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Schistura colossa and *S. klydonion*, two new species of loaches from Bolaven Plateau, southern Laos (Teleostei: Nemacheilidae)

Maurice Kottelat

Abstract. *Schistura colossa*, new species, is described from the Xe Pian, Xe Set and Houay Champi on Bolaven Plateau in southern Laos. It is distinguished by its large size (up to at least 98 mm SL); the body has 16–21 bars, quite regularly shaped in juveniles and with increasing size becoming more irregular; in the largest individuals the bars on the caudal peduncle are broken up in irregular blotches. *Schistura klydonion*, new species, is described from the Xe Namnoy, also on Bolaven Plateau. It is distinguished by its relatively large size (up to at least 76 mm SL); the body has a midlateral row of 12–21 bars that do not reach the dorsal midline and that alternate with a middorsal row of saddles or small blotches, leaving a pale zigzag line between the two rows; the lips have a few sparsely-set pointed papillae. The topography of the plateau and the distribution of the endemic species suggest an earlier connection of the Houay Makchang Gnai and the Xe Katam with the Xe Pian instead of the Xe Namnoy. Both species are endemic to the Bolaven Plateau, have a limited distribution and are impacted by hydropower and agricultural activities.

Key words. Cobitoidei, *Schistura*, Mekong basin, stone loach

INTRODUCTION

Loaches of the genus *Schistura* typically occur in fast flowing waters of small streams as well as in other habitats such as large rivers and caves. The genus presently includes about 210 valid species (pers. obs., updated from Kottelat, 2012, 2013). The genus has its greatest diversity in Southeast Asia (Irrawaddy, Salween, Mae Khlong, Chao Phraya, Mekong and Red River drainages, and drainages in between) from where about 160 species have been described; most are described and figured in Kottelat (1990, 1998, 2000, 2001) and Freyhof & Serov (2001). Besides, new species are still regularly described (e.g., Bohlen & Šlechtová, 2010, 2013a, 2013b; Ou et al., 2011; Plongsesthee et al., 2011, 2013; Chen & Neely, 2012; Bohlen et al., 2014, 2016; Kottelat, 2017a–c). The interrelationships within *Schistura* have not been thoroughly studied yet but the accumulating morphological, molecular and distribution data unsurprisingly show that the genus is paraphyletic (Kottelat, 1990, 2017b, 2017c and unpublished; see also, e.g., Freyhof et al., 2016).

Bolaven Plateau is a volcanic massive in southern Laos, at about 900–1,400 masl, surrounded by lowland around 100–200 masl (Fig. 1). The plateau is about 90 × 70 km, surrounded by cliffs and steep escarpments, especially on the southern and eastern sides. The plateau is drained by the Xe Pian to the south, the Xe Namnoy and Xe Katam to the east, the Xe Set to the north and a number of smaller rivers to the west. The Xe Pian, Xe Namnoy and Xe Katam flow to the Xe Kong, while the others flow to the Xe Don or directly to the Mekong. All rivers exit the plateau through high waterfalls, except on the northern slope where the gradient is lower and waterfalls of smaller heights. The Xe Kong and Xe Don are two tributaries of the Mekong; they enter the Mekong mainriver downstream and upstream of Khone Falls, respectively. The Khone Falls are an important zoogeographic boundary in the Mekong drainage.

A survey of the fishes of Bolaven Plateau was conducted in 2013 in connection with the construction of the Xe Pian–Xe Namnoy hydropower scheme. Thirty-five species were observed on the plateau and its slopes, of which 17 (49%) are endemic (Kottelat, unpubl.), including 12 species new or probably new to science at the time of the survey. *Clarias serniosus*, *Glyptothorax forabilis*, *G. porrectus* and *Schistura systomos* have already been described (Ng & Kottelat, 2014, 2017; Kottelat, 2017c). Two new species of *Schistura* are described in the present article.

MATERIAL AND METHODS

Measurements and counts follow Kottelat (1990) and Kottelat & Freyhof (2007). Last 2 branched dorsal and anal-fin rays articulating on a single pterygiophore are noted as "1½". Frequencies of meristic values are indicated in parentheses, if more than one value is observed; asterisks indicate the condition for the holotype. Abbreviations used: CMK, collection of the author; MHNG, Muséum d'Histoire naturelle, Genève; and ZRC, Lee Kong Chian Natural History Museum, Singapore.

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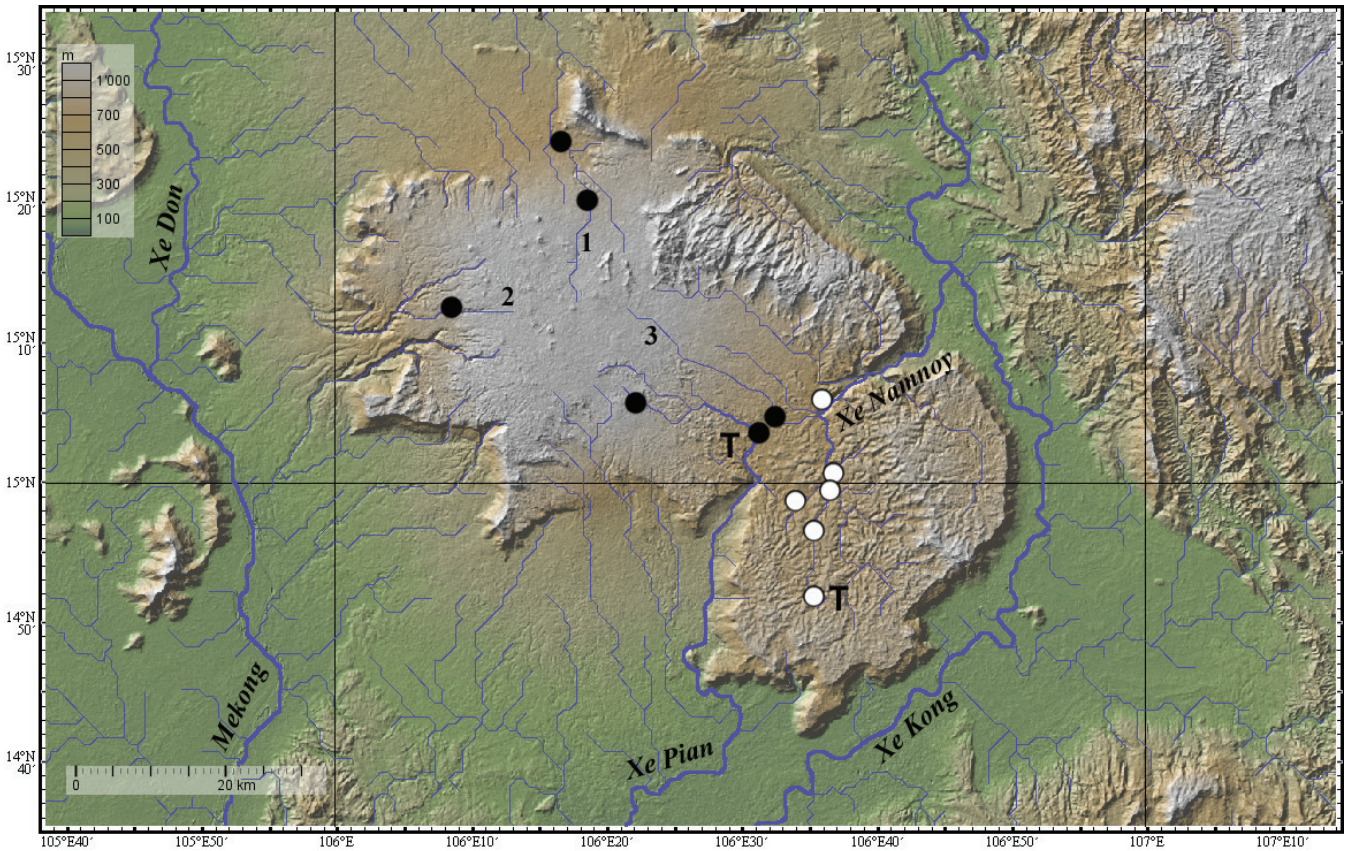

Fig. 1. Sampling sites of *Schistura colossa* (black circles) and *S. klydonion* (white circles) on Bolaven Plateau, southern Laos. 1, Xe Set; 2, Houay Champi; 3, Houay Makchan-Gnai (a tributary of Xe Namnoy); T, type localities.

