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# *Schistura diminuta*, a new miniature loach from the Mekong River drainage of Cambodia (Teleostei: Nemacheilidae)

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*Schistura diminuta*, new species, is described from the lower Sekong River, Mekong drainage, Cambodia. It is distinguished from congeners by the following characters: tiny adult body size (maximum known size 19.5 mm SL); lateral line incomplete, with 14–17 pores, terminating on the flank anterior to vertical through pelvic-fin origin; absence of axillary pelvic lobe; processus dentiformis weakly developed; dorsal-fin rays iii-iv.8.i; principal caudal-fin rays 8+8 (7+7 branched caudal-fin rays); a distinct dark brown spot at centre of caudal-fin base; and 9–10 irregular light brown bars along dorsal body surface.

## Introduction

Members of the family Nemacheilidae are small, benthic fishes, distributed throughout Asia, Europe and the Tana Lake basin of Ethiopia where they mainly inhabit running waters and well oxygenated hill streams (Kottelat, 1990). With close to 200 valid species, the genus *Schistura* McClelland is currently the largest and one of the most widespread of all the nemacheilid genera (Kottelat, pers. comm.). To date, roughly 70 species have been described from the Indochinese region alone (Kottelat, 1990, 1998, 2000; Freyhof & Serov, 2000) with two known to exist in the Mekong drainage in Cambodia (Kottelat, 1990; Rainboth, 1996), viz. *S. daubentoni* (northern Cambodian Mekong, including the Sesan River) and *S. magnifluvis* (middle Cambodian Mekong). In addition to these two species of *Schistura,* Rainboth (1996) listed four more *(S. kengtungensis*, *S. kohchangensis*, *S. laterimaculatus* and *S. nicholsi)* as probable inhabitants of the Cambodian Mekong, given their presence in bordering areas of Thailand, although presence of these latter species in Cambodia has yet to be confirmed.

A recent ichthyological survey of the lower Sekong River (one of the three major tributaries of the Mekong in Cambodia) in northeastern Cambodia (January, 2010) obtained five tiny specimens of *Schistura* that differ markedly from other species of the genus presently reported from the region. Further investigation has revealed that these specimens represent a new species, which is described herein.

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## Materials and methods

Measurements follow Kottelat (1990) except for head measurements, which are expressed as a percentage of lateral head length (HL). Counts and osteological terminology follow Conway (2011). Measurements were taken to the nearest 0.1 mm on the left side of specimens using a Zeiss DRC stereomicroscope equipped with an ocular micrometer. Counts were obtained from the left side of specimens with the aid of transmitted light. Specimen photographs were obtained using a Zeiss Stereo Discovery V20 stereomicroscope equipped with an axiocam MRc5. A single specimen was cleared and double stained (c&s) following the protocol of Taylor & van Dyke (1985) and 4 specimens were radiographed. Only total vertebral counts are reported for the holotype and non-c&s paratype material because it was not possible to distinguish between abdominal and caudal vertebrae in the radiographs. Materials examined are housed in the following collections: ZRC, Raffles Museum of Biodiversity Research, National University of Singapore, Singapore; TCWC, Texas Cooperative Wildlife Collection, Texas A&M University, College Station; IFReDI, Fish collection of the Inland Fisheries Research and Development Institute, Phnom Penh.

## *Schistura diminuta*, new species
(Fig. 1)

**Holotype.** ZRC 53105, female, 18.1 mm SL; Cambodia: Stung Treng province: Mekong River drainage, lower Sekong River in Siem Pang district, 14°07'11.88"N 106°23'11.36"E; C. Ou, C. G. Montaña, K. O. Winemiller & S. Putrea, 18 January 2010.

**Paratypes.** TCWC 14766.01, 2 (1 c&s), 18.1–19.0 mm SL; ZRC 53106, 1, 19.1 mm SL; IFReDI uncatalogued, 1, 19.5 mm SL; same locality as holotype.

**Diagnosis.** A miniature species, distinguished from other members of the genus by the following combination of characters: tiny adult body size (largest specimen examined 19.1 mm SL); lateral line incomplete, with 14–17 pores, terminating on flank anterior to vertical through pelvic-fin origin; presence of a distinct dark brown spot at centre of caudal-fin base; presence of 9–10 irregular light brown bars along dorsal body surface; absence of axillary pelvic lobe; weakly developed processus dentiformis; dorsal-fin rays iii-iv.8.i; principal caudal-fin rays 8+8 (7+7 branched caudal-fin rays).

