal to the gap between the anterior and posterior sets of the posterior byssal retractor muscle complex (Category 3 of Morton, 2015). Posterior region of mantle edge forming the inhalant aperture is thickened containing yellowish-white subcutaneous pigment grains. The crenulate margin is thrown into multiple folds, whose surface is lightly shaded with greyish-black pigment. The inside edge of the mantle edge is smooth, and guard papillae are absent from the inhalant siphon.

Geographical distribution. Currently known from southern Thailand (Thale Noi and Thale Sap, Songkhla Lake; Annandale, 1916), East Malaysia (Sarawak River, Kuching) and Indonesia (Maros River, Makassar, South Sulawesi).

Taxonomic remarks. *Parabrachidontes leucostictus* (von Martens, 1897) was described from material collected in the Maros River near Makassar in South Sulawesi, Indonesia. Von Martens (1897: 86) described the shell as '…olivaceo-fusca, punctis albis adspersa…', the latter referring to the whitish spots present on the valve surfaces of the holotype and some paratypes (see Tan et al., 2023: fig. 3) for which the species name is presumably derived. On careful examination of images of the type material however, these 'spots' are actually the bases of byssal hairs adhering to the shell surface. Such hairs are absent in the syntypes of *Parabrachidontes evansi* (Smith 1903) described several years later from Thale Noi, the innermost freshwater lake of the Songkhla Basin in southern peninsular Thailand (Smith, 1903; not Malacca as erroneously referred to in the title of the paper). We also did not observe byssal hairs on the material collected recently from the type locality in Indonesia as well as from Malaysia and Thailand. However, the deposition of these byssal hairs may be a habitat-specific response and it is not uncommon to observe individuals with and without such hairs from different environments, as in *Limnoperna fortunei* (e.g., Montalto & Molina, 2014) and *Xenostrobus securis* (Tan KS, pers. obs.). At the same time, the type materials of both *P. leucostictus* and *P. evansi* have fine radial ribs that are tinged dark brown. Based on these observations, together with additional morphological details seen in this study, we conclude that the two species are likely to be the same.

Brandt (1974) erroneously referred to *Modiola evansi* as '*Brachidontes arcuatulus*', while Swennen et al. (2001) mistook it as a species of *Limnoperna*. More recently, *P. leucostictus* (as *evansi*) was placed in the genus *Brachidontes* by Huber (2010). It remains to be seen if brackish water specimens from India identified as '*Brachidontes striatulus*' (see Tan et al., 2021; not *Byssogerdius striatulus*) are related to *Parabrachidontes leucostictus*. Apart from their resemblance in shell colour and sculpture, the position of the pericardium in '*Modiolus striatulus*' from Calcutta as observed by Morton (1977) is similar to *P. leucostictus* observed in this study (i.e., Category 3 of Morton, 2015; see above).

***Parabrachidontes amnicus* Tan, Tan, Sanpanich, Duangdee & Ambarwati, 2023**

(Fig. 1)

ZooBank registration. urn:lsid:zoobank.org:act:B92166DD-5FA0-4656-BDD1-DC2C4AA51A4D

'*Parabrachidontes*' *amnicus* Tan et al., 2023: 7, figs. 1, 2, 6A, 7; Suppl. Info., pp. 2–4, figs. S1A, S2A.

Holotype. THAILAND, Satun Province, Khlong Pak Bala, upper reaches of river, 17 May 2018 (PMBC 30680)
Paratypes. Same location data as for holotype, 6 individuals preserved in ethanol (PMBC 30681, sequenced); PMBC 30682; ZRC.MOL.29857; ZRC.MOL.29858).

Other material. Same data as for holotype, 6 individuals fixed in formalin (ZRC.MOL.24957).

Etymology. The species is named for the riverine (Latin: 'amnicus', of a stream) habitat from which it was collected.

Diagnosis. Valve surface with numerous narrow but distinct radial ribs across the dorsal half of the shell that become obsolete towards the anterior end; periostracum greenish at posterior half of shell and along the posterior margin, while the anterior half of shell is brown.