***Schistura colossa*, new species**
(Figs. 2–6)

Holotype. MHNG 2767.084, 98.0 mm SL; Laos: Champasak Province: Bolaven Plateau: Xe Pian at dam site, near Ban Nongphanouan; 15°03′28″N 106°31′29″E; 757 masl; M. Kottelat & T. Phommavong, 12 January 2013.

Paratypes. CMK 23313, 7, 43.1–83.9 mm SL; ZRC 26222, 2, 41.9–54.1 mm SL; same data as holotype. — CMK 23378, 7, 33.0–81.1 mm SL; Laos: Champasak Province: Bolaven Plateau: Xe Pian north of Ban Houaxang; 15°04′45″N 106°24′14″E; 960 masl; M. Kottelat & T. Phommavong, 17 January 2013. – CMK 23397, 1, 77.7 mm SL; Laos: Champasak Province: Bolaven Plateau: Tad Set on Houay Set (Xe Set, tributary of Xe Don), near Ban Nonghinkhao; 15°18′03″N 106°18′23″E; 1136 masl; M. Kottelat & T. Phommavong, 19 January 2013. — CMK 23390, 1, 51.4 mm SL; Laos: Champasak Province: Bolaven Plateau: Tad Champi (waterfall) on Houay Champi (tributary of Xe Don), off road from Pakse to Paksong, north at Ban Lak 38 [Km-38 village]; 15°12′09″N 106°07′51″E; 938 masl; M. Kottelat & T. Phommavong, 18 January 2013.

Other material (non types). CMK 23443, 1, 36.0 mm SL; Laos: Champasak Province: Bolaven Plateau: Houay Makchan-Gnai at bridge on road from Ban Ta-Od to Ban Nongphanouan; 15°04′15″N 106°32′34″E; 784 masl; M. Kottelat & T. Phommavong, 23 January 2013. — CMK 15931, 1, 87.2 mm SL; Laos: Salavan Province: Xe Don basin, Xe Set upstream of reservoir; K. Vattahanatham, no date.

Diagnosis. *Schistura colossa* is distinguished from the other species of the genus in Southeast Asia by its colour pattern: the body has 16–21 bars, wider than interspaces, quite regularly shaped in juveniles; with increasing size, the bars become more irregular, some become interrupted or joined; in largest individuals (above 60 mm SL), on the caudal peduncle, the bars are broken up in blotches of irregular shape and size and irregularly set. The black pattern at the base of the caudal-fin is made of a vertically elongated blotch occupying the middle half of the fin base, sometimes with a constriction at the level of the lateral line; above and below, this blotch is continued by an arched band, along the base of the principal rays, not reaching the dorsal and ventral midlines.

Additional diagnostic characters, not unique to the species are: relatively large size (up to at least 98 mm SL); depth of caudal peduncle 1.3–1.6 times in its length; 7–8½ branched dorsal-fin rays; pelvic axillary lobe rudimentary and free; usually 9+8 branched caudal-fin rays; no suborbital flap; upper lip with a small median notch; processus dentiformis present, pointed; and origin of dorsal fin above or slightly behind origin of pelvic fin.

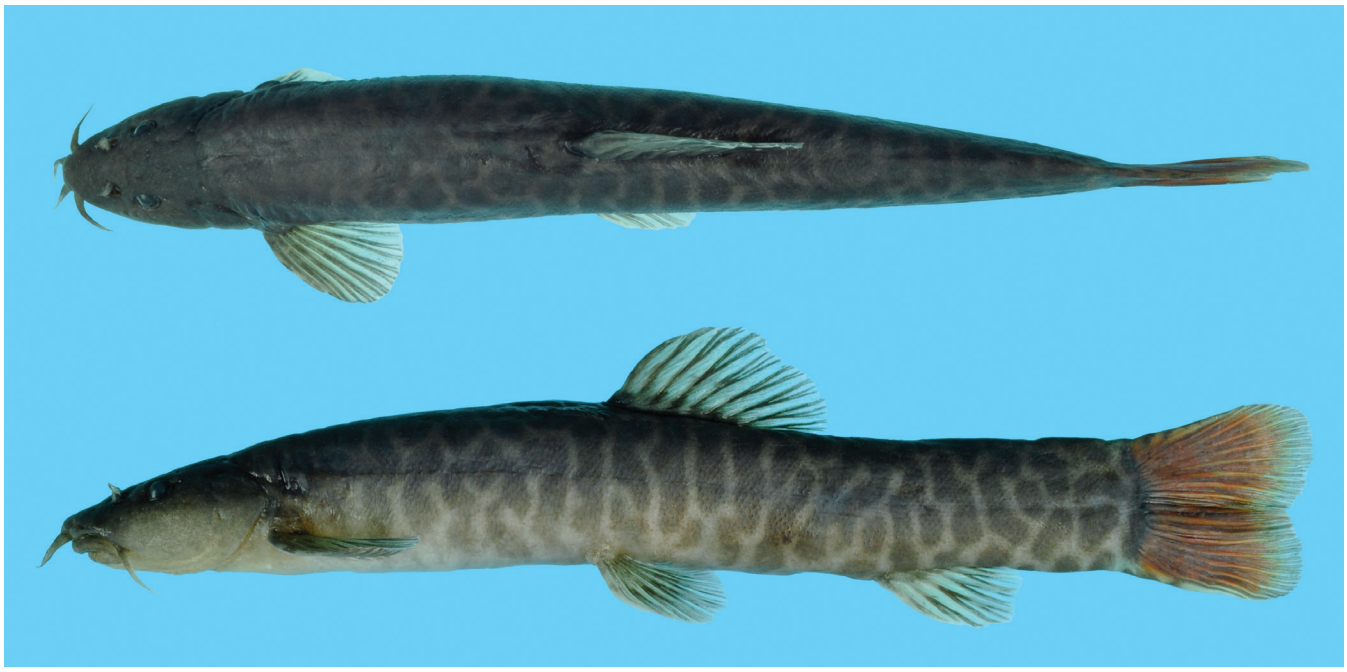

Fig. 2. *Schistura colossa*, MHNG 2767.084, holotype, 98.0 mm SL; Laos: Xe Pian River on Bolaven Plateau.

Description. See Figs. 2–6 for general appearance and Table 1 for morphometric data of holotype and 9 paratypes. An elongate nemacheilid with body depth slowly increasing up to dorsal-fin origin. Behind dorsal fin, body depth almost uniform until caudal-fin base. Dorsal profile continuous between head and body (no hump). Head slightly depressed; body slightly compressed anteriorly to very compressed posteriorly. Interorbital area flat. In lateral view, upper margin of eye flushed with dorsal profile of head. Cheeks not swollen. Snout pointed. Depth of caudal peduncle 1.3–1.6 times in its length. Low dorsal keel on posterior half of post-dorsal area. Low ventral keel on entire length of caudal peduncle. Dorsal keel continuous with upper margin of caudal fin. Largest recorded size 98.0 mm SL.