**Description.** General body shape as in Figure 1. Morphometric and meristic characters listed in Table 1. A miniature species (sensu Weitzman & Vari, 1988), largest specimen examined 19.1 mm SL (range 18.0–19.5). Body moderately elongate, cross-section circular to slightly compressed anteriorly, becoming increasingly more oval posterior to dorsal-fin origin. Body depth greatest midway between occiput and dorsal-fin origin, decreasing slightly in depth towards caudal peduncle. Head moderately depressed, cheeks somewhat inflated. Eye relatively large, positioned high on side of head. Mouth subterminal and strongly arched (Fig. 2), upper and lower lips fleshy; lower lip with median interruption. Two pairs of rostral barbels and one pair of maxillary barbels present. Inner rostral barbel reaching slightly past base of outer rostral barbel when extended; outer rostral barbel reaching slightly past base of maxillary barbel when extended; maxillary barbel reaching to or slightly past horizontal through center of eye when extended. Rostral cap poorly developed, not extended as a fleshy flap between base of rostral barbels. Deep groove present between upper lip and rostral cap. Upper and lower jaws with a sharp horny sheath, processus dentiformis poorly developed. Anterior nostil situated at tip of a short tube, posterior edge of opening bordered by a triangular flap; posterior nostril larger than anterior nostril, situated between base of tube surrounding anterior nostril and anterior margin of orbit.

Dorsal fin with iii.8.i (3) or iv.8.i (1) rays. Anal fin with ii.5.i rays. Principal caudal rays 8+8, branched caudal fin rays 7+7. Dorsal procurrent rays 8 (1), 10 (2) or 11 (1), ventral procurrent rays 4 (3) or 5 (1). Pelvic fin with i.5.i rays, pectoral fin with i.7.ii (2) or i.7.iii rays. Dorsal-fin origin situated slightly posterior to vertical through pelvic-fin insertion. Posterior margin of dorsal fin straight to slightly concave. Anal-fin origin opposite last dorsal-fin ray, not reaching caudal-fin base when depressed. Posterior margin of anal fin slightly convex. Pectoral fin rounded, horizontally placed, posteriormost tip reaching point midway between pectoral-fin origin and pelvic-fin origin when adpressed. Pelvic fin small, horizon-

**Fig. 1.** *Schistura diminuta*, ZRC 53105, holotype, 18.1 mm SL, female; Cambodia, Sekong River.

tally placed, posteriormost tip reaching anal-fin origin when depressed. Base of pelvic fin without axillary lobe. Caudal fin weakly forked, tips of upper and lower lobes rounded. Lower lobe slightly longer than upper lobe.

Total number of vertebrae 36–38, consisting of 21 abdominal and 16 caudal in single c&s specimen. Following osteological remarks based on single c&s specimen. Caudal skeleton with five hypurals. Second (free) uroneural of caudal skeleton and supraneurals posterior to third absent. Anterior swim-bladder chamber bilaterally paired, housed within an ossified capsule formed by lateral process of second vertebral centrum and outer arm of os suspensorium. Swim bladder capsule with two openings laterally; anteriormost opening circular, posteriomost opening lozenge-shaped. Neurocranium with large bell-shaped postepiphysial fontanelle, narrowest posteriorly, bordered by frontal, parietal and supraoccipital bones. Fifth ceratobranchial with a single row of nine to 10 curved teeth with pointed tips.

Cephalic lateral line system composed of supraorbital, infraorbital, otic and supratemporal sensory canals only. Preopercular-mandibular canal absent. Anteriormost portion of supraorbital and entire infraorbital and otic canals enclosed in a series of short, poorly ossified tube-like bones, which lack contact with underlying dermal ossifications. Frontal portion of supraorbital canal, and parietal and supraoccipital portion of supratemporal canal enclosed in underlying bone. Lateral line incomplete, with 14–17 pores, terminating on body side anterior to vertical through pelvic-fin insertion.

Scales small, cycloid, present on posterior half of body only; deeply embedded in skin and widely separate from each other; general features

of scales (focus, circuli and radii) not discernable. Stomach large, sac-like, intestine straight, uncoiled.