Description. Shell thin, small (SL to 20 mm), elongate, mytiliform, somewhat flattened laterally with a moderate keel. Shell surface with broad radial ribs crossed by irregularly spaced major commarginal lines interspersed with fine, closely spaced minor commarginal lines. Radial

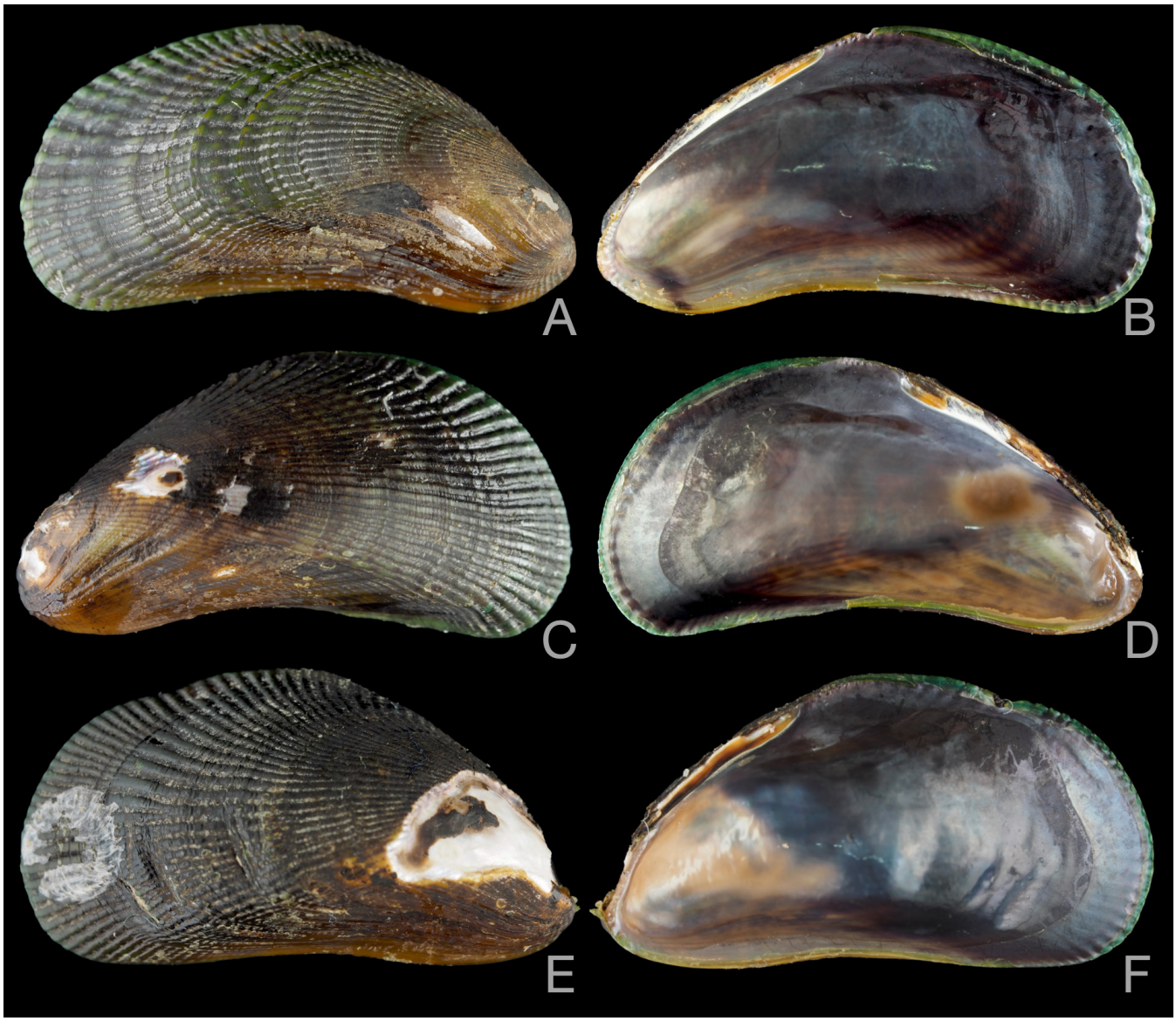

Fig. 1. *Parabrachidontes amnicus*, Khlong Pak Bara, Satun Province, Thailand. A, B, holotype, PMBC 30680, SL=15.2 mm; C, D, paratype, ZRC.MOL.29857, SL=14.8 mm; E, F, paratype, PMBC 30681, SL=15.6 mm (see also Tan et al., 2023).