Dorsal fin with 4 unbranched and 7½ (1) or 8½ (9*) branched rays; distal margin convex; branched ray 2 or 3 longest. Pectoral fin with 1 unbranched and 8 (1) or 10 (9*) branched rays, rounded, reaching about halfway of distance to pelvic-fin base; origin over base of simple or first branched pelvic-fin rays. No axillary pectoral lobe. Pelvic fin with 1 unbranched and 7 branched rays; reaching about two thirds of distance to anus; rounded; posterior margin convex; axillary pelvic lobe rudimentary, entirely free. Anus situated about 2 eye diameters in front of anal fin. Anal fin with 3 unbranched and 5½ branched rays; distal margin rounded; branched ray 2 longest. Caudal fin with 9+8 (9*) or 8+8 (1) branched rays; dorsal and ventral procurrent rays cannot be counted; emarginate, lobes rounded, subequal.

Body entirely scaled, except belly in front of pelvic fins and predorsal area (anterior extremity in smaller specimens, entirely in specimens over about 60 mm SL). Scales embedded, deeply embedded in anterior predorsal area. Lateral line complete, with 92–107 pores (difficult to count with accuracy). Cephalic lateral line system with 6 supraorbital, 4 + 12–13 infraorbital, 9–11 preoperculo-mandibular and 3 supratemporal pores.

Anterior nostril pierced in front side of a pointed flap-like tube. Posterior nostril adjacent to anterior one. Mouth strongly arched, gape about 2–2½ times wider than long (Fig. 7). Lips thick. Upper lip with small median notch, with a few shallow furrows in median area and near corner of mouth, edge not crenulated. Processus dentiformis present. Lower lip with narrow median interruption; median part with 1–3 shallow sulcus, lateral part smooth. Tip of lower jaw not exposed. A deep median concavity in lower jaw (in adults). Inner rostral barbel reaching corner of mouth; outer one almost reaching vertical of anterior margin of eye. Maxillary barbel reaching vertical of posterior margin of eye. Intestine with a bend behind stomach (Fig. 8). Air bladder without posterior chamber in abdominal cavity.

Sexual dimorphism. None observed. Ripe females deeper bodied.

Colouration. About 3 weeks after fixation. Head and body background colour pale brown; throat, belly and lower part of caudal peduncle pale greyish. Except otherwise stated, all markings dark brown. Body with 16–21 bars (6–7 predorsal, 3–4 subdorsal, 7–10 postdorsal), extending from dorsal midline to level of pectoral fin, wider than interspaces, some continuous across back with contralaterals, others dissociated into blotches in predorsal area. Bars of quite regular shape in juveniles. With increasing size, bars becoming more irregular in shape, some becoming interrupted or joined, more obvious posteriorly. In specimens above about 60 mm SL, on caudal peduncle, bars broken up in blotches of irregular shape and size and irregularly set. Axial inner stripe faint or indistinct.

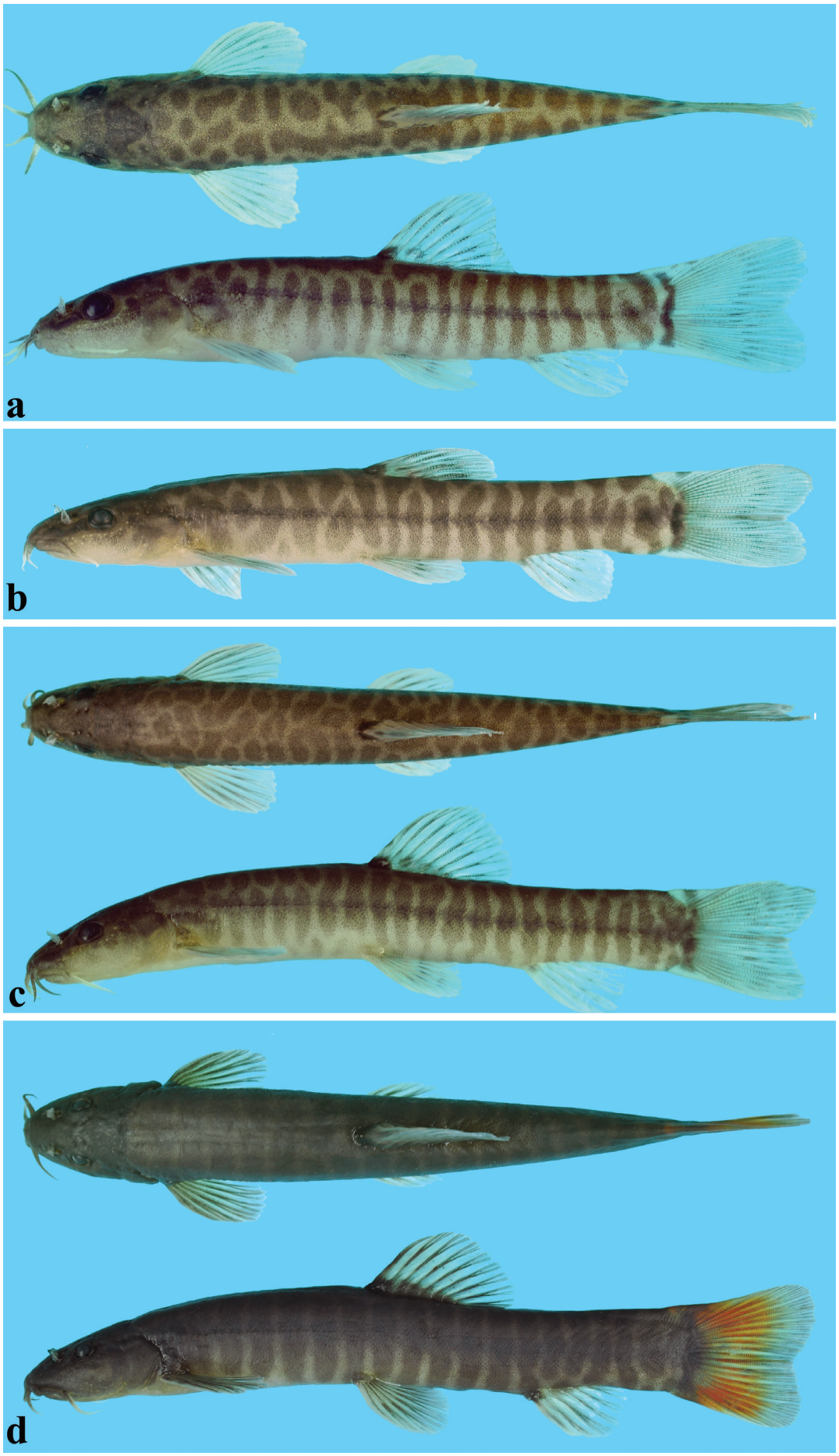

Fig. 3. *Schistura colossa*, paratypes; Laos: Xe Pian on Bolaven Plateau; a, CMK 23378, 33.0 mm SL; b, CMK 23313, 43.1 mm SL; c, CMK 23313, 51.5 mm SL; and d, CMK 23313, 71.9 mm SL.

Table 1. Morphometric data of type material of *Schistura colossa* (n=10; MHNG 2767.084, holotype; CMK 23313, 6; CMK 23378, 3). Ranges and means include holotype data.

