

Lefua torrentis, a new species of loach from western Japan (Teleostei: Nemacheilidae)

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Lefua torrentis, new species, is described from western Japan. *Lefua torrentis* is distinguished from its congeners by the following combination of characters: eyes located dorsally on the head (vs. dorsolaterally on the head), presence of a narrow conspicuous dark brown band between the base of the outer rostral barbel and the eye (vs. absence, or light and/or indistinct if present), absence of a rhomboid or triangular dark blotch on the middle of the caudal-fin base (vs. presence), and absence of dark spots on the dorsal and caudal fins, or sparse if present (vs. presence). *Lefua torrentis* is mainly distributed in areas surrounding the Seto Inland Sea, and partly in areas near the Sea of Japan coast. It is also unique in inhabiting only mountain streams, whereas its congeners have a preference for more lentic waters in swampy streams and ditches.

Introduction

The nemacheilid loach genus *Lefua* is characterised by having a round caudal fin, the anterior nostril formed as long nasal barbel and absence of postcleithrum and epural (Nichols, 1943; Sawada, 1982; Prokofiev, 2005). *Lefua* was originally established by Herzenstein (1888), replacing *Octonema* Martens, 1868, which was preoccupied. According to Kottelat (2013) the genus consists of five valid species: *L. costata*, *L. pleskei*, *L. nikonis*, *L. echigonia*, and *L. sayu*. *Lefua hoffmanni* is neither an *Oreonectes* nor a *Lefua* but its generic position could not be decided (Prokofiev, 2005; Kottelat, 2012).

Long-term comparative studies on the variation in Japanese forms of *Lefua echigonia* demon-

strated that *Lefua* populations inhabiting areas around the Seto Inland Sea that lies between Honshu, Shikoku and Kyushu are distinguished from *L. echigonia* in morphology, ecology, and genetics (Yamashina et al., 1994; Hosoya, 1994; Hosoya, 2002; Sakai et al., 2003; Mihara et al., 2005; Miyazaki et al., 2007, 2011). These populations have been referred to as *Lefua* sp. Herein, we describe and name this new species.

Material and methods

Methods for measurements and counts follow Hubbs & Lagler (2004) except for vertebral counts, which followed Hosoya (1983). These were counted from radiographs and included

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the first four vertebrae of the Weberian apparatus and one fused vertebra to the pleurostyle in the hypural complex. The last two rays of the dorsal and anal fins were counted as one ray, each pair associated with a single pterygiophore. Counts and proportions are given first for the holotype, followed by those for the paratypes (if different) in parentheses. The terminology of the cephalic lateral line system follows Coombs et al. (1988). The cephalic lateral line systems were stained using Cyanin suminol 5R. In order to examine osteological features of the pectoral girdle and the caudal skeleton, several specimens were cleared and stained (cs) using the method of Kawamura & Hosoya (1991). Osteological terminology follows Sawada (1982).

Collection acronyms are: AIFS, Aogaki Ikimono Fureaino-Sato, Tanba; CAS, California Academy of Sciences, San Francisco; CAS-SU, Stanford University, now at CAS; FAKU, Department of Fisheries, Faculty of Agriculture, Kyoto University, Kyoto and Maizuru; KUN-P, Department of Fisheries, Kindai University, Nara; FRLM, Fisheries Research Laboratory, Mie University, Shima; MNHA, Museum of Nature and Human Activities, Sanda; NSMT-P, National Museum of Nature and Science, Tsukuba; OMNH-P, Osaka Museum of Natural History, Osaka; TKPM-P, Tokushima Prefectural Museum, Tokushima; USNM, National Museum of Natural History, Smithsonian Institution, Washington; WMNH-PIS, Wakayama Prefectural Museum of Natural History, Kainan.

Lefua torrentis, new species

(Figs. 1–3)

Lefua echigonia: Fujita & Okawa, 1975: 179–182 (partim).