**Sexual dimorphism.** No obvious sexual dimorphism present. Large ova visible in the holotype (Fig. 1, ventral view) and two of the paratypes, indicating that these individuals are adult females.

**Coloration.** In alcohol, body background colour pale cream. Dorsal surface of body with eight to 10 light brown bars, highly variable in size, shape and degree of connectivity. Majority of bars ex-

**Table 1.** Morphometric and meristic characters of holotype and 4 paratypes of *Schistura diminuta* expressed as a percentage of standard length (SL) or head length (HL).

| | holotype | paratypes | | | | mean | SD |
|---|---|---|---|---|---|---|---|
| | ZRC 53105 | TCWC 14766.01 | TCWC 14766.01 | ZRC 53106 | IFReDI Uncat. | | |
| Standard length (mm) | 18.1 | 18.0 | 19.1 | 19.0 | 19.5 | | |
| **In percent of standard length** | | | | | | | |
| Head length | 23.2 | 21.6 | 22.1 | 22.1 | 22.0 | 22.2 | 0.57 |
| Body depth at dorsal-fin origin | 15.4 | 14.4 | 16.6 | 17.9 | 13.8 | 15.6 | 1.6 |
| Predorsal length | 55.8 | 53.8 | 54.7 | 54.2 | 52.8 | 54.2 | 1.1 |
| Prepelvic length | 53.0 | 51.1 | 50.3 | 53.1 | 53.3 | 52.2 | 1.4 |
| Preanus length | 72.9 | 70.0 | 71.8 | 71.6 | 69.2 | 71.1 | 1.5 |
| Preanal length | 76.2 | 74.4 | 75.7 | 74.2 | 73.9 | 75.1 | 0.8 |
| Length of caudal peduncle | 13.8 | 14.4 | 14.9 | 14.7 | 13.8 | 14.3 | 0.5 |
| Depth of caudal peduncle | 8.3 | 8.8 | 8.8 | 8.9 | 8.2 | 8.6 | 0.3 |
| Width at dorsal-fin origin | 13.8 | 13.3 | 13.8 | 14.7 | 12.8 | 13.7 | 0.7 |
| Width at anal-fin origin | 7.7 | 8.3 | 6.1 | 7.9 | 6.1 | 7.2 | 1.0 |
| Dorsal-fin height | 13.8 | 13.8 | 13.8 | 13.1 | 14.5 | 13.8 | 0.4 |
| Anal-fin depth | 16.0 | 17.7 | 16.6 | 15.8 | 15.4 | 16.3 | 0.9 |
| Length of upper caudal-fin lobe | 21.4 | 22.7 | 20.9 | 21.0 | 21.5 | 21.6 | 0.7 |
| Length of lower caudal-fin lobe | 23.2 | 25.0 | 23.7 | 23.7 | 22.5 | 23.6 | 0.9 |
| Length of pelvic fin | 17.1 | 18.8 | 16.0 | 18.4 | 17.9 | 17.7 | 1.1 |
| Length of pectoral fin | 20.4 | 22.7 | 22.0 | 21.0 | 22.0 | 21.7 | 0.9 |
| Eye diameter | 5.5 | 5.5 | 5.5 | 5.7 | 5.1 | 5.5 | 0.2 |
| Head depth at eye | 11.6 | 11.6 | 11.6 | 12.1 | 11.8 | 11.7 | 0.2 |
| Head depth at nape | 13.8 | 12.7 | 13.8 | 13.1 | 12.8 | 13.2 | 0.5 |
| Snout length | 6.1 | 6.1 | 7.2 | 6.3 | 7.2 | 6.5 | 0.5 |
| Head width at nares | 8.3 | 7.7 | 7.7 | 7.9 | 7.7 | 7.9 | 0.2 |
| Maximum head width | 14.4 | 15.0 | 14.4 | 15.8 | 14.9 | 14.9 | 0.6 |
| Interorbital width | 7.2 | 6.6 | 7.2 | 6.8 | 6.6 | 6.9 | 0.2 |
| **In percent of head length** | | | | | | | |
| Eye diameter | 23.8 | 25.6 | 25.0 | 26.2 | 23.5 | 25.1 | 1.0 |
| Head depth at eye | 50.0 | 53.8 | 52.5 | 54.8 | 53.5 | 52.7 | 2.1 |
| Head depth at nape | 59.5 | 58.9 | 62.5 | 59.5 | 58.1 | 60.1 | 1.6 |
| Snout length | 26.2 | 28.2 | 32.5 | 28.6 | 32.5 | 28.8 | 2.6 |
| Head width at nares | 35.7 | 35.9 | 35.0 | 35.7 | 34.9 | 35.6 | 0.4 |
| Maximum head width | 62.0 | 69.2 | 65.0 | 71.4 | 67.4 | 66.9 | 4.2 |
| Interorbital width | 30.9 | 30.7 | 32.5 | 30.9 | 30.2 | 31.3 | 0.8 |
| Dorsal-fin rays | iv.8.i | iii.8.i | iii.8.i | iii.8.i | iii.8.i | – | – |
| Anal-fin rays | iii.5.i | iii.5.i | iii.5.i | iii.5.i | iii.5.i | – | – |
| Principal caudal-fin rays | 8+8 | 8+8 | 8+8 | 8+8 | 8+8 | – | – |
| Pelvic-fin rays | i.5.i | i.5.i | i.5.i | i.5.i | i.5.i | – | – |
| Pectoral-fin rays | i.8.i | i.7.ii | i.7.iii | i.7.iii | i.7.iii | – | – |
| Abdominal vertebrae | – | – | 21 | – | – | – | – |
| Caudal vertebrae | – | – | 16 | – | – | – | – |
| Total vertebrae | 36 | 38 | 37 | 37 | – | – | – |

