

## Two new species of viviparous halfbeaks (Atherinomorpha: Beloniformes: Zenarchopteridae) endemic to Sulawesi Tenggara, Indonesia

Jan Huylebrouck<sup>1</sup>, Renny Kurnia Hadiaty<sup>2</sup> & Fabian Herder<sup>1\*</sup>

**Abstract.** Two new viviparous species of the zenarchopterid genus *Nomorhamphus* are described from Sulawesi Tenggara, Indonesia. The two new species are allopatric, share the same anal-fin morphology of adult males, but differ clearly in the length of the lower jaw and by features of fin pigmentation. *Nomorhamphus lanceolatus*, new species, and *N. sagittarius*, new species, are distinguished from all other congeners by a lanceolate, dorsally slightly curved spiculus in the male andropodium and by presence of a distinct black spot on the base of the pectoral fin. *Nomorhamphus lanceolatus*, from the Sampara river basin at the west coast of south-east Sulawesi, is further distinguished from congeners by its conspicuously short (15.0–25.3 times in SL) lower jaw, and black pigmentation in dorsal and anal fins. *Nomorhamphus sagittarius*, from the Mangolo river basin, has a longer (6.4–15.0 times in SL) lower jaw, and is further distinguished from all other members of the genus by presence of a few conspicuous teeth on the dorsal surface of the extended portion of the lower jaw. This brings the number of *Nomorhamphus* species endemic to Sulawesi to 12.

**Key words.** *Nomorhamphus*, taxonomy, Sulawesi, Tawo-Tawo River, Mangolo River, Pondok Stream, Wawolambo River, freshwater fish

### INTRODUCTION

Halfbeaks of the family Zenarchopteridae are mostly small atherinomorph fishes inhabiting freshwaters, estuaries, and marine habitats of the Indo-West Pacific region (Anderson & Collette, 1991; Lovejoy et al., 2004; Nelson, 2006). The family is composed of 55 valid species in the five genera *Dermogenys*, *Hemirhamphodon*, *Nomorhamphus*, *Tondanichthys*, and *Zenarchopterus* (Collette, 2004; Huylebrouck et al., 2012). The Indonesian island of Sulawesi harbours 10 of the 17 valid species of the viviparous genus *Nomorhamphus*; the other seven species are endemic to the Philippines (Meisner, 2001). In Sulawesi, *Nomorhamphus* is restricted to hillstream habitats; exceptions are two species endemic to large freshwater lakes (Brembach, 1991; Kottelat et al., 1993; Meisner, 2001).

Nearly 100 years after the description of the first viviparous halfbeak, *Dermogenys pusilla* Kuhl & van Hasselt, 1823, a species commonly present in rice fields and widely distributed in tropical Southeast Asia, the genus *Nomorhamphus* was erected for *N. celebensis* by Weber and de Beaufort in 1922. Three revisions are available (Mohr, 1936 a–c; Brembach, 1991; Meisner, 2001), but *Nomorhamphus* taxonomy suffered,

like that of other freshwater fishes of Sulawesi, from the limited status of exploration of the island's freshwater fauna. Accordingly, a number of recent discoveries from Sulawesi and nearby islands, which included several ricefishes (Herder & Chapuis, 2010; Parenti & Hadiaty, 2010; Herder et al., 2012; Parenti et al., 2013) and a colourful *Nomorhamphus* (Huylebrouck et al., 2012), was not surprising and highlighted the need for further ichthyological surveys in the region.

In *Nomorhamphus*, the morphology of the andropodium, the male copulatory organ which is composed of the first 5–7 anal-fin rays, provide characters important for species discrimination (Mohr, 1936 a–c; Brembach, 1976, 1991; Meisner & Burns, 1997; Meisner & Louie, 2000; Meisner, 2001). These rays are strongly curved and thickened, especially the second anal-fin ray, which is most noticeably modified with a pair of distal spines and a terminal structure referred to as the spiculus. Here, we describe two new species of *Nomorhamphus* from Sulawesi Tenggara, characterised by a lanceolate spiculus and a distinct black spot on the base of the pectoral fins.

### MATERIAL AND METHODS

Specimens of the two new *Nomorhamphus* were obtained from five sites in Sulawesi Tenggara, Indonesia, by electrofishing with a portable electroshocker or by seine- and tray-netting. Single individuals of both sexes were photographed immediately after catching to record live colouration. Subsequently, fish were preserved in 4% formalin and later transferred to 80% ethanol for storage. Counts and measurements as specified in Huylebrouck et al., 2012; measurements are taken from point to point, recorded

<sup>1</sup>Zoologisches Forschungsmuseum Alexander Koenig, Sektion Ichthyologie, Adenauerallee 160, D-53113 Bonn, Germany; Email: f.herder@zfmk.de (\*corresponding author FH)