Lefua sp.: Yamashina et al., 1994: 5–11; Hosoya, 2002: 277, 1467; Sakai et al., 2003: 501–514; Mihara et al., 2005: 157–168; Miyazaki et al., 2007: 666–675; 2011: 416–427.

Lefua sp. 1: Hosoya, 2013: 334; Nakajima 2017: 194–195, 211.

Holotype. KUN-P 45408, 44.9 mm SL; Japan: Hyogo: Tanba: Kasuga: Yura river system; 35°08'09"N 135°11'09"E; K. Hosoya; 6 May 1994.

Paratypes. All from Japan. AIFS 0001, 1, 29.9 mm SL; CAS 243685, 1, 33.6 mm SL; NSMT-P 127393,

1, 40.5 mm SL; USNM 440343, 1, 40.9 mm SL; collected with holotype. – FAKU 50366, 1, 53.1 mm SL; Nara: Yoshino: Kumano river system; K. Hosoya et al., 20 July 1980. – KUN-P 42271, 1, 48.2 mm SL; OMNH-P 45847, 1, 50.3 mm SL; Kagawa: Syodo-shima: Yoshida River; T. Ito, 12 October 2010. – KUN-P 44141, 1, 39.5 mm SL; KUN-P 44166, 1, 56.9 mm SL; KUN-P 44581, 1, 44.4 mm SL; Hyogo: Minami-Awaji: Sumoto river system: Ayuya River; T. Ito & S. Aoyama, 19 August 2012. – KUN-P 44162, 1, 48.9 mm SL; KUN-P 44164, 1, 49.3 mm SL; Hyogo: Tatsuno: Shingu: Tsunogame: Chikusa river system; T. Ito & S. Aoyama, 27 August 2011. – KUN-P 44180, 1, 35.2 mm SL; Hyogo: Takarazuka: Tamase: Muko river system: Sou River; T. Ito & S. Aoyama, 3 July 2011. – KUN-P 44585, 1, 55.7 mm SL; KUN-P 44593, 1, 47.9 mm SL; Okayama: Mimasaka: Ohara: Yoshino river system; T. Ito, 7 August 2014. – KUN-P 44594, 1, 56.5 mm SL; Kagawa: Nakatado: Mannou: Doki River; T. Ito, 7 August 2014. – KUN-P 45410, 1, 39.6 mm SL; WMNH-PIS 10007, 1, 39.9 mm SL; Wakayama: Hidaka: Hidakagawa: Hidaka river system; T. Ito et al., 9 September 2013. – MNHA A-1014160, 1, 48.7 mm SL; MNHA A-1014161, 1, 44.6 mm SL; Hyogo: Kobe: Kita-ku: Muko river system: Kamagatani River, 26 October 1992. – TKPM-P 7377, 1, 43.1 mm SL; Tokushima: Myozai: Kamiyama: Yoshino river system; T. Ito, 6 August 2014.

Non-types. All from Japan. FAKU 50367, 1, 40.2 mm SL; FAKU 115864, 1, 48.5 mm SL; Nara: Yoshino: Kumano river system; K. Hosoya et al., 20 July 1980. – KUN-P 42269, 1, 55.6 mm SL; KUN-P 42270, 1, 56.0 mm SL; Kagawa: Syodo-shima: Yoshida River; T. Ito, 11 October 2010. – KUN-P 45409, 1, 41.6 mm SL; Wakayama: Hidaka: Hidakagawa: Hidaka river system; T. Ito et al., 9 September 2013. – KUN-P 44147, 1 cs, 50.6 mm SL; Hyogo: Minami-Awaji: Sumoto river system: Ayuya River; T. Ito & S. Aoyama, 19 August 2012. – KUN-P 44148, 1, 52.2 mm SL; Hyogo: Tanba: Kasuga: Yura river system; T. Ito & S. Aoyama, 27 May 2012. – KUN-P 44178, 1, 40.9 mm SL; Hyogo: Takarazuka: Muko river system; T. Ito, 3 July 2011. – KUN-P 44595, 1, 45.5 mm SL; Kagawa: Nakatado: Mannou: Doki River; T. Ito, 7 August 2014. – KUN-P 44717, 1, 41.1 mm SL; KUN-P 44720, 1, 40.1 mm SL; KUN-P 44722, 1, 39.5 mm SL; Tokushima: Myozai: Kamiyama: Yoshino river system; T. Ito, 6 August 2014. – KUN-P 45450, 1, 34.9 mm SL; Kagawa: Higashi-Kagawa: Omi: Omi river system; A. Inotsuka, 4 March 2013. – KUN-P 45731, 1 cs, 59.2 mm SL; Hyogo: Tatsuno: Shingu: Tsunogame: Chikusa river system; T. Ito & S. Aoyama, 27 August 2011.