tended ventrally to form series of seven to nine irregular light brown vertical bars across body sides. Variable number of interspaces between irregular dark brown vertical bars occupied by light brown blotches or thin light brown horizontal stripes (Fig. 3). Such markings present on both right and left sides of body in two paratypes (TCWC 14766.01, 18.1 mm; ZRC 53106, 19.0 mm SL); present only on right side of holotype and remaining paratype (Fig. 3). Distinctive dark brown spot located at centre of caudal-fin base, level with horizontal septum. Dorsal surface of head and occiput light brown. Small, indistinct dark brown blotch extending across cheek below orbit. Ventral surface devoid of pigmentation except for small scattering of dark brown melanophores around insertions of branched anal-fin rays. Dorsal fin with two indistinct rows of light brown spots across centre, running parallel to contour of dorsal body surface. Caudal fin with two irregular vertical bars; proximalmost bar formed by irregular light brown spots situated close to base of principal rays; distalmost bar formed by small regular light brown spots positioned at fork of branched principal caudal-fin rays. Pectoral fin with two minute dark brown markings, positioned at the fork of the first and second branched pectoral-fin rays respectively. Pelvic and anal fins without pigmentation.

Coloration in life unknown.

**Distribution.** *Schistura diminuta* is known presently only from the type locality on the Sekong River, Mekong Drainage (Fig. 4). The Sekong River originates in Vietnam and flows through Xekong and Attapeu provinces in southern Laos before entering Stung Treng province of Cambodia, where it merges with the Sesan and Srepok rivers. *Schistura diminuta* was collected in the mainstream of the river, from moderate flow, over a sandy substrate (Fig. 5). Water parameters at the type locality included: pH: 7.9; water conductivity: 69 $\mu S \cdot cm^{-1}$ and dissolved oxygen: 6.5 $mg \cdot l^{-1}$. The vegetation in the area is dominated by open deciduous dipterocarp forest with grass understory (Rundel, 2009).

Roughly 90 species of freshwater fishes were collected at the type locality together with *S. diminuta*. Many of these specimens require more detailed examination before they can be identified, and we therefore list here only congeneric species – *S. daubentoni*, *S.* cf. *clatrata* and *S.* sp. indet.

**Etymology.** *Diminutis*, the verbal adjective of the Latin verb *diminuo*, meaning to break into small pieces, in reference to the small size of this species.

## Discussion

With 185 valid species (Kottelat, pers. comm.), *Schistura* is the most species-rich genus-level grouping of the Nemacheilidae and one of the largest of the order Cypriniformes. Its sheer diversity and composite nature has lead several authors to question whether it represents a natural (monophyletic) group (e.g. Kottelat, 1990; Banarescu & Nalbant, 1995), though an alternative classification scheme has yet to be proposed. The most recent revision of nemacheiline loaches from Indochina (Kottelat, 1990) highlighted the difficulty of recognizing monophyletic groups within *Schistura* and proposed two, possibly non-monophyletic groups of species (A&B) that subsequent authors have nonetheless found useful working definitions (Kottelat, 1998; Vishwanath & Kongbrailatpam, 2004; Bohlen & Šlechtová, 2010).