<sup>2</sup>Museum Zoologicum Bogoriense (MZB), Ichthyology Laboratory, Division of Zoology, Research Center for Biology, Indonesian Institute of Sciences (LIPI), JL. Raya Bogor Km 46, Cibinong 16911, Indonesia; Email: rani\_hadiaty@yahoo.com (RKH)

to the nearest 0.1 mm with a digital caliper. Data listed in *Description* and *Comparisons* below refer to the type material. Counts of the unpaired fins and vertebrae (total = abdominal + caudal) were obtained from radiographs (Faxitron LX-60). In the caudal fin, all rays were counted including unbranched rays in the upper and lower lobes, reported below as upper principal rays/lower principal rays and upper principal rays/lower principal rays. Vertebral counts exclude the last centrum supporting the hypural complex. In both of the new species described here, the predorsal scales are deeply embedded, preventing reliable counts in most of the specimens; therefore, counts of predorsal scales are restricted to 17 of 36 type specimens in *Nomorhamphus sagittarius* and are not provided for *N. lanceolatus*. Counts obtained from holotype are listed in square brackets []. Terms used for describing the modified anal-fin rays of males follow Brembach (1976, 1991), Meisner & Burns (1997) and Meisner (2001). A resume of these terms is given in Huylebrouck et al., 2012. In undissected specimens the first segments of each ray and entire anal-fin rays 4–7 are not clearly visible. For this reason, the drawing of the andropodium was made by using a camera lucida and a cleared and stained male specimen of *Nomorhamphus sagittarius* (MZB 20443, 35.0 mm SL). Comparative material of *Nomorhamphus* from Sulawesi Tenggara, Tengah, and Selatan was collected between 1978 and 2004 (see *Comparative Material*). Material examined is deposited in the Museum Zoologicum Bogoriense (MZB), Research and Centre for Biology, the Indonesian Institute of Sciences (LIPI), Cibinong, Indonesia, the Zoologisches Forschungsmuseum Alexander Koenig, Bonn (ZFMK), the Zoologisches Museum Hamburg (ZMH), and the Museum of Wildlife and Fish Biology, University of California, Davis (WFB).

## TAXONOMY

### *Nomorhamphus lanceolatus*, new species (Figs 1–4, 7; Table 1)

**Material examined. Holotype** – MZB 21299 (40.8 mm SL), male, Indonesia, Sulawesi, Southeast Sulawesi Province, Regency of Kolaka Utara, Wawolambo River, near the bridge on the road, between Kolaka and Kendari, 04°02'51.6"S 121°42'40.8"E, R. K. Hadiaty, D. Wowor & S. Sauri, 8 July 2011.

**Paratypes.** MZB 21300, 3 males (30.5–43.0 mm SL), 2 females (36.4–53.8 mm SL), all collected with the holotype; ZFMK 49526–49529, 2 males (33.7–34.8 mm SL), 2 females (45.3–48.9 mm SL), all collected with the holotype; ZMH 25920–25921, 1 male (33.6 mm SL), 1 female (49.2 mm SL), all collected with the holotype; WFB 3125–3128, 2 males (32.5–33.4 mm SL), 2 females (33.7–49.8 mm SL), all collected with the holotype.

**Additional non-type material.** MZB 20455, 3 immature females (22.5–25.7 mm SL), 4 undet. (16.6–19.5 mm SL), all collected with the holotype.

**Diagnosis.** *Nomorhamphus lanceolatus* is distinguished from all other *Nomorhamphus* by the combination of the following characters: lower jaw short; absence of a fleshy lower jaw appendage in males; presence of black pigmentation in anal and dorsal fin, life colouration with yellow and orange

coloured anal, dorsal, and caudal fin, ventral surface of lower jaw orange and yellow belly; a lanceolate, dorsally slightly curved spiculus in the male andropodium, with the middle segments of the spiculus in contact with the distal tip of the third anal-fin ray (Fig. 1); nine to ten segments proximal to spinae (mode nine segments); segments three or four to six or seven (mode four to seven) of second anal-fin ray in males with a dorsal and a ventral row of “subsegments” forming small squares and rectangles of different sizes, so that these segments seem to be subdivided; third anal-fin ray slightly constricted longitudinally, giving the appearance of two distinct rays, distal part of this ray is slightly curved ventrally to contact spiculus.

**Description.** Morphometric and meristic characters are provided in Table 1. Body deep,  $BDP_1$  18.2–20.6 % SL,  $BDP_2$  17.9–21.4% SL. Lower jaw short (LJLB 15.0–25.3 times in SL), upper jaw longer than wide (UJL/UJW 1.2–1.4). Eye relatively large, bony orbital diameter 20.0–22.9% HDL. One row of conical teeth at the front of the upper and lower jaws, followed by three rows of conical teeth up to the end of the jaws. Gill rakers tear-drop shaped, without teeth on the dorsal surface of the gill rakers. Vertebrae number 36–38 [37]. Predorsal scales deeply embedded. Anal-fin rays 15–16 [15]. Dorsal-fin origin over anal-fin ray 2, 3 or 4 [3]. Dorsal-fin rays 11–13 [12]. Pectoral-fin rays 13. Pelvic-fin rays 6. Fifth hypural fused to dorsal hypural plate. Caudal peduncle depth 8.7–9.8% SL. Caudal fin truncate, principal caudal-

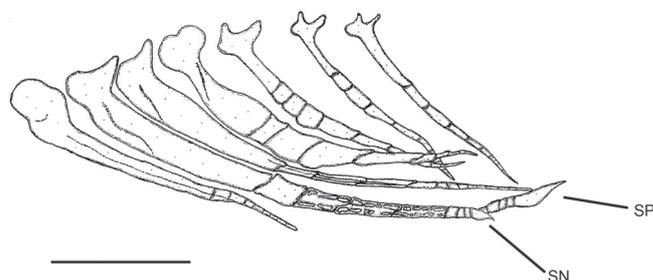


Fig. 1. Diagrammatic representation of the modified anal-fin rays (andropodium) of *Nomorhamphus lanceolatus* and *N. sagittarius*, MZB 20443, 35.0 mm SL, cleared and stained male specimen of *N. sagittarius*. Scale bar = 1 mm. SN, Spinae; SP, Spiculus.