	Holotype	Range	Mean
Standard length (mm)	98.0	52.0–98.0	
Total length (mm)	115.9	62.7–115.9	
In percent of standard length			
Total length	118.3	116.3–121.4	119.1
Head length (dorsal)	17.4	17.4–20.7	19.5
Head length (lateral)	21.1	21.1–23.8	22.6
Predorsal length	51.3	51.3–55.1	53.5
Prepelvic length	48.8	48.8–52.2	50.2
Pre-anus length	69.0	66.9–71.2	68.4
Pre-anal length	75.1	73.9–76.4	75.4
Head depth	9.6	9.6–11.8	10.6
Body depth at dorsal-fin origin	14.5	12.0–17.9	14.8
Depth of caudal peduncle	12.1	10.8–12.3	11.8
Length of caudal peduncle	17.9	15.6–17.9	16.9
Head width	12.6	11.8–14.7	13.3
Body width at dorsal-fin origin	10.9	9.9–13.5	11.2
Snout length	8.8	8.8–10.3	9.6
Eye diameter	2.7	2.7–4.1	3.2
Interorbital width	5.3	5.3–7.0	6.3
Length of dorsal fin	15.6	15.6–19.8	17.5
Length of upper caudal-fin lobe	19.1	17.9–21.7	19.7
Length of median caudal-fin rays	14.3	14.3–17.9	15.9
Length of lower caudal-fin lobe	17.2	17.2–22.5	19.3
Length of anal fin	14.3	14.3–16.7	15.2
Length of pelvic fin	13.5	13.4–16.8	14.9
Length of pectoral fin	14.4	14.4–18.7	16.7
In percent of dorsal head length			
Snout length	51	44–54	49
Eye diameter	16	15–20	17
Interorbital width	30	29–38	32
In percent of lateral head length			
Snout length	42	39–46	43
Eye diameter	13	13–17	14
Interorbital width	25	25–31	28

Fig. 4. *Schistura colossa*, CMK 23390, paratype, 51.4 mm SL; Laos: Houay Champi on Bolaven Plateau.

Fig. 5. *Schistura colossa*, CMK 23397, paratype, 77.7 mm SL; Laos: Xe Set on Bolaven Plateau.

Fig. 6. *Schistura colossa*, CMK 23443, 36.0 mm SL; Laos: Houay Makchan-Gnai on Bolaven Plateau.

Black mark at caudal-fin base made of a vertically elongated blotch occupying middle half of fin base, sometimes with constriction at level of lateral line (best seen in Fig. 3c). Above and below, blotch continued by an arched band, along base of principal rays, not reaching dorsal and ventral midlines; these bands less intensely black than central blotch (Fig. 3a). Pattern sometimes blurred by other dark brown marks overimposed, but central black blotch always distinct.

Dorsal-fin membranes hyaline, with pigments on whole length of rays. With increasing size, membranes becoming covered by tiny pigments and pigments on rays becoming denser at level of first branching but not forming a row of spots. In largest specimen (holotype), most membranes covered by densely set small pigments. A black blotch at base of simple rays.

Caudal fin dark orange to red. Caudal, anal, pelvic and pectoral fins with membranes hyaline, with pigments on whole length of rays. With increasing size, membranes becoming covered by tiny pigments, and pigments on rays becoming denser at level of first branching but not forming a row of spots.

Notes on biology. A dissected female (CMK 23378, 76.6 mm SL) had ripe ovaries with ova about 2.1 mm diameter. Its stomach was empty, which is probably related with low activity because of the very low temperature at time of collection (night air temperature was about 7°C; air and water temperatures were estimated around 15°C at time of collecting, in the morning). *Schistura colossa* was observed in streams 3 to about 30 m wide, over a pebble to boulder bottom, in clear, moderate to fast current, in riffles. Other species of *Schistura* collected together with *S. colossa* are: in the Xe Pian: *S. tizardi*, *S. clatrata*; in the Houay Makchan-Gnai: *S. bolavenensis*, *S. clatrata*, *S. tizardi*; in the Houay Champi: *S. clatrata*; and in the Xe Set: *S. clatrata*, *S. systomos*.

Distribution. *Schistura colossa* has been collected on Bolaven Plateau in the Xe Pian drainage, a tributary of the Xe Kong, in southern Laos (Fig. 9). A single specimen caught in the Champi and one caught in the Xe Set, both on Bolaven Plateau, cannot be distinguished from the samples from the Xe Pian.

Etymology. The Latin adjective *colossus* (*-a*, *-um*) means giant. Allusion to the size of the species, a giant among Southeast Asian nemacheilids.

Remarks. With a maximum size of at least 98 mm SL, *S. colossa* is a giant among Southeast Asian nemacheilines. Its general appearance and the colour pattern (see description and diagnosis) are observed in no other species of the genus.

Four species of *Schistura* have been collected together with *S. colossa*: *S. bolavenensis*, *S. clatrata*, *S. systomos* and *S. tizardi*. *Schistura tizardi* (Fig. 10) has a distinctive

Fig. 7. *Schistura colossa*, CMK 23378, paratype, 81.1 mm SL; mouth.

appearance, with a flat head, depressed snout, eyes protruding over the dorsal profile, and humped back; besides, *S. colossa* has a larger size (up to 98 mm SL, vs. 59), and 16–21 bars, contrasted, of quite regular shape in juveniles, becoming interrupted or joined and irregularly set in adults, especially in posterior part of body (vs. 7–10 bars, not very contrasted and regularly shaped at all sizes). *Schistura systomos* reaches a maximum known size of 36 mm SL (ovigerous females), has a very small mouth (gape about 3 times in maximum head width, occupying only median half of head width), a blunt snout and the eyes are visible in ventral view (Kottelat, 2017c).

Further to the differences mentioned above, *S. colossa* is distinguished from *S. bolavenensis* (Fig. 11) by its stouter body and caudal peduncle, 16–21 bars, often dissociated into small blotches in predorsal area, wider than interspaces, irregularly set and shaped in adults, especially in posterior part of body (vs. 15–24, meeting contralaterals on back, about as wide as interspaces, regularly shaped and set), a different black pattern at caudal-fin base (bar made of a vertically elongated blotch occupying middle half of fin base; above and below, the blotch is continued by an arched band, along the base of the principal rays, not reaching the dorsal and ventral midlines, vs. a bold black bar usually reaching the dorsal and ventral midlines).

Schistura colossa is further distinguished from *S. clatrata* (Fig. 12), among others, by having 16–21 bars on the body, often dissociated into small blotches in predorsal area, irregularly set and shaped in adults, especially in posterior part of body (vs. 7–13 bars, meeting contralaterals on back, in most individuals regularly shaped and set), no distinct pattern along dorsal-fin base (a black spot at base of unbranched and first branched rays, followed by a bright orange spot at base of second branched ray and then a black band along base of remaining rays); a different black pattern at caudal-fin base (bar made of a vertically elongated blotch occupying middle half of fin base; above and below, the blotch is continued by an arched band, along the base of the principal rays, not reaching the dorsal and ventral midlines, vs. a bold black bar

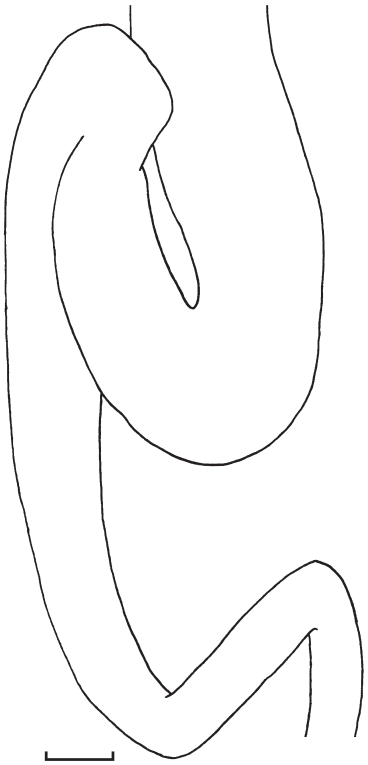

Fig. 8. *Schistura colossa*, CMK 23378, paratype, 76.6 mm SL; digestive tract. Scale bar = 1 mm.

Fig. 9. Type locality of *Schistura colossa*; Laos: Bolaven Plateau: Xe Pian near Ban Nongphanouan; 12 January 2013.

between bases of upper and lower unbranched principal rays, sometimes reaching the dorsal and ventral midlines); and the presence of a median notch in the upper lip (vs. absence).