Based on its small size, reduced number of pelvic, pectoral and caudal rays and reduced lateral line, *Schistura diminuta* would belong to the group B of Indochinese *Schistura* (Kottelat, 1990), grouped together solely by a number of reductive, likely convergent characters (Kottelat, 1998). Species assigned to this group include: *S. acuticephalus*, *S. cincticauda*, *S. daubentoni*, *S. kangjupkhulensis*, *S. malaisei*, *S. paucicincta*, *S. paucifasciata* and *S. robertsi* (Kottelat, 1990, 1998). *Schistura diminuta* can be distinguished from all of these species by its lower number of branched caudal-fin rays (7+7 vs. 8+7 in *S. kangjupkhulensis* and *S. paucicincta*, 8+8 in *S. daubentoni* and possibly also *S. acuticephalus*, 8–9+8 in *S. malaisei* and *S. robertsi*, and 9+8 in *S. cincticauda* and *S. paucifasciata*) and from all excluding *S. daubentoni* by the presence of a dark round marking at the base of the caudal fin (vs. complete or incomplete vertical bar at base of caudal fin). *Schistura diminuta* is easily distinguished from *S. daubentoni* (which is found in sympatry at the type locality) by its shorter lateral line (lateral line canal with 14–17 pores, terminating on body side anterior to pelvic fin insertion in *S. diminuta* vs. 32–39 pores, terminating on body side posterior to vertical through pelvic fin insertion, roughly opposite vertical through anus in *S. daubentoni*)

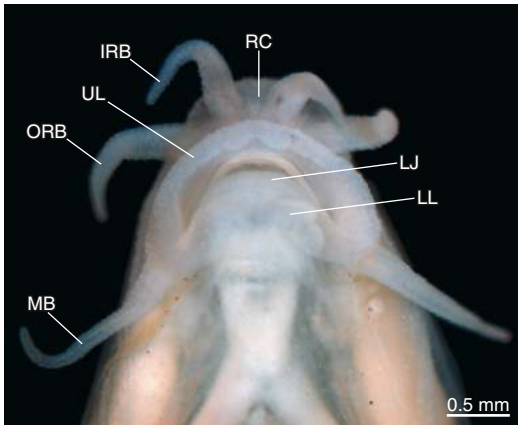


**Fig. 2.** *Schistura diminuta*, TCWC 14766.01, paratype, 19.0 mm SL, female; mouth. Abbreviations: **IRB,** inner rostral barbel; **LJ,** lower jaw; **LL,** lower lip; **MB,** mandibular barbel; **ORB,** outer rostral barbel; **RC,** rostral cap; **UL,** upper lip.


**Fig. 3.** *Schistura diminuta,* predorsal region. **a,** ZRC 53105, holotype, 18.1 mm SL, right side (image reversed); **b,** TCWC 14766.01, paratype, 19.0 mm SL, right side (image reversed).

and by differences in vertical barring (eight to ten irregular vertical bars along the side of the body in *S. diminuta* vs. six regular vertical bars in *S. daubentoni*). The shape and size of the dark round marking at the base of the caudal fin also differs between *S. diminuta* and *S. daubentoni*. In *S. daubentoni* this marking is best described as