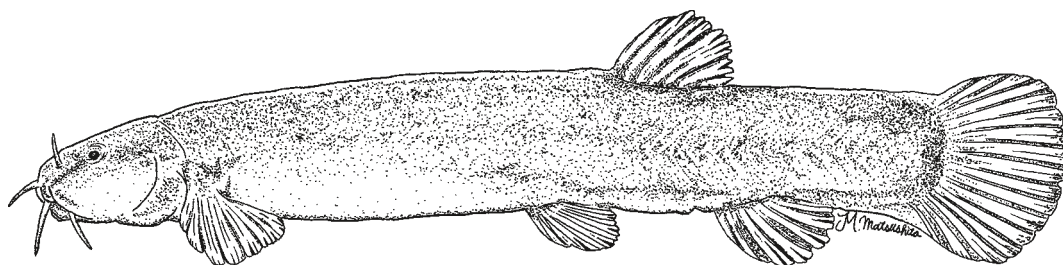


Fig. 1. *Lefua torrentis*; KUN-P 45408, holotype, 44.9 mm SL, Japan: Hyogo: Tanba: Kasuga: Yura River system.

Diagnosis. *Lefua torrentis* is distinguished from other species of *Lefua* by presence of a narrow conspicuous dark brown band between the base of outer rostral barbel and eye (vs. absence, or light and/or indistinct if present) (Figs. 1–3) and eyes located dorsally on the head (vs. dorsolaterally) (Fig. 4). *Lefua torrentis* is distinguished from *L. costata*, *L. pleskei*, *L. nikkonis*, and *L. sayu* by absence of a rhomboid or triangular dark blotch on the middle of the caudal-fin base (vs. presence). It is distinguished from *L. echigonia* by absence of dark spots on the dorsal and caudal fins, or sparse if present (vs. presence) (Fig. 5).

Description. Morphometric data in Table 1. Body elongated, slender, and moderately depressed; dorsal profile of body almost horizontal from nape to caudal-fin base, ventral profile slightly convex. Head depressed. Snout long; its tip bluntly rounded. Mouth small and inferior; mouth cleft almost horizontal; lip fleshy and smooth (Fig. 6). No median incision in upper lip. A median notch in lower lip. No processus dentiformis. Two pairs of rostral barbels and one pair of maxillary barbels. Inner rostral barbel reaching to or slightly posterior to horizontal through anterior of eye when extended. Outer rostral barbel longest, when extended reaching to or slightly surpassing horizontal through posterior border of eye. Maxillary barbel posterior to horizontal through posterior of eye when extended. Nostrils separated from each other; anterior nostril formed as long nasal barbel; posterior nostril larger than anterior one; anterior nostril at anterior border of nasal barbel, close to its base (Fig. 7). Nasal barbel reaching to or slightly surpassing centre of eye when extended. Eye very small, located on dorsal side of head, not visible in ventral view of head. Caudal peduncle 1.2 (0.9–1.6) times longer than its depth (depth including keels) with developed dorsal and ventral keels. Scales embedded on body.

Lateral line absent. Origin of dorsal fin nearer to caudal-fin base than to tip of snout. Pectoral fin horizontal. Pelvic fin origin in front of dorsal-fin origin. Anus positioned slightly anterior to anal fin. Caudal fin rounded.

Dorsal fin with 4 simple and 6 branched rays (Fig. 5). Second branched ray longest. Anal fin with 4 simple and 5 branched rays. Pectoral fin with 1 simple and 9 (7–10) branched rays. Pelvic fin with 1 simple and 5 (5–6) branched rays. No pelvic axillary lobe. Caudal fin with 2 (1–3) simple, 6 (5–7) + 8 (7–8) branched, and 1 (1–2) simple principal rays (Fig. 5). Total vertebrae 37 (36–40); abdominal vertebrae 19 (19–21); caudal vertebrae 18 (17–20).

Table 1. Morphometric data for holotype and paratypes (n=21) of *Lefua torrentis*. H, holotype; SD, standard deviation. Values of holotype included in range.

	H	range	mean	SD
			(n=22)	
Standard length (mm)	44.9	29.9–56.9		
Percents of standard length				
Head length	20.9	19.1–24.3	20.8	1.2
Body depth	14.4	11.7–16.3	14.2	1.3
Body width	13.9	9.5–14.1	12.3	1.2
Depth of caudal peduncle	12.4	10.1–13.6	11.9	1.0
Length of caudal peduncle	14.8	11.5–19.3	15.3	2.3
Predorsal length	67.2	61.7–76.0	66.9	3.1
Preanal length	76.0	73.9–81.9	78.3	2.6
Prepelvic length	56.1	54.2–62.1	57.1	2.2
Height of dorsal fin	10.9	6.1–14.1	11.4	1.8
Length of dorsal fin base	8.1	7.1–11.6	8.7	1.2
Height of anal fin	12.5	9.2–14.8	11.6	1.3
Length of anal fin base	8.1	5.9–10.3	7.9	1.0
Pectoral fin length	13.6	11.8–17.4	14.2	1.5
Percents of head length				
Snout length	34	34–46	40.4	3.2
Orbit diameter	13	10–18	13.2	2.2
Interorbital width	39	28–44	36.4	4.2



Fig. 2. Typical body coloration of *Lefua torrentis*; KUN-P 45408, holotype, 44.9 mm SL.



Fig. 3. Colour variant of *Lefua torrentis*; TKPM-P 7377, paratype, 43.1 mm SL, Japan: Tokushima: Myozai: Kamiyama: Yoshino River system.

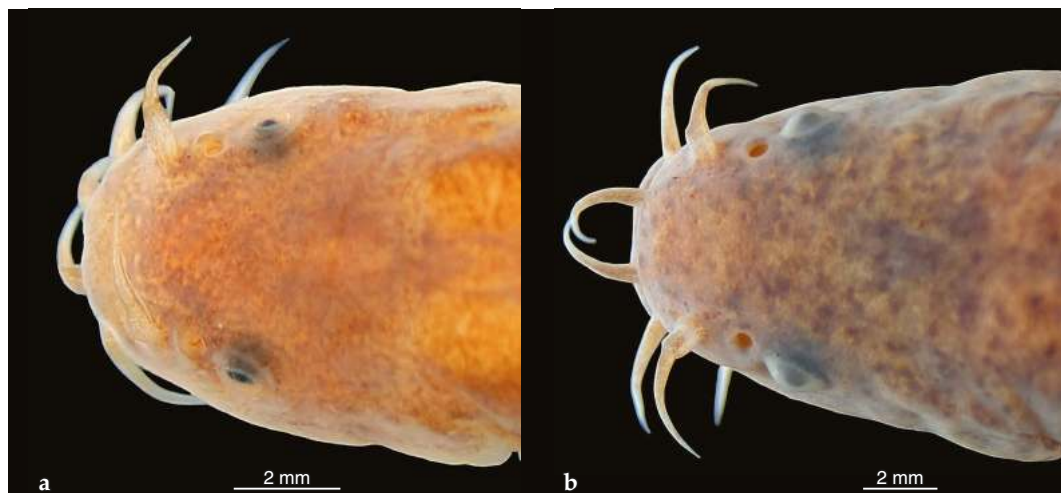


Fig. 4. Close-up of the head in dorsal view. **a**, *Lefua torrentis*, KUN-P 45408, holotype, 44.9 mm SL; **b**, *L. echigonia*, FRLM 11159, 59.3 mm SL.

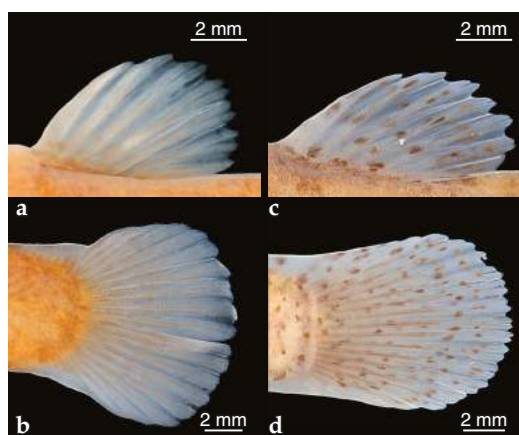


Fig. 5. Pigmentation on the dorsal and caudal fins in: **a-b**, *Lefua torrentis*, KUN-P 45408, holotype, 44.9 mm SL; **c-d**, *L. echigonia*, KUN-P 45399, 47.6 mm SL.

Cephalic lateral line system composed of conspicuous superficial neuromasts (Fig. 8). No ossified sensory canals.

Pectoral girdle (Fig. 9) consisting of cleithrum, coracoid, posttemporal, scapula, and supra-cleithrum; postcleithrum absent. Caudal skeleton (Fig. 10) consisting of first and second pre-ural centra, five hypurals, haemal spine and arch, parhypural, and pleurostyle; epural and uroneural absent.

Sexual dimorphism: no obvious sexual dimorphism. Females usually longer than males.



Fig. 6. Ventral view of mouth of *Lefua torrentis*, KUN-P 45408, holotype, 44.9 mm SL.

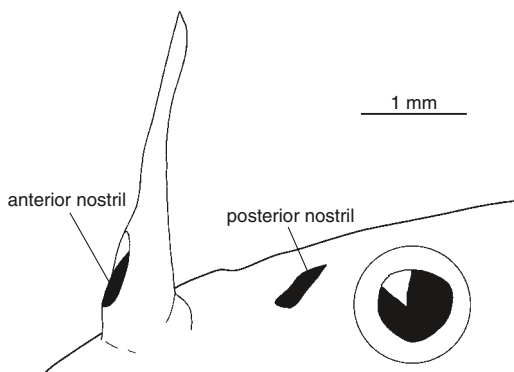


Fig. 7. Nostrils of *Lefua torrentis*, KUN-P 42268, non-type, 62.3 mm SL.

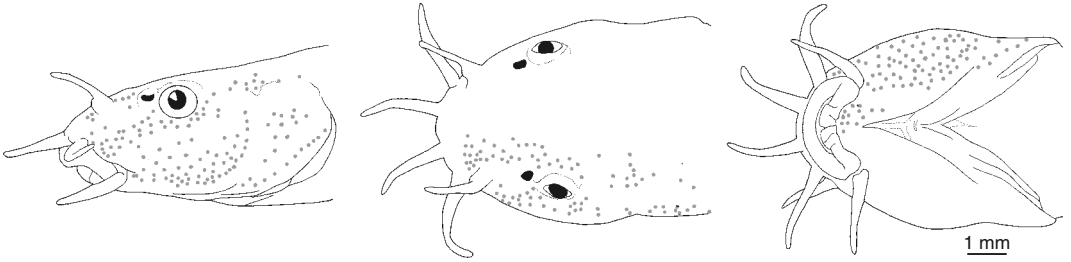


Fig. 8. Diagram of the cephalic lateral line system of *Lefua torrentis*, KUN-P 45450, non-type, 34.9 mm SL. Gray dots indicate superficial neuromasts.

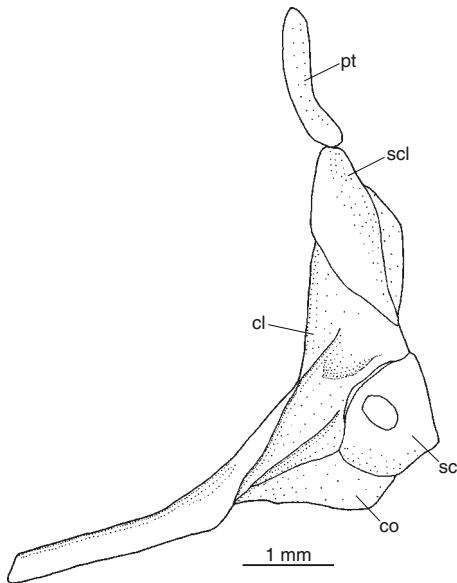


Fig. 9. Lateral view of pectoral girdle of *Lefua torrentis*, KUN-P 45731, non-type, 59.2 mm SL. cl, cleithrum; co, coracoid; pt, posttemporal; sc, scapula; scl, supra-cleithrum.

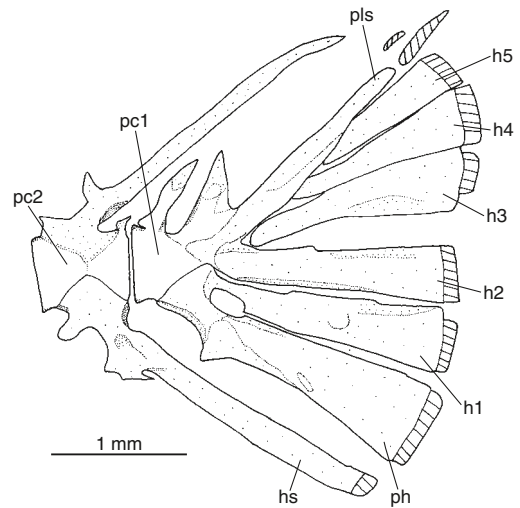


Fig. 10. Caudal skeletal system of *Lefua torrentis*, KUN-P 44147, non-type, 50.6 mm SL. Cartilage is cross-hatched. h, hypural; hs, haemal spine and arch; pc1, first preural centrum; pc2, second preural centrum; ph, parhypural; pls, pleurostyle.

Coloration. In formalin, body and head yellowish gray except for whitish gray ventral surface (Fig. 2). Both lips white. A narrow conspicuous longitudinal black mark between base of outer rostral barbel and eye. All fins pale to transparent without speckles, or sparse if present. In individuals from some rivers in Wakayama Prefecture, Shikoku, and Awaji Island, variable sizes of dark brown blotches on side and dorsal area of body and caudal peduncle (Fig. 3); large blotches on dorsal area of body and caudal peduncle, small blotches on side of body. In life, body slightly translucent.

Habitat. *Lefua torrentis* is confined to the uppermost reaches of mountain streams surrounded by dense natural vegetation (Fig. 11). It has a preference for sandy bottoms with gravel or pebbles, where it hides under rocks and stones. *Lefua torrentis* is syntopically distributed together with *L. echigonia* in the Yura and Kako rivers, although *L. echigonia* has a tendency to inhabit more lentic waters in swampy streams and ditches.

Distribution. *Lefua torrentis* is distributed in western Japan, around the Seto Inland Sea from Okayama to Wakayama prefectures in Honshu, and Ehime to Tokushima prefectures in Shikoku including the Awaji and Shodoshima islands



Fig. 11. Type locality of *Lefua torrentis*. One of the head waters of Yura river system, Hyogo Prefecture, Japan.

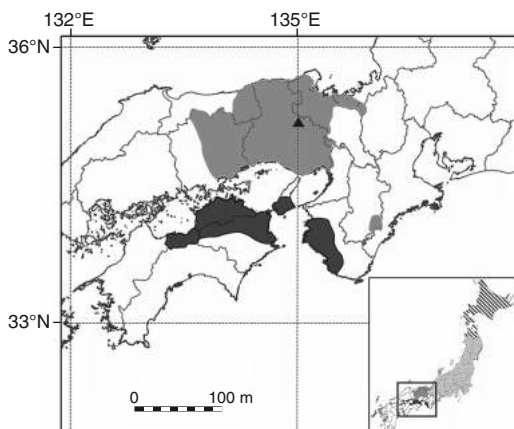


Fig. 12. Distribution of *Lefua torrentis* (gray: the typical body coloration, and black: colour variant), *L. nikkonis* (cross-hatched) and *L. echigonia* (dots). The type locality of *L. torrentis* is indicated by a black triangle.

(Fig. 12). *Lefua torrentis* is also distributed in some rivers along the coast of the Sea of Japan.

Etymology. The specific Latin name *torrentis* is a noun in genitive case and means “of the torrents” or “of running water”.

Remarks. *Lefua torrentis* shows a appearance similar to some species of *Oreonectes* (i.e. having a narrow conspicuous dark brown band between the base of the outer rostral barbel and the eye, a round caudal fin, the anterior nostril formed as a long nasal barbel and the absence of a postcleithrum). However, *L. torrentis* does not possess an epural, which is present in species of *Oreonectes* (cf. Prokofiev, 2005). Sawada (1982) considered the absence of the epural as synapomorphic for the genus *Lefua*. Prokofiev (2005) pointed out the absence of the epural also in the clade *Nemacheilus abyssinicus* + *Seminemacheilus lendli*, which emerged independently of *Lefua*. Prokofiev (2005) considered the loss of the epural in *Lefua* a non-unique synapomorphy.

Lefua torrentis differs from *L. costata*, *L. pleskei*, and *L. sayu* (see Kessler, 1876; Herzenstein, 1887; Herre & Lin, 1936) by having a narrow conspicu-

ous dark brown band between the base of the outer rostral barbel and the eye (vs. absence, or light and/or indistinct), and absence of a rhomboid or triangular dark blotch on the middle of the caudal fin base (vs. presence).

Lefua torrentis is endemic to western Japan and partly coexists with *L. echigonia* in the Yura and Kako rivers. *Lefua torrentis* is similar to *L. echigonia* in its general characteristics, but differs by presence of a narrow conspicuous dark brown band between base of outer rostral barbel and eye (vs. absence, or light and/or indistinct if present), eyes located dorsally on the head (vs. dorsolaterally on the head) and absence of dark spots on the dorsal and caudal fins, or sparse if present (vs. presence). These two species are, however, reproductively isolated from each other in the Yura and Kako rivers because of differences in mitochondrial and nuclear DNA sequences (see Sakai et al., 2003; Mihara et al., 2005; Miyazaki et al., 2007, 2011). By sequencing the mitochondrial D-loop region of specimens covering their distribution range, Miyazaki et al. (2011) showed that *L. torrentis* (*Lefua* sp. in Miyazaki et al., 2011) belongs to a clade distinct from that of *L. echigonia*. The genetic distinctiveness of *L. torrentis* as well as its unique morphological and ecological traits indicate that *L. torrentis* is a distinct species.

Individuals of *L. torrentis* from some rivers in Wakayama Prefecture, Shikoku, and Awaji Island exhibit variable sizes of dark brown blotches on side and dorsal area of the body and caudal

peduncle (Fig. 12). Presence or absence of dark brown blotches on the body and caudal peduncle may be intraspecific variation, because both colour types coexist in some rivers, and no supporting genetic differentiation has been found.

Comparative material. *Lefua echigonia*: All from Japan: CAS-SU 20164, 1, holotype, 39.3 mm SL; Niigata: Nagaoka. – FAKU 115835, 1, 56.8 mm SL; FAKU 115895, 1, 71.3 mm SL; FAKU 115896, 1, 37.8 mm SL; Kyoto: Kamo River. – FAKU 115849, 1, 51.6 mm SL; FAKU 115850, 1, 30.7 mm SL; FAKU 115851, 1, 58.4 mm SL; FAKU 115854, 1, 47.8 mm SL; Mie: Tsu: Geino. – FAKU 51051, 1, 52.6 mm SL; FAKU 115871, 1, 50.0 mm SL; FAKU 115872, 1, 40.8 mm SL; FAKU 115873, 1, 43.4 mm SL; FAKU 115874, 1, 40.1 mm SL; FAKU 115875, 1, 38.9 mm SL; FAKU 115876, 1, 37.9 mm SL; FAKU 115877, 1, 36.8 mm SL; FAKU 115878, 1, 38.5 mm SL; FAKU 115879, 1, 35.0 mm SL; FAKU 115881, 1, 32.3 mm SL; Tochigi: Otawara. – FAKU 51052, 1, 47.7 mm SL; Tokyo: Akikawa. – FAKU 51053, 1, 48.0 mm SL; FAKU 115894, 1, 40.9 mm SL; Chiba: Yoro River. – FAKU 51056, 1, 27.7 mm SL; FAKU 115870, 1, 27.2 mm SL; Shiga: Yogo River. – FAKU 51058, 1, 65.2 mm SL; Shiga: Hikone: Echigawa. – FAKU 51059, 1, 53.9 mm SL; Kyoto: Uji. – FRLM 11157, 1, 61.2 mm SL; FRLM 11158, 1, 60.9 mm SL; FRLM 11159, 1, 59.3 mm SL; FRLM 11160, 1, 59.0 mm SL; FRLM 11161, 1, 52.3 mm SL; FRLM 11162, 1, 36.4 mm SL; Mie: Miya River. – FRLM 11167, 1, 47.3 mm SL; FRLM 11168, 1, 45.1 mm SL; Mie: Yokowa River. – KUN-P 45398, 1, 62.4 mm SL; KUN-P 45399, 1, 47.6 mm SL; Akita: Konoura. – KUN-P 45400, 1, 66.8 mm SL; KUN-P 45401, 1, 51.7 mm SL; Yamagata: Hatsume River. – KUN-P 45403, 1, 60.9 mm SL; KUN-P 45404, 1, 42.3 mm SL; KUN-P 45405, 1, 45.4 mm SL; KUN-P 45406, 1, 44.7 mm SL; KUN-P 45407, 1, 39.3 mm SL; Hyogo: Tanba: Kasuga: Yura river system. – MNHA 1014140, 1, 49.5 mm SL; MNHA 1014141, 1, 46.1 mm SL; MNHA 1014142, 1, 40.9 mm SL; MNHA 1014143, 1, 40.9 mm SL; MNHA 1014144, 1, 40.4 mm SL; MNHA 1014145, 1, 31.4 mm SL; Hyogo: Tanba: Aogaki: Kako river system.

Lefua nikkonis: All from Hokkaido, Japan: CAS-SU 7848, 1, holotype, 59.4 mm SL; Chitose. – FAKU 51060, 1, 54.7 mm SL; FAKU 115882, 1, 54.0 mm SL; FAKU 115883, 1, 51.1 mm SL; FAKU 115884, 1, 51.1 mm SL; FAKU 115885, 1, 43.2 mm SL; FAKU 115886, 1, 42.7 mm SL; FAKU 115887, 1, 40.6 mm SL; Tomakomai: Tarumae.

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