ribs number about 26 dorsal to keel, sometimes bifurcating towards the shell margins; finer, closely set ribs are present ventral to the keel, becoming obsolete towards the anterior, but reappearing again at the anterior end as broad but closely spaced radial ribs. Umbones subterminal. Periostracum green at the posterior half of the shell and along the posterior valve margins, while the anterior half of the shell is dark brown. Byssal hairs absent. Interior of shell tinged with purple; inside margins of dorsal and anterior regions crenulate, which correspond to the terminations of the radial ribs on the shell surface. The ligament is robust, relatively wide, resilium pits absent. The inside shell margins immediately posterior to the ligament bears about 10 crenules, whilst those at the anterior margin ventral to the umbones has 17 strongly impressed denticles that become smaller towards the posterior. The anterior adductor muscle scar traces a shallow arc just inside the antero-ventral edge of the shell. The posterior adductor muscle scar is relatively large, ovate-circular in shape (diameter about 2.7 mm) and is conjoined with the broadly elongate posterior byssal and foot retractor muscle scar that extends about ¼ way along the length of the ligament. In addition, a series of small circular attachment scars (about 25 in total, but not always visible) occurs along the inside shell surface of the keel from the posterior mantle attachment towards the anterior, ending at the mid-region of the shell. Shell microstructure comprising a thin (10–15µm) subperiostracal homogeneous layer and thicker 250–300 µm nacreous layer. A simple prismatic myostracum occurs as the innermost layer. Shell is predominantly aragonitic (98.8% w/w) with presence of trace amounts of calcite (0.8%). Animal with very short labial palps (about ⅕ length of ctenidium) with about 22 folds. Upper edges of the ascending lamellae of outer demibranchs attached to the inside surface of mantle about ⅔ way dorsally. Upper edges of ascending lamellae of inner demibranchs attached to roof of mantle cavity. Plicate glands absent. Foot elongate, muscular. The posterior pedal/byssal retractor muscle complex is distinctly separated into two regions, comprising an anterior set that is barely split into two equal bundles near the shell attachment region, and a posterior set with two equally elongate bundles

that is each subdivided into two smaller bundles at the attachment region. The pericardium is located between the anterior and posterior sets of the posterior byssal retractor muscle complex (Category 3 of Morton, 2015). Midgut and style sac separate. The posterior region of the thickened mantle edge has up to 10 short, simple, unbranched papillae in a single row on either side of the inhalant region, where subcutaneous white pigment grains are present. The mantle margin is entire and slightly crenulate.

Shell (holotype). Shell length 15.2 mm (PMBC 30680) (see Fig. 1A, B)

Geographical distribution. Currently known only from Pak Bara in Satun Province, southwest Thailand.

Taxonomic remarks. The prominent and numerous radial ribs present on the external shell surface of *Parabrachidontes amnicus* distinguish this species from its congener *P. leucostictus* (see Tan et al., 2023). In the latter species, radial ribs are present but are weak and generally flattened. The prominent radial sculpture in *P. amnicus* is reminiscent of many marine *Brachidontes* species often found intertidally on seashores around the world. However, apart from their convergence in shell sculpture, *P. amnicus* can be easily distinguished from true *Brachidontes* species in having the terminal edges of the ascending lamella of its outer demibranch attached to the mantle lobe. As far as we are aware, the ascending lamellae of the outer demibranchs of *Brachidontes* species are free and not attached to the mantle surface. The disparate positions of the two genera in phylogenetic trees based on multiple genes (see Fig. 1 in Tan et al., 2023) also attest to their evolutionary divergence.

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