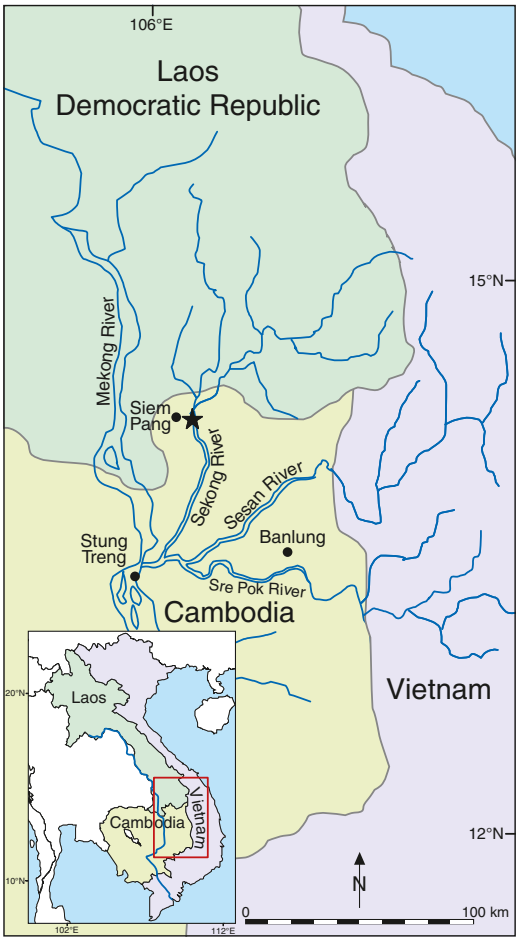


**Fig. 4**. Type locality of *Schistura diminuta* (★).

blotch-like in appearance and is much larger than the orbit, whereas in *S. diminuta* the spot is distinctly round and smaller than the orbit, reminiscent to that exhibited by certain members of the genus *Nemacheilus* (Kottelat, 1990). In addition to *S. daubentoni*, we are aware of only one other Indochinese species of *Schistura* with a dark round marking at the base of the caudal fin, *S. dorsizona* (Kottelat, 1998). *Schistura diminuta* and *S. dorsizona* are easily distinguished based on the number of pores in the lateral line canal (14–17 vs. 26–59) and by the number of branched caudal fin rays (7+7 vs. 8–9+7–8). *Schistura diminuta* is further distinguished from *S. dorsizona* by the absence (vs. presence) of a wide horizontal stripe along the body side, level with the horizontal septum.

**Fig. 5.** Lower Sekong River, Siem Pang district, Cambodia. Type locality of *Schistura diminuta*.

In addition to *Schistura diminuta* and *S. daubentoni*, only one other species of *Schistura* (*S. magnifluvis*) has been reported with certainty from the Cambodian Mekong (Kottelat, 1990; Rainboth, 1996; *S. pellegrini* was also listed as an inhabitant of the Cambodian Mekong by Rainboth (1996) but this species was later shown to be restricted to small coastal streams in eastern Vietnam; Freyhof & Serov, 2001). *Schistura diminuta* is easily distinguished from *S. magnifluvis* by its lower number of branched caudal fin rays (7+7 vs. 9+8) and by features of its colour pattern, including the presence of a dark round marking at the base of the caudal fin (vs. complete or incomplete dark vertical bar at base of caudal fin), and by the absence (vs. presence) of a distinctive dark spot at the dorsal-fin origin.

Given the high diversity of *Schistura* in the neighbouring countries of Thailand (Kottelat, 1990), Laos (Kottelat, 1998, 2000, 2001a, 2009) and Vietnam (Freyhof & Serov, 2001; Kottelat, 2001b) it is highly likely that additional (described and undescribed) species of *Schistura* will result from future ichthyofaunal surveys in Cambodia. For example, twelve additional species of *Schistura* have been recorded from the mainstem and tributaries of the Xe Kong in Laos (Sekong in Cambodia), upstream from the border with Cambodia, including, *S. bolavenensis*, *S. clatrata*, *S. dorsizona*, *S. fusinotata*, *S. imitator*, *S. isostigma*, *S. khamtanhi*, *S. kongphengi*, *S. nicholsi*, *S. nomi*, *S. rikiki* and *S. tizardi* (Kottelat, 2009) and several of these species may also be present downriver in Cambodia (M. Kottelat, pers. comm.). Based on available information (Kottelat, 1998, 2000, 2001a), *S. diminuta* does not appear to be conspecific with any of these aforementioned species of *Schistura*, differing based on features of colour pattern, meristics, or a combination of both (see above for characters distinguishing *S. diminuta* from *S. dorsizona*).

With mature individuals less than 19.0 mm SL, *S. diminuta* is clearly a miniature species (Weitzman & Vari, 1988; Kottelat & Vidthayanon, 1993) and the smallest species of *Schistura* described to date (a title held previously by *S. rikiki*,

the largest recorded specimen of which is 24.2 mm SL; Kottelat, 2000, 2001a). Based on its well-ossified skeleton with relatively few reductions, *S. diminuta* is best described as a proportioned dwarf (vs. developmentally truncated miniature sensu Rüber et al., 2007; Britz & Conway, 2009).