Fig. 2. A, B, *Nomorhamphus lanceolatus*; Indonesia, Sulawesi: Sulawesi Tenggara; Wawolambo River, near the bridge on the road, between Kolaka and Kendari, 04°02'51.6"S 121°42'40.8"E (© R. K. Hadiaty). A, male; B, female.

fin rays  $i,5-6/5-6,i$  (mode and holotype  $i,6/6,i$ ), procurent caudal-fin rays  $5-7/5-6$  (mode  $6/5$ ; holotype  $5/5$ ).

**Life colouration.** Body yellowish brown (Fig. 2). Ventral surface of lower jaw orange. Interoperculum and belly yellow. Iris grey with a yellow edge. Diffuse black, oval spot anterior to the pectoral fin and distinct black, oval spot on the base of the pectoral fin, proximal part of the pectoral-fin rays yellowish hyaline, which merges into transparent distally. Pelvic fins yellow. Base of dorsal-fin rays and anal-fin rays yellowish hyaline, distal parts light orange with black pigment on distal tips of posterior fin rays, in females small black parts on distal half of anterior dorsal-fin rays and anal-fin rays. Base of caudal fin yellowish hyaline, followed by an orange hyaline part.

**Preserved colouration.** Background colour beige (Fig. 3) with thin mid-lateral stripe from pectoral to caudal fin, more prominent posteriorly. Distinct oval spot on pectoral-fin base. Uniform distribution of melanophores on the head and on the dorsal and flank of the trunk; high concentration of melanophores anterior and dorsal to the distinct oval spot on pectoral-fin base. Black pigment on distal tips of posterior dorsal-fin rays and on distal tips of posterior anal-fin rays. In larger females black pigment on distal half of anterior dorsal-fin rays and anal-fin rays.

**Sexual dimorphism.** Females grow larger than males (maximum SL recorded: 43.0 mm in males, 53.8 mm in females). Males with andropodium.



Fig. 3. A, *Nomorhamphus lanceolatus*, MZB 21299, holotype, 40.8 mm SL, male, right side, reversed; B, MZB 21300, paratype, 53.8 mm SL, female.

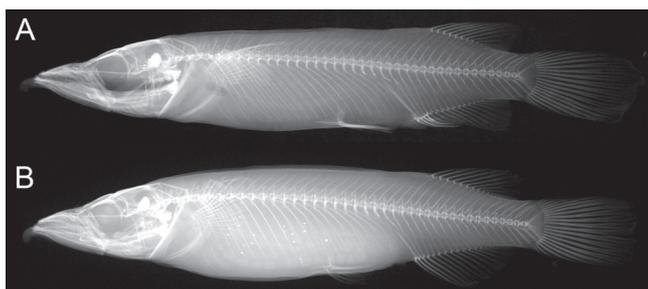


Fig. 4. Radiograph of *Nomorhamphus lanceolatus*. A, MZB 21299, holotype, 40.8 mm SL, male; B, MZB 21300, paratype, 53.8 mm SL, female.

**Distribution and habitat.** *Nomorhamphus lanceolatus* is known from Sungai Wawolambo in Sulawesi Tenggara, Indonesia (Fig. 5). The stream belongs to the Sampara river basin. The holotype and the paratypes were taken from a locality near the bridge on the road between Kolaka and Kendari. The stream of this locality ( $04^{\circ}02'51.6''S$   $121^{\circ}42'40.8''E$ ) is about 7–9 m wide and 50 cm deep, partially shaded by forest canopy, with a bed of sand and gravel (Fig. 6).

**Etymology.** From the late Latin adjective *lanceolatus* (“lanceolate”), in allusion to the shape of the spiculus of the new species.

**Comparisons.** In contrast to other *Nomorhamphus* species from Sulawesi with exception of *N. sagittarius*, *N. lanceolatus*

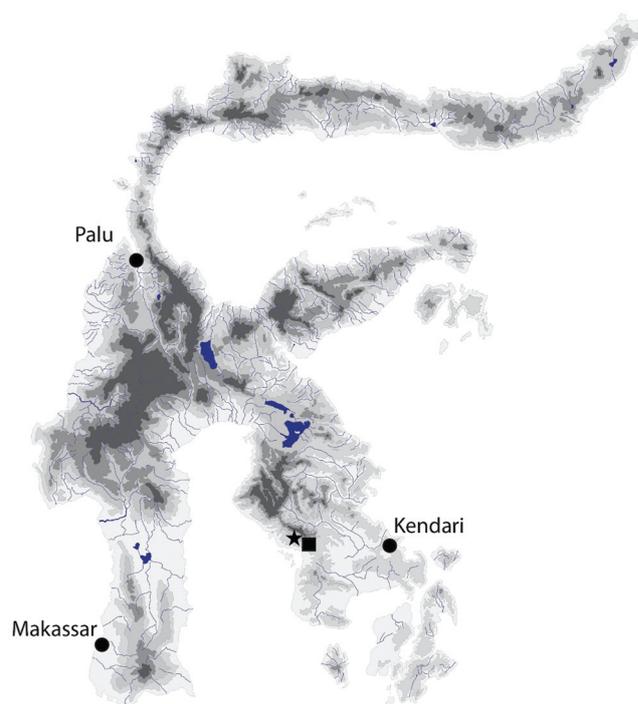


Fig. 5. Map of Sulawesi with highlighted sampling locations. Star, sampling locations of *N. sagittarius*; Square, sampling location of *N. lanceolatus* (© map T. von Rintelen, modified).



Fig. 6. Wawolambo River, type locality of *Nomorhamphus lanceolatus* (© R. K. Hadiaty).



has a characteristic lanceolate male spiculus, and is further distinguished by the presence of a black spot on the base of the pectoral fin (absent in all other *Nomorhamphus*, except of *N. sagittarius*). *Nomorhamphus lanceolatus* is distinguished from *N. sagittarius* by having a short lower jaw approximately equal in length of the upper jaw (LJLB 15.0–25.3 times in SL vs. 6.4–15.0 times in SL in *N. sagittarius*), and by the black pigmentation of the dorsal and anal fins lacking in *N. sagittarius*. Among other characters, the new species differs from *N. megarrhamphus* and *N. weberi* by having a first anal-fin pterygiophore which is thickened and not angled anteriorly (see Meisner, 2001) and a much less elongated lower jaw (lower jaw length following Brembach 15.0–25.3 times in SL in *N. lanceolatus*, vs. 4.0–5.7 times in SL in *N. megarrhamphus* and 3.7–4.9 times in SL in *N. weberi*; Meisner, 2001). Furthermore, the new species is distinguished from *N. megarrhamphus* and *N. weberi* by a yellowish brown body colouration (vs. a silvery-bluish life colouration in *N. megarrhamphus* and *N. weberi*) and the absence of a large concentration of melanophores on the dorsal surface (vs. presence in preserved condition in *N. megarrhamphus* and *N. weberi*; Meisner, 2001). The new species is distinguished from *N. brembachi* and *N. liemi* by lacking a fleshy appendage of the lower jaw in males. In *N. brembachi* and *N. liemi*, the second male anal-fin ray is curved at approximately  $\frac{1}{4}$  its length so that the distal  $\frac{1}{2}$  slopes ventrally (see Meisner, 2001). *Nomorhamphus lanceolatus* is distinguished from *N. rex*, *N. ebrardtii*, and *N. kolonodalensis* by its shorter lower jaw (LJLB 15.0–25.3 times in SL vs. 5.7–11.3 in *N. rex*, 13.4–15.9 in *N. ebrardtii* and 8.8–22.2 in *N. kolonodalensis*; Meisner & Louie, 2000; Meisner, 2001; Huylebrouck et al., 2012), having the fifth hypural plate completely fused to the dorsal hypural plate (vs. the fifth hypural partially separate from the dorsal hypural plate along most of its length in *N. kolonodalensis*; Meisner & Louie, 2000), and presence of black pigments on distal tips of posterior dorsal- and anal-fin rays (vs. no fin pigmentation in *N. ebrardtii*; Brembach, 1991).

The habitus of *Nomorhamphus lanceolatus* is most similar to *N. celebensis* and *N. towoetii*. *Nomorhamphus lanceolatus* is however clearly distinguished from these species by the shape of the spiculus, which is lanceolate (vs. a straight spiculus that is not noticeably thickened in *N. celebensis* and *N. towoetii*; Meisner, 2001), and by the painted life colouration composed of yellow- and orange-coloured anal, dorsal and caudal fin, orange-coloured ventral surface of lower jaw, and yellow-coloured belly (vs. grey to black bodies in *N. celebensis* and *N. towoetii*). The new species is distinguished from *N. celebensis* by its comparatively narrow upper jaw (UJL/UJW 1.2–1.4 in *N. lanceolatus* vs. 0.70–0.94; Meisner, 2001), and from *N. towoetii* by its yellowish brown body colouration (vs. olive body with a large concentration of melanophores on lateral and dorsal body surfaces, which gives females a dusky appearance whereas large males are completely melanistic in *N. towoetii*; Meisner, 2001).

The shape of the andropodium, viz the elongated spiculus, of *Nomorhamphus lanceolatus* is superficially similar to certain species of *Nomorhamphus* endemic to the Philippines,

including *N. bakeri*, *N. manifesta*, *N. pectoralis*, *N. philippina*, *N. vivipara*, and *N. pinnimaculata*. *Nomorhamphus lanceolatus* differs from these however in lower jaw length (LJLB 15.0–25.3 times in SL vs. 5.1 times in SL in *N. bakeri*, 6.1–11.5 times in SL in *N. manifesta*, 6.9–18.6 times SL in *N. pectoralis*, 10.4–18.8 times in SL in *N. philippina*, 5.6–20.6 times in SL in *N. pinnimaculata*, 4.5–8.3 times in SL in *N. rossi* and 5.3–7.9 times in SL in *N. vivipara*; Meisner, 2001), the lanceolate spiculus which is curved dorsally (vs. slender and curved ventrally in *N. bakeri*, *N. manifesta*, *N. pectoralis*, *N. philippina*, *N. vivipara*, and *N. pinnimaculata* respectively short and thick in *N. rossi*; Meisner, 2001), and the presence (vs. absence) of a distinct black spot on the base of the pectoral fin. With exception of *N. pectoralis*, the new species is distinguished by the fifth hypural plate which is fused to the dorsal hypural plate (vs. fifth hypural plate separate from the dorsal hypural plate among most of its length; see Fig. 7; Meisner, 2001). *Nomorhamphus pectoralis* is distinguished from *N. lanceolatus* by a dorsally offset spiculus giving the anal-fin ray an appearance of a small step located at the spines (vs. no offset spiculus in *N. lanceolatus*; Meisner, 2001).

***Nomorhamphus sagittarius*, new species**  
(Figs 8–10, 12; Table 2)

**Material examined.** **Holotype** – MZB 21301 (42.8 mm SL), male, Indonesia, Sulawesi, Southeast Sulawesi Province, Regency of Kolaka Utara, District Kolaka, Village Ulunggolaka, Mangolo River, R. K. Hadiaty, D. Wowor & S. Sauri, 5 July 2011.

**Paratypes.** MZB 21302, 1 male (30.5 mm SL), 6 females (51.6–72.5 mm SL), all collected with the holotype; MZB 21303, 2 males (33.4–37.1 mm SL), 2 females (49.5–60.6 mm SL), Mangolo River, about 500 m away from locality

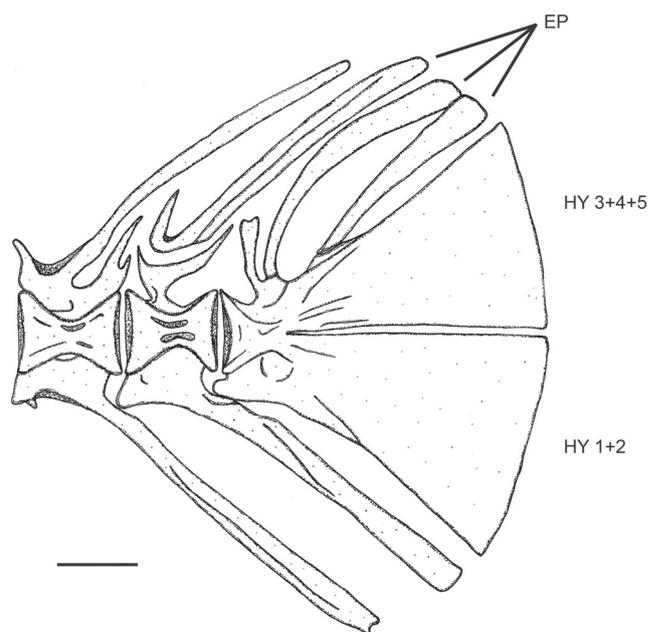


Fig. 7. Diagrammatic representation of the caudal skeleton of *Nomorhamphus lanceolatus*, MZB 21299, holotype, 40.8 mm SL, male. Scale bar 500  $\mu$ m. EP, epural; HY, hypural. The hook shaped first epural is only present in the holotype; all other specimens exhibit a straight first epural.

of holotype, 03°58'56.6"S 121°34'05.5"E, R. K. Hadiaty, D. Wowor & S. Sauri, 5 July 2011; MZB 21304, 2 males (38.0–38.3 mm SL), 2 females (52.8–54.7 mm SL), Regency of Kolaka Utara, District Kolaka, Village Ulunggolaka, Tawo-Tawo River, 03°59'08.8"S 121°33'45.5"E, R. K. Hadiaty, D. Wowor & S. Sauri, 7 July 2011; MZB 21305, 1 male (30.6 mm SL), 3 females (50.2–51.7 mm SL), Watumbasi River, 03°59'07.2"S 121°34'10.7"E, R. K. Hadiaty, D. Wowor & S. Sauri, 7 July 2011; ZFMK 49530–49531, 1 male (37.2 mm SL), 1 female (67.0 mm SL), same data as MZB 21302; ZFMK 49532–49533, 1 male (36.7 mm SL), 1 female (59.5 mm SL), same data as MZB 21303; ZFMK 49534–49535, 1 male (38.9 mm SL), 1 female (60.3 mm SL), same data as MZB 21304; ZFMK 49536–49537, 1 male (39.7 mm SL), 1 female (65.1 mm SL), same data as MZB 21305; ZMH 25922–25923, 1 male (38.1 mm SL), 1 female (60.8 mm SL), same data as MZB 21304; ZMH 25924–25925, 1 male (32.3 mm SL), 1 female (66.1 mm SL), same data as MZB 21305; WFB 3129–3130, 1 male (39.3 mm SL), 1 female (63.9 mm SL), same data as MZB 21304; WFB 3131–3132, 1 male (33.3 mm SL), 1 female (65.7 mm SL), same data as MZB 21305.

**Additional non-type material.** MZB 20437, 5 males (26.4–33.8 mm SL), 10 females (33.1–76.5 mm SL), 1 undet. (22.9 mm SL), all collected with the holotype; MZB 20431, 6 males (24.4–37.2 mm SL), 5 females (32.4–66.9 mm SL), 4 undet. (12.7–22.1 mm SL), same data as MZB 21303; MZB 20443, 45 males (25.1–38.1 mm SL, of which one specimen has been cleared and counterstained), 33 females (27.8–55.4 mm SL), 26 undet. (16.5–26.3 mm SL), same data as MZB 21304; MZB 20452, 4 males (27.3–31.9 mm

SL), 13 females (32.0–51.4 mm SL), 1 undet. (18.5 mm SL), same data as MZB 21305.

**Diagnosis.** *Nomorhamphus sagittarius* is distinguished from all other *Nomorhamphus* by the following combination of characters: lower jaw elongated; one to seven teeth along dorsal surface of extended portion of lower jaw (absent in some specimens); fins and ventral surface of lower jaw orange; black fin pigmentation absent; a distinct black spot on the base of the pectoral fin; a lanceolate, dorsally slightly curved spiculus in the male andropodium, its middle segments in contact with the distal tip of the third anal-fin ray (Fig. 1); seven to ten segments proximal to spinae (mode eight); segments three to seven (mode three to five) of second anal-fin ray in males with a dorsal and a ventral row of “subsegments” forming small squares and rectangles of different sizes, so that these segments seem to be subdivided. Some males (78.6% of the adult male type specimens) with an elongated fourth or fifth segment (mode fifth) in second anal-fin ray. Third anal-fin ray slightly constricted longitudinally, giving the appearance of two distinct rays, distal part of this ray is slightly curved ventrally to contact spiculus.

**Description.** Morphometric and meristic characters are provided in Table 2. Body deep,  $BDP_1$  16.1–19.1% SL,  $BDP_2$  17.5–20.7% SL. Lower jaw elongate (LJLB 6.4–15.0 times in SL), upper jaw longer than wide (UJL/UJW 1.3–1.8). Eye relatively large, bony orbital diameter 15.7–21.7 % HDL. One row of conical teeth at the front of the upper and lower jaws, followed by three rows of conical teeth up to the end of the upper and lower jaws in larger females. Males and smaller females with one row of conical teeth at the front of the upper and lower jaws, followed by two rows of conical teeth up to the end of the upper jaw and three rows up to the end of the lower jaw. Gill rakers tear-drop shaped, without teeth on the dorsal surface of the gill rakers. Vertebrae number 37–39 [39]. 46–54 predorsal scales. Anal-fin rays 14–17 [17]. Dorsal-fin origin over anal-fin ray 3, 4, 5 or 6 [5]. Dorsal-fin rays 11–13 [12]. Pectoral-fin rays 11–12 [12]. Pelvic-fin rays 6. Fifth hypural fused to dorsal hypural plate. Caudal peduncle depth 7.5–9.2% SL. Caudal fin truncate, principal caudal-fin rays i,6/6,i, procurrent caudal-fin rays 5–6/4–5 (mode and holotype 5/5).

**Life colouration.** Body brown (Fig. 8). Ventral surface and distal tip of lower jaw orange. Iris light yellowish. Very diffuse black, oval spot anterior to the pectoral fin and a distinct



Fig. 8. A, B, *Nomorhamphus sagittarius*; Indonesia, Sulawesi: Sulawesi Tenggara; Mangolo River, 03°58'56.6"S 121°34'05.5"E (© R. K. Hadiaty). A, male; B, male, immediately after catching.



Fig. 9. A, *Nomorhamphus sagittarius*, MZB 21301, holotype, 42.8 mm SL, male; B, MZB 21302, paratype, 72.5 mm SL, female.

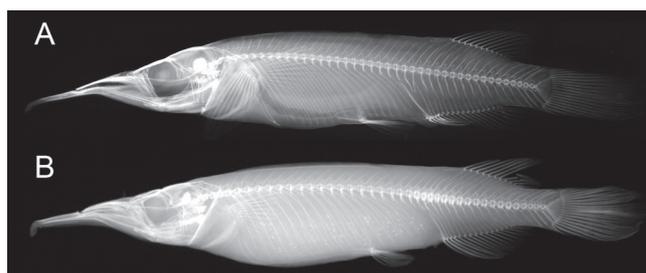


Fig. 10. Radiograph of *Nomorhamphus Sagittarius*: A, MZB 21301, holotype, 42.8 mm SL, male; B, MZB 21302, paratype, 72.5 mm SL, female.



black, oval spot on the base of the pectoral fin; distal tips of pectoral fins orange. Proximal half of pelvic fins yellowish hyaline; distal half of pelvic fins orange. Bases of dorsal, anal and caudal fin yellowish hyaline; distal parts of the dorsal, anal and caudal fin orange. Black pigment absent in all fins.

**Preserved colouration.** Background colour beige (Fig. 9) with thin midlateral stripe from pectoral to caudal fin, more prominent posteriorly. Distinct oval spot on the base of the pectoral fin. Uniform distribution of melanophores on the head and on the dorsal and flank of the trunk; high concentration of melanophores anterior and dorsal to the distinct oval spot on pectoral-fin base. Black pigment absent in all fins. Small black spot on the base of any pelvic fin.

**Sexual dimorphism.** Females grow larger than males (maximum SL recorded: 39.7 mm in males, 72.5 mm in females). Males in average with a longer lower jaw (SL/LJLB 6.4–10.8 vs. 6.9–15.0 in females) and with larger eyes compared to their head length (18.5–21.7 ORBL in % HDL vs. 15.7–18.5 in females). Males with andropodium.

**Distribution and habitat.** *Nomorhamphus sagittarius* is known from three streams in Sulawesi Tenggara, Indonesia (Fig. 5). The Sungai Mangolo is about 6–8 m wide and 10–100 cm deep with a sandy and rocky bottom and clear water at the type locality near the Scout Camping Ground of the Forestry Department area (Fig. 11). The second sample site from Sungai Mangolo is characterised by murky water due to traditional gold mining in the area. The river is about 5–7 m wide, 10–50 cm deep and moderate running with a few boulders and stones at this point and is covered by rain forest canopy (03°58'56.6"S 121°34'05.5"E). The Mangolo River belongs to the Mangolo river basin; the tributaries are the Sungais Tawo-Tawo and Watumbasi, which are the other two localities of *N. sagittarius*. Sungai Tawo-Tawo is about 3–5 m wide and 10–50 cm deep at the sample site (03°59'08.8"S 121°33'45.5"E). This habitat is characterised by a sandy and gravel bottom and by clear water with much riparian vegetation. The Sungai Watumbasi locality is 1–3 m wide, 10–30 cm deep and is characterised by a muddy-sandy bottom (03°59'07.2"S 121°34'10.7"E).

**Etymology.** From the Latin *sagittarius*, an archer, in allusion to the body shape of the new species, reminiscent of the shape of an arrow. A noun in apposition.

**Comparisons.** In contrast to other *Nomorhamphus* species from Sulawesi, with exception of *N. lanceolatus*, *N. sagittarius* has a characteristic lanceolate spiculus in males, a distinct black spot on the base of the pectoral fin and a few teeth along the dorsal surface of the extended portion of the lower jaw (absent in all other *Nomorhamphus*). *Nomorhamphus sagittarius* is distinguished from *N. lanceolatus* by having an elongated lower jaw (LJLB 6.4–15.0 times in SL vs. upper and lower jaw approximately equal in length in *N. lanceolatus*, LJLB 15.0–25.3 times in SL) and by the pigmentation of the pelvic, dorsal and anal fin which is lacking in *N. sagittarius*. The new species is distinguished from *N. megarrhamphus* and *N. weberi* by having a first anal-fin pterygiophore which

is thickened and not angled anteriorly (see Meisner, 2001) and a much less elongated lower jaw (lower jaw length following Brembach 6.4–15.0 times in SL in *N. sagittarius*, vs. 4.0–5.7 times in SL in *N. megarrhamphus* and 3.7–4.9 times in SL in *N. weberi*; Meisner, 2001). Furthermore, the new species is distinguished from *N. megarrhamphus* and *N. weberi* by a brown body colouration (vs. a silvery-bluish life colouration in *N. megarrhamphus* and *N. weberi*) and the absence of a large concentration of melanophores on the dorsal surface (vs. presence in preserved condition in *N. megarrhamphus* and *N. weberi*; Meisner, 2001). The new species is distinguished from *N. brembachi* and *N. liemi* by lacking a fleshy appendage of the lower jaw in males. In *N. brembachi* and *N. liemi* the second anal-fin ray in males is curved at approximately  $\frac{1}{4}$  its length so that the distal  $\frac{1}{2}$  slopes ventrally (see Meisner, 2001). In addition, *N. brembachi*, *N. liemi*, *N. celebensis*, and *N. towoetii* are characterised by lacking an elongate lower jaw and instead, have an upper and lower jaw approximately equal in length (Meisner, 2001). The painted life colouration with orange coloured fins and ventral surface of lower jaw distinguishes *N. sagittarius* from *N. celebensis* and *N. towoetii* (grey to black bodies in *N. celebensis* and *N. towoetii*). *Nomorhamphus sagittarius* is distinguished from *N. rex* and *N. kolonodalensis* by its absence of black pigment on fin rays (vs. black pigment on distal tips of dorsal- and anal-fin rays in *N. kolonodalensis* and *N. rex*; Meisner & Louie, 2000; Huylebrouck et al., 2012) and fifth hypural plate completely fused to dorsal hypural plate (vs. fifth hypural partially separate from dorsal hypural plate along most of its length in *N. kolonodalensis*; Meisner & Louie, 2000). The new species is distinguished from *N. ebrardtii* by the dorsal-fin origin over anal-fin ray 3–6 (vs. 6–7 in *N. ebrardtii*; Meisner, 2001).

The habitus of *Nomorhamphus sagittarius* is most similar to the seven species of *Nomorhamphus* endemic to the Philippines. *Nomorhamphus sagittarius* is clearly distinguished from these species by the absence of fin pigmentation (vs. black fin pigmentation in *N. bakeri*, *N. manifesta*, *N. pectoralis*, *N. philippina*, *N. pinnimaculata*, *N. rossi*, and *N. vivipara*; see Meisner, 2001), the fifth hypural plate which is fused to the dorsal hypural plate (vs. fifth hypural plate separate from the dorsal hypural plate among most of its length, except in *N. pectoralis*; Meisner, 2001), a few teeth along dorsal surface of the extended portion of the lower jaw and a distinct black spot on the base of the pectoral fin (vs. absent in all of these species). *Nomorhamphus sagittarius* is distinguished from *N. pectoralis* by the centrally offset spiculus (vs. spiculus offset dorsally in *N. pectoralis*; Meisner, 2001). The new species is distinguished from *N. philippina* by the spiculus which is not clearly segmented, lanceolate, turned dorsally and the terminal segment is longer than the segmented region (vs. clearly segmented, slender, terminal segment turned ventrally and shorter than segmented region, Meisner, 2001). The male anal fin of *N. sagittarius* is most similar to those of *N. vivipara*, *N. manifesta*, and *N. pinnimaculata* in that the spiculus is elongate. The spiculus of the andropodium of the new species is curved dorsally (vs. curved slightly ventrally in *N. vivipara*, *N. manifesta* and *N. pinnimaculata*; Meisner, 2001).

**Remarks.** Following Meisner (2001), the species described herein are clearly assigned to the genus *Nomorhamphus* (vs. *Dermogenys*, *Hemirhamphodon*, and *Zenarchopterus*) by exhibiting the following combinations of characters: oval lacrimal; elongate, expanded autopalatine; teeth along the extended portion of the lower jaw absent in *Nomorhamphus lanceolatus*, and teeth not reaching to the frontal tip of the lower jaw in *N. sagittarius*; uniserial teeth not extending medially in a concave row from outer row of teeth; modified anal-fin rays in males with a fleshy covering (cryptoplica); second anal-fin ray in males without a distinct geniculus; melanophores anterior to the anal fin in females not forming a distinct spot.

**Comparative material.** *Nomorhamphus rex* Indonesia, Sulawesi Selatan: Wewu River, 2°28.226'S 121°04.125'E; F. Herder & R. K. Hadiaty 4 May 2004: ZFMK 44944–44955, 12 ex. (paratypes, 7 females, 34.5–63.9 mm SL,

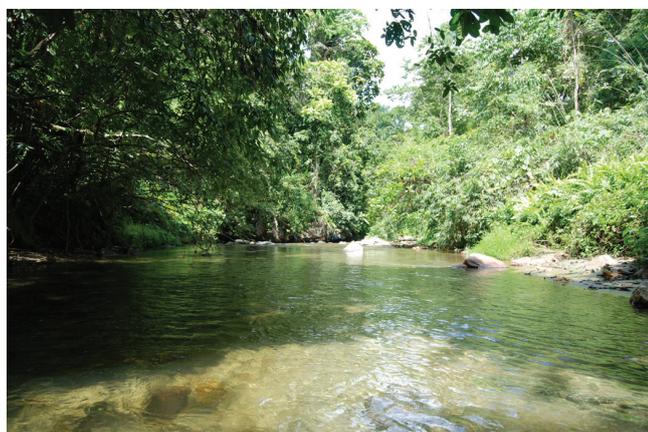


Fig. 11. Mangolo River, type locality of *Nomorhamphus sagittarius* (© R. K. Hadiaty).

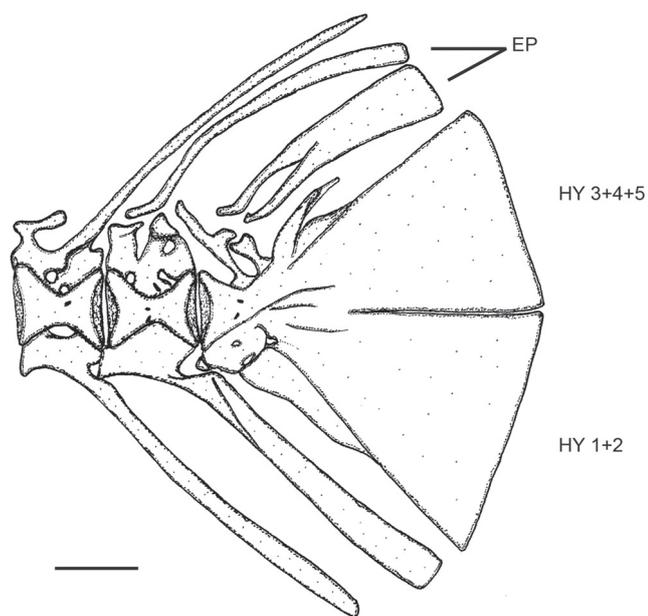


Fig. 12. Diagrammatic representation of the caudal skeleton of *Nomorhamphus sagittarius*, MZB 21301, holotype, 42.8 mm SL, male. Scale bar = 500  $\mu$ m. EP, Epural; HY, Hypural.

5 males, 28.9–41.5 mm SL). – *Nomorhamphus ebrardtii* Indonesia, Sulawesi Tenggara: Island of Wawoni; D. Vogt July 1979: ZMH 7150, 27 ex. (18 females, 38.0–60.0 mm SL, 9 males, 34.6–48.3 mm SL, of which two males are cleared and counterstained). – *Nomorhamphus celebensis* Indonesia, Sulawesi Tengah: Lake Poso; L. R. Parenti 11 August 1995: MZB 6402, 43 ex. (20 females, 29.5–60.4 mm SL, 23 males, 31.0–39.5 mm SL). – *Nomorhamphus kolonodalensis* Indonesia, Sulawesi Selatan: stream near Nuha, 02°25.356'S, 121°21.426'E; J. Pfaender & J. Schwarzer 6 December 2002: ZFMK 48876–48944, 69 ex. (24 females, 26.6–61.8 mm SL, 32 males, 25.6–44.3 mm SL, 13 undet., 15.8–21.8 mm SL). – *Nomorhamphus towoetii* Indonesia, Sulawesi Selatan: Sungai Balambano, about 500 m above Balambano (road from Malili to Soroako); M. Kottelat & A. K. Kloetzli 19 June 1988: MZB 5973, 6 ex. (2 females, 39.3–49.4 mm SL, 3 males, 38.5–41.6 mm SL, 1 juv., 14.6 mm SL). – *Nomorhamphus liemi* Indonesia, Sulawesi Selatan: Highlands of Maros; D. Vogt August 1978: ZMH 7157, 35 ex. (paratypes of *Nomorhamphus liemi snijdersi* (synonym of *N. liemi* (Meisner, 