Schistura klydonion (described below) is the only other species of the genus found on the Bolaven Plateau but not in the same drainages as *S. colossa*. *Schistura colossa* differs from *S. klydonion* in having the pattern of bars and saddles becoming irregular in posterior part of body in largest specimens (vs. quite regular on whole body at all sizes), the head is shorter (lateral head length 21.1–23.8% SL, vs. 23.2–25.1), presence of a median notch in the upper lip (vs. no notch), and the spots at the base of the caudal fin form a continuous band reaching close to dorsal and ventral midlines (vs. the spots are separated).

Fig. 10. *Schistura tizardi*, CMK 23331, 48.1 mm SL; Laos: Xe Namnoy on Bolaven Plateau.

Fig. 11. *Schistura bolavenensis*, CMK 23330, 50.5 mm SL; Laos: Xe Namnoy on Bolaven Plateau.

Fig. 12. *Schistura clatrata*, CMK 23381, 77.9 mm SL; Laos: Xe Pian on Bolaven Plateau.

***Schistura klydonion*, new species**
(Figs. 13–15)

Holotype. MHNG 2767.085, 75.8 mm SL; Laos: Champasak Province: Bolaven Plateau: Houay Xoy, a tributary of Xe Namnoy, 14°52′41″N 106°34′49″E; 790 masl; M. Kottelat & T. Phommavong, 14 January 2013.

Paratypes. All from Laos: Champasak Province: Bolaven Plateau: CMK 23344, 29, 26.0–66.5 mm SL; ZRC 56223, 5, 43.6–54.4 mm SL; same data as holotype. — CMK 23320, 25, 25.7–76.0 mm SL; Houay Namkong, a creek tributary of Xe Namnoy; 14°58′14″N 106°33′44″E; 755 masl; M. Kottelat & T. Phommavong, 12 January 2013. — CMK 23337, 5, 18.4–59.6 mm SL; Houay Xoy, a creek tributary of Xe Namnoy; 14°56′49″N 106°35′02″E; 771 masl; M. Kottelat & T. Phommavong, 14 January 2013. — CMK 23361, 1, 68.6 mm SL; unnamed creek on road from Tayerkseua to Ban Namtouad; 15°06′32″N 106°35′31″E; 838 masl; M. Kottelat & T. Phommavong, 15 January 2013. — CMK 22363, 1, 51.0 mm SL; Xe Namnoy at bridge downstream of dam site; 15°03′28″N 106°36′10″E; 708 masl; M. Kottelat et al., 22 January 2011.

Additional material (non types). CMK 24737, 2 (ethanol fixed); Laos: Champasak Province: Bolaven Plateau: Xe Namnoy, first rapids downstream of dam site; 15°01′38″N 106°36′16″E; 833 masl; M. Kottelat & T. Phommavong, 13 January 2013.

Diagnosis. *Schistura klydonion* is distinguished from the other species of the genus in Southeast Asia by the following combination of characters: relatively large size (up to at least 76 mm SL); body with a midlateral row of 12–21 bars not reaching the dorsal midline, alternating with a middorsal row of saddles or small blotches, and leaving a pale zigzag line between the two rows; lips with a few sparsely set papillae; and black pattern at base of caudal fin made of a vertically elongated blotch, usually with a median constriction at level of lateral line, and a smaller black blotch at base of upper simple and 2–3 posterior procurrent rays, sometimes also a patch of brown pigments on base of lower unbranched and posterior procurrent rays.

Additional diagnostic characters, not unique to the species are: 8½ branched dorsal-fin rays; no known sexual dimorphism; axillary pelvic lobe rudimentary or small, free; marked dorsal and ventral keels on posterior half of caudal peduncle; depth of caudal peduncle 1.1–1.5 times in its length; pelvic-fin origin about under dorsal-fin origin; 9+8 branched caudal-fin rays; no median notch in upper lip; lateral line complete.

Description. See Figs. 13–15 for general appearance and Table 2 for morphometric data of holotype and 10 paratypes. An elongate nemacheiline with body depth slowly increasing up to slightly in front of dorsal-fin origin. Behind dorsal fin, body depth almost uniform until shortly in front of caudal-fin base, then increasing to caudal-fin base. Dorsal profile continuous between head and body. Head slightly depressed; body slightly compressed anteriorly to compressed posteriorly. Interorbital area flat. In lateral view, eye flushed with or slightly protruding over dorsal profile of head. Cheeks not swollen. Snout pointed but rounded at tip. Depth of caudal peduncle 1.1–1.5 times in its length, deeper posteriorly. Marked dorsal keel on posterior fourth of post-dorsal area (posterior half of caudal peduncle) and ventral keel on posterior half of caudal peduncle. Dorsal keel continuous with upper margin of caudal fin. Largest recorded size 76.0 mm SL.

Dorsal fin with 4 unbranched and 8½ branched rays; distal margin slightly convex; second branched ray longest. Pectoral fin with 1 unbranched and 9 (7*) or 10 (4) branched rays (including small last ray, usually unbranched), rounded,

Table 2. Morphometric data of *Schistura klydonion* (n=11; MHNG 2767.085, holotype; CMK 23344, 5; CMK 23320, 5). Ranges and means include holotype data.

	Holotype	Range	Mean
Standard length (mm)	75.8	52.7–76.0	
Total length (mm)	90.9	63.7–91.9	
In percent of standard length			
Total length	119.9	119.4–122.3	121.3
Head length (dorsal)	20.8	19.9–22.1	20.8
Head length (lateral)	25.1	23.2–25.1	24.2
Predorsal length	54.0	53.3–56.5	54.4
Prepelvic length	50.9	50.3–52.2	51.0
Pre-anus length	69.8	68.1–71.5	69.8
Pre-anal length	75.9	75.3–78.2	76.8
Head depth	11.9	10.7–12.6	11.7
Body depth at dorsal-fin origin	17.2	13.9–17.5	16.2
Depth of caudal peduncle	13.1	11.2–13.8	12.6
Length of caudal peduncle	15.9	15.1–17.6	16.5
Head width	16.1	13.3–16.1	14.9
Body width at dorsal-fin origin	12.7	10.8–14.1	12.5
Snout length	10.3	8.8–10.7	10.0
Eye diameter	3.8	3.6–4.7	4.3
Interorbital width	7.2	6.3–7.9	7.1
Length of dorsal fin	15.7	15.7–19.0	17.6
Length of upper caudal-fin lobe	19.7	19.7–22.8	21.4
Length of median caudal-fin rays	14.3	14.3–19.9	17.6
Length of lower caudal-fin lobe	20.0	20.0–23.6	22.0
Length of anal fin	15.6	15.4–17.6	16.5
Length of pelvic fin	15.0	15.0–16.8	15.9
Length of pectoral fin	16.8	16.8–18.9	17.8
In percent of dorsal head length			
Snout length	50	44–52	48
Eye diameter	18	18–22	20
Interorbital width	35	29–40	34
In percent of lateral head length			
Snout length	41	37–45	41
Eye diameter	15	15–20	18
Interorbital width	29	26–33	29

reaching about halfway to pelvic-fin base; no ray with filamentous extension. Pelvic fin with 1 unbranched and 7 branched rays (including small last ray, usually unbranched); reaching almost to anus; rounded; posterior margin convex; origin at vertical through dorsal-fin origin or below base of unbranched dorsal-fin rays 2–3. Axillary pelvic lobe present, rudimentary to small, free. Anus situated about 1.5–2 eye diameters in front of anal fin, behind posterior extremity of pelvic-fin. Anal fin with 3 unbranched and 5½ branched rays; distal margin convex. Caudal fin with 9+8 branched rays; emarginate, lobes rounded, subequal.

Body entirely scaled. Scales embedded, more deeply in anterior part. Lateral line complete, with 78–92 pores. Cephalic lateral line system with 6 supraorbital, 4 + 10–12 infraorbital, 9–10 preoperculo-mandibular and 3 supratemporal pores.

Anterior nostril pierced in front side of a pointed flap-like tube. Posterior nostril adjacent to anterior one, about same size. Mouth strongly arched, gape about 2–2.5 times wider than long (Fig. 16). Lips thick, with sparsely-set, small papillae. Upper lip without median notch (small notch in one individual), with a few furrows near corner of mouth, edge smooth. crenulated. Processus dentiformis present. Lower lip with narrow median interruption; median part with 2–3 sulci, lateral part with a few shallow ridges. Tip of lower jaw not exposed. A shallow median concavity in lower jaw. Barbels with sparsely set papillae similar to those on lips. Inner rostral barbel reaching corner of mouth; outer one reaching vertical of anterior margin of eye. Maxillary barbel reaching middle of postorbital area. Intestine with a loop immediately behind stomach (Fig. 17). Air bladder without posterior chamber in abdominal cavity.

Sexual dimorphism. None observed.

Fig. 13. *Schistura klydonion*, MHNG 2767.085, 75.8 mm SL, holotype; Laos: Xe Namnoy on Bolaven Plateau (right side, reversed).

Colouration. About 3 weeks after fixation. Head and body background colour pale greyish brown, throat and belly whitish; except otherwise stated, markings dark grey to black. Head with a few spots on top and interorbital area. Body with 12–21 bars (4–7 predorsal, 2–4 subdorsal, 6–10 postdorsal), regular in most specimens, slightly wider than interspaces. Bars extending on about median ⅔ of body depth, reaching downwards to level of pectoral fins, behind pelvic fins reaching close to ventral midline but not continuous with contralaterals. Anterior bars only slightly wider than posterior ones in specimens with numerous bars (for example holotype; Fig. 13) and wider in specimens with few anterior bars (maybe equivalent to 2 bars) (Figs. 14a, 15c). A row of saddles alternating with bars, leaving a narrow pale line zigzagging between row of saddles and row of bars. Saddles regular (especially in specimens with few bars; Fig. 14a), sometimes divided into spots (especially in specimens with many bars in anterior part of body; Fig. 13), sometimes irregular and occasionally connected with some bars (Fig. 14c).

A conspicuous black blotch on caudal fin base, vertically elongated, occupying about middle third, usually with a constriction at level of lateral line (Fig. 13). A smaller black blotch at base of upper simple ray and 2–3 posterior procurrent rays. Both blotches more or less extensively covered by superficial brown pigments. Sometimes also a patch of superficial brown pigments on base of lower unbranched ray and posterior procurrent rays (Fig. 14b). A triangular unpigmented area over procurrent rays and adjacent areas of caudal peduncle and unbranched principal rays. A faint inner axial stripe.

Dorsal fin hyaline, with blackish pigments along all rays; a black spot at base of simple rays and first branched ray; an elongated blotch at base of branched rays 2–8, usually dissociated in a subproximal row of diffuse spots on rays; space between these spots hyaline.

Caudal fin orange red, with blackish pigments along rays, especially between branches and appearing as two vague, indistinct vertical rows of spots. Anal fin hyaline, with blackish pigments along rays, especially at inner sides of branches. Pelvic fin hyaline, with few blackish pigments along rays. Pectoral fin hyaline, with blackish pigments along dorsal side of rays.

In smallest available specimens (less than about 30 mm SL; Fig. 15), adult pattern already distinct, although bars shorter, more rounded, sometimes partly fused to form a very irregular midlateral stripe. Saddles irregular, sometimes fused into an irregular middorsal blotch.

Notes on biology. One female (CMK 23344, 66.5 mm SL) had apparently almost ripe ova, about 1.0 mm diameter; another one (CMK 23320, 69.0 mm SL) had apparently more advanced ova, about 1.4 mm diameter. In both, the ovaries were narrow, elongated, and ova were few and on one or two rows. *Schistura klydonion* was observed in water bodies ranging from small forest streams 2 m wide to the Xe Namnoy main river about 30 m wide, with fast current, riffles and rapids, clear water, over a gravel to rock bottom (Fig. 18). Other species of *Schistura* collected together with *S. klydonion* are *S. tizardi* and *S. bolavenensis*.

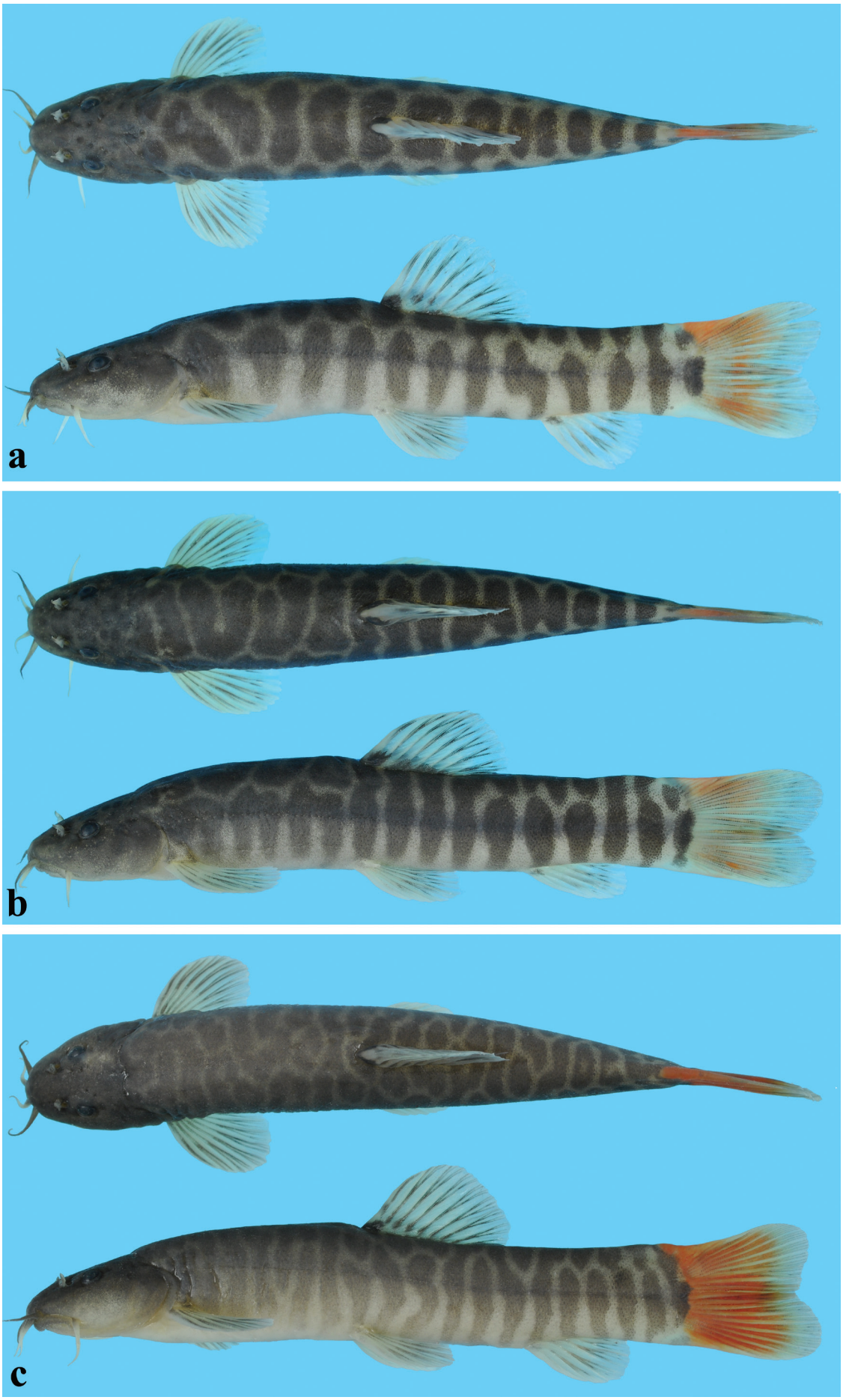

Fig. 14. *Schistura klydonion*, paratypes; Laos: Xe Namnoy on Bolaven Plateau; a, CMK 23344, 57.7 mm SL; b, CMK 23344, 61.9 mm SL; and c, CMK 23320, 76.0 mm SL.

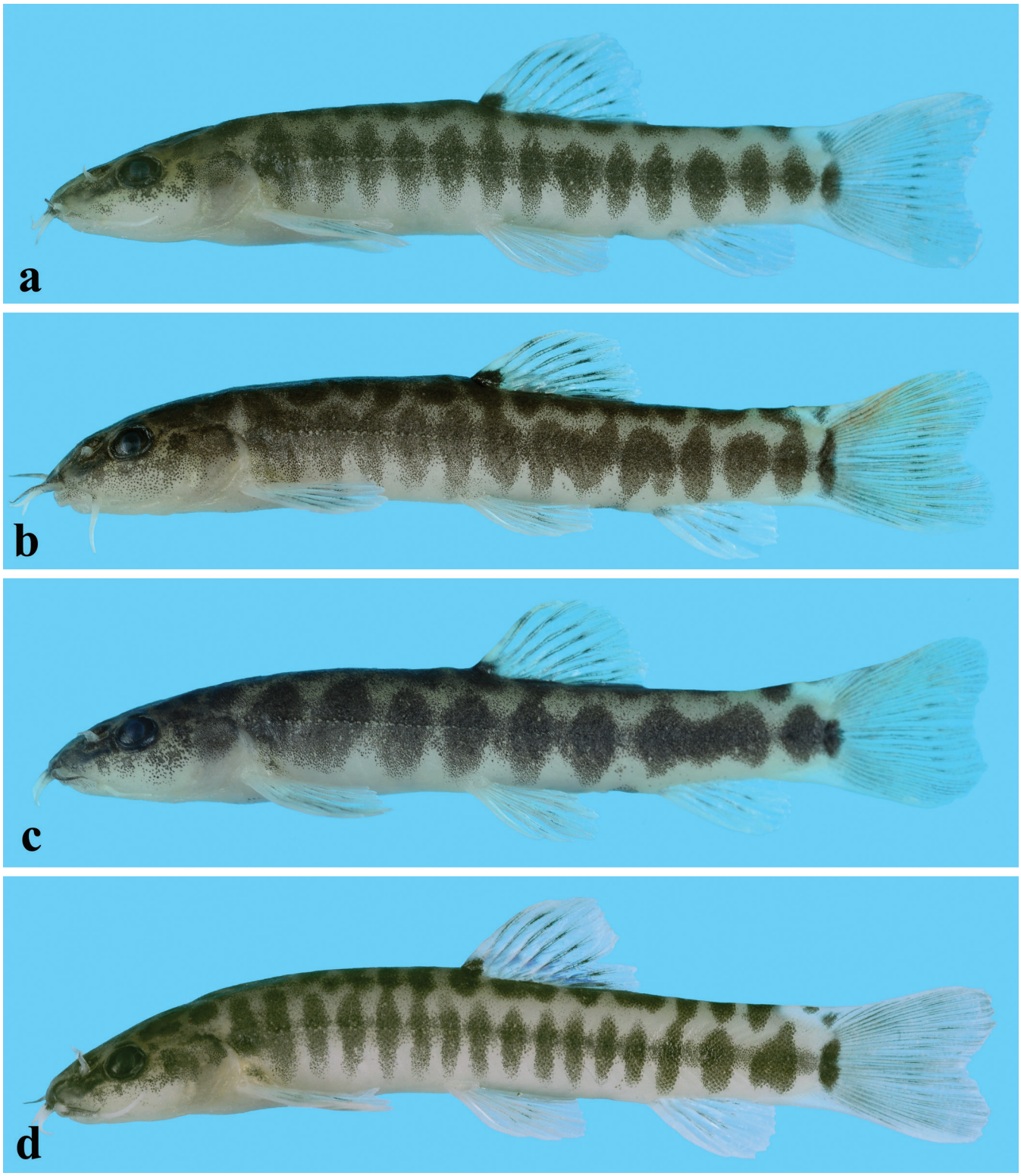

Fig. 15. *Schistura klydonion*, paratypes; Laos: Xe Namnoy on Bolaven Plateau; a, CMK 23344, 26.4 mm SL; b, CMK 23344, 27.3 mm SL; c, CMK 23344, 28.1 mm SL; and d, CMK 23320, 29.0 mm SL.

Distribution. *Schistura klydonion* has been observed only in the Xe Namnoy on the Bolaven Plateau, southern Laos.

Etymology. From the classical Greek *κλυδώνιον* (klydonion) meaning small wave, ripple, undulation; allusion to the wavy stripe running along the flank between the row of saddles and the row of bars. A noun in apposition.

Remarks. The projecting papillae on the lips of *S. klydonion* have not been observed or reported in other species of *Schistura*. The colour pattern of *S. klydonion* made of a midlateral row of bars alternating with a middorsal row of saddles or small blotches, and leaving a pale zigzag line between them is unique among species of *Schistura* in Southeast Asia. Some individuals of *S. colossa* (also from Bolaven Plateau, see above) have a colour pattern made of

Fig. 16. *Schistura klydonion*, CMK 23320, paratype, 76.0 mm SL; mouth.

bars that do not reach the dorsal midline, but in this case they are dissociated into an irregular pattern of blotches and do not leave a pale zigzag line. Further, in *S. klydonion*, the pattern of bars and saddles is quite regular on the whole body at all sizes (vs. becoming irregular in posterior part of body in largest specimens in *S. colossa*), the head is longer (lateral head length 23.2–25.1% SL, vs. 21.1–23.8), there is no median notch in the upper lip (vs. presence), and the spots at the base of the caudal fin are separated (vs. form a continuous band reaching close to dorsal and ventral midlines).

Schistura dalatensis from the Dong Nai drainage in Vietnam has a colour pattern somewhat similar to that of *S. klydonion*, but it has a midlateral row of irregular blotches instead of the quite regular bars of *S. klydonion* and the predorsal area is marbled by irregular spots, saddles and bars (Freyhof & Serov, 2001: 151). Besides, in *S. klydonion*, the dorsal and ventral keels on the caudal peduncle are more developed resulting in the caudal peduncle clearly higher posteriorly (vs. uniform depth; 11.2–13.8% SL, mean 12.6, vs. 9.7–11.5, mean 10.5), the body is deeper anteriorly than behind dorsal fin (vs. depth very uniform from head to caudal-fin base; depth at dorsal-fin origin 13.9–17.5% SL, mean 16.2, vs. 12.5–15.3, mean 12.8), lateral line complete (vs. variable, reaching to middle of anal in most specimens). In *S. klydonion*, there is a vertically elongated black blotch at the middle of caudal-fin base, a blotch at base of upper simple principal ray and sometimes one at the base of the lower one. In *S. dalatensis* the black marks at caudal-fin base are fused into a continuous bar, including also the spot at the base of the lower simple principal ray, which seems to always be present. In *S. klydonion*, the juveniles have a midlateral row of elongated blotches and a middorsal row of small saddles, while juveniles *S. dalatensis* have about 10–12 irregular bars, some reaching the dorsal midline, many widened in a blotch at level of lateral line (morphometric data from Freyhof & Serov, 2001; other characters confirmed on paratypes CMK 15999).

Two other species of *Schistura* have been collected together with *S. klydonion*: *S. tizardi* and *S. bolavenensis*. *Schistura tizardi* (Fig. 16) has a distinctive appearance, with a flat head, depressed snout, eyes protruding over the dorsal

Fig. 17. *Schistura klydonion*, CMK 23344, paratype, 66.5 mm SL; digestive tract. Scale bar = 1 mm.

Fig. 18. Type locality of *Schistura klydonion*; Laos: Bolaven Plateau: Houay Xoy; 14 January 2013.

profile, and humped back. Besides, *S. klydonion* has 12–21 very contrasted bars restricted to the flank (vs. 7–10, not very contrasted and meeting their contralaterals on the back).

Schistura klydonion is distinguished from *S. bolavenensis* (Fig. 17) by its stouter body (depth 13.9–17.5% SL, vs. 12.8–14.6), a stouter caudal peduncle (depth 11.2–13.8% SL, vs. 9.8–12.0; 1.1–1.5 times in its length, vs. 1.5–1.7), a longer head (lateral head length 23.2–25.1% SL, vs. 19.7–23.3), no median notch in upper lip (vs. presence), 12–21 bars restricted to the flank (vs. 15–24, meeting their contralateral on back), black pattern at caudal-fin base made of a vertically elongated black blotch at the middle, a small one at the base of the upper simple principal ray and sometimes one at the base of the lower one (vs. blotches fused to form a bar often reaching the dorsal and ventral midlines).

DISCUSSION

Both *S. klydonion* and *S. colossa* are endemic to the Bolaven Plateau. *Schistura klydonion* has been observed only in the Xe Namnoy. Downstream of the waterfalls that border the plateau, the species has not been observed in the Xe Kong floodplain. It was not found in the Houay Makchang Gnai, a tributary of the Xe Namnoy that enters it after a high waterfall. It was also missing in the samples from the Xe Katam, another Xe Namnoy tributaries; the Xe Katam enters the Xe Namnoy on the Xe Kong floodplain, below a high waterfall.

Schistura colossa was collected in the Xe Pian on the Bolaven Plateau. The Xe Pian leaves the plateau on the south through a succession of waterfalls. *Schistura colossa* was not observed downstream of the plateau. A single specimen caught in the Houay Champi and one caught in the Xe Set, both on Bolaven Plateau, cannot be distinguished from the samples from the Xe Pian. The Houay Champi and Xe Set are two tributaries of the Xe Don, which they join after leaving the Bolaven Plateau through waterfalls on the west and on the north, respectively. A single juvenile collected in the Houay Makchang Gnai is tentatively referred to *S. colossa*. The Houay Makchang Gnai is a tributary of the Xe Namnoy (see above). *Schistura colossa* has not been observed in the Xe Namnoy itself.

Several species present in the Xe Pian are shared with the Houay Makchang Gnai but are missing in the Xe Namnoy (*Poropuntius solitus*, *Glyptothorax forabilis*) and vice versa several species present in the Xe Namnoy have not been observed in the Houay Makchang Gnai (*P. bolovenensis*, *P. lobocheiloides*, *S. klydonion*, *G. porrectus*). This might be an artefact resulting from an insufficient number of sampling sites in the Houay Makchang Gnai; however, it seems easily explained by topography. The Houay Makchang Gnai flows parallel to the Xe Pian, coming as close as 2.5 km apart (near the sampling site of CMK 23443 and near the type locality of *S. colossa*, respectively). The altitude of the plateau above the respective shores is about 790 masl, and the maximum altitude between them about 820 masl. A third stream (Houay Liang) flows between them, tributary of the Xe Pian, and at one point less than 1 km from the Houay Makchang Gnai; there, around 15°04′36″N 100°32′01″E, the altitude difference between the respective shores is about 6 m. A former connection between the Houay Makchang Gnai and the Xe Pian seems therefore a reasonable hypothesis.

Although the Houay Makchang Gnai is a tributary of the Xe Namnoy, it reaches it in the gorges descending the plateau and in its last km it descends from about 740 masl to about 600 masl, through rapids and waterfalls. It seems a reasonable hypothesis that the connection is relatively recent and that fishes endemic to the Xe Namnoy are not able to ascend the Houay Mackchang Gnai. An exception is possibly *S. bolavenensis* known from the Xe Namnoy and Houay Makchang Gnai but not observed in the Xe Pian.

The Xe Katam descends from the plateau through a very high waterfall and enters the Xe Namnoy at the foot of the plateau. Similarly, the topography of the plateau shows that there is no geomorphological obstacle to an earlier connection between the Xe Katam and the Houay Makchang Gnai, and the Xe Pian, which may explain the presence of *G. forabilis* and *P. solitus* in both rivers and their absence in the Xe Namnoy, and the absence of the Xe Namnoy endemics in the Xe Katam.

Rivers on the plateau have been impacted by agriculture (especially coffee plantations), deforestation and small-scale mining. With the abrupt drop of about 700 meters, the plateau is of great interest for hydropower development. A complex scheme is under construction that includes two dams diverting waters from the Houay Makchang-Gnai and Xe Pian to a reservoir created on the Xe Namnoy by a third dam, and from there by a penstock to the Xe Kong. These dams result/will result in severe impacts on the aquatic habitats (inundation of rapids, reduction of volume and velocity of discharge below dams, disturbance of annual cycles, turbidity, siltation, genetic exchanges between watersheds, etc.) (see Kottelat et al., 2012).

Two of the known sites of *S. colossa* are directly impacted (at Xe Pian dam site and near Houay Makchang Gnai dam site); the remaining three known sites are not impacted by this hydropower scheme, are quite distant and are in two other drainages (Xe Set and Houay Champi). Certainly *S. colossa* is not restricted to these four sites and has a wider distribution in the respective catchments. Still the whole known range is impacted by agriculture and the potential for more hydropower development exists. The decrease in range and habitat quality probably qualifies *S. colossa* to the Near Threatened category under the International Union for Conservation of Nature (IUCN) criteria (IUCN, 2001).

Schistura klydonion has been observed in the Xe Namnoy mainstream, which will be entirely impacted, and in some of the few headwaters, above the maximum level of the reservoir, presently not much impacted. However, these are small water bodies with limited flow and are not able to support large populations of large adults. The sharp decrease in range, habitat quality and population size probably qualifies *S. klydonion* to the Endangered or Critically Endangered categories under IUCN criteria (IUCN, 2001).

Material used for comparison. *Schistura bolavenensis*: CMK 22362, 66, 18.8–53.5 mm SL; CMK 23330, 21, 30.5–50.5 mm SL; CMK 23336, 2, 33.4–51.9 mm SL; CMK 23342, 1, 39.1 mm SL; CMK 23343, 5, 32.3–39.3 mm SL; CMK 23418, 22, 31.5–60.2 mm SL; CMK 26646, 25, 24.6–43.8 mm SL; Laos: Xe Namnoy on Bolaven Plateau. — CMK 15520, 17 paratypes, 20.5–63.5 mm SL; CMK 23432, 4, 28.9–40.3 mm SL; CMK 23440, 12, 23.0–36.5 mm SL; CMK 23353, 1, 54.1 mm SL; Laos: Houay Makchang Gnai on Bolaven plateau.

S. clatrata: CMK 23381, 30, 29.3–77.7 mm SL; Laos: Xe Pian drainage on Bolaven Plateau.

S. dalatensis: CMK 15999, 8, 30.4–50.3 mm SL; Vietnam: Lam Dong Prov.: small tributary of River Da Dung south of Da Lat.

S. tizardi: CMK 23331, 109, 28.4–59.3 mm SL; Laos: Xe Namnoy on Bolaven Plateau.

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