### Comparative material

*Schistura daubentoni*: TCWC 14766.02, 1, 32 mm SL; Cambodia: Stung Treng province, Mekong River drainage, Sekong River in Siem Pang district.

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## Literature cited

Bohlen, J. & V. Šlechtová. 2010. *Schistura udomritthiruji*, a new loach from southern Thailand (Cypriniformes: Nemacheilidae). Ichthyological Exploration of Freshwaters, 20: 319–324.

Britz, R. & K. W. Conway. 2009. Osteology of *Paedocypris*, a miniature and highly developmentally truncated fish (Teleostei: Ostariophysi: Cyprinidae). Journal of Morphology, 270: 389–412.

Conway, K. W. 2011. Osteology of the South Asian Genus *Psilorhynchus* McClelland, 1839 (Teleostei: Ostariophysi: Psilorhynchidae) with investigation of its phylogenetic relationships within the Order Cypriniformes. Zoological Journal of the Linnean Society, 163: 50–154.

Freyhof, J. & D. V. Serov. 2001. Nemacheiline loaches from Central Vietnam with descriptions of a new genus and 14 new species (Cypriniformes: Balitoridae). Ichthyological Exploration of Freshwaters, 12: 133–191.

Kottelat, M. 1990. Indochinese nemacheilines. A revision of nemacheiline loaches (Pisces: Cypriniformes) of Thailand, Burma, Laos, Cambodia and southern Viet Nam. Pfeil, München, 262 pp.

— 1998. Fishes of the Nam Theun and Xe Bangfai basins, Laos, with diagnoses of twenty-two new species (Teleostei: Cyprinidae, Balitoridae, Cobitidae, Coiidae and Odontobutidae). Ichthyological Exploration of Freshwaters, 9: 1–128.

— 2000. Diagnoses of a new genus and 64 new species of fishes from Laos (Teleostei: Cyprinidae, Balitoridae, Bagridae, Syngnathidae, Chaudhuriidae and Tetraodontidae). Journal of South Asian Natural History, 5: 37–82.

— 2001a. Fishes of Laos. WHT Publications, Colombo, 198 pp.

— 2001b. Freshwater fishes of northern Vietnam. A preliminary check-list of the fishes known or expected to occur in northern Vietnam with comments on systematics and nomenclature. The World Bank. Environment and Social Development Unit, East Asia and Pacific Region, iii + 123 pp.

— 2009. Fishes of the Xe Kong drainage in Laos. Aquatic Resource Management to Improve Rural Livelihoods of the Xe Kong Basin. World Wildlife Fund, Greater Mekong Programme, Vientiane, 29 pp.

Kottelat, M. & C. Vidthayanon. 1993. *Boraras micros*, a new genus and species of minute freshwater fish from Thailand (Teleostei: Cyprinidae). Ichthyological Exploration of Freshwaters, 4: 161–176.

Rainboth, W. 1996. Fishes of the Cambodian Mekong. MRC-FAO-DANIDA, Rome, 265 pp., 27 pls.

Rüber, L., M. Kottelat, H. H. Tan, P. K. L. Ng & R. Britz. 2007. Evolution of miniaturization and the phylogenetic position of *Paedocypris*, comprising the world's smallest vertebrate. BMC Evolutionary Biology, 7: 38–47.

Rundel, P. W. 2009. Vegetation in the Mekong basin. Pp. 143–160 in: I. C. Campbell, The Mekong – Biophysical environment of an international river basin. Academic Press, Oxford.

Taylor, W. R. & G. C. Van Dyke. 1985. Revised procedures for staining and clearing small fishes and other vertebrates for bone and cartilage study. Cybium, 9: 107–119.

Vishwanath, W. & K. Nebeshwar Sharma. 2004. *Schistura reticulata*, a new species of balitorid loach from Manipur, India, with a redescription of *S. chindwinica*. Ichthyological Exploration of Freshwaters, 15: 323–330.

Weitzman, S. H. & R. P. Vari. 1988. Miniaturization in South American freshwater fishes; an overview and discussion. Proceedings of the Biological Society of Washington, 101: 444–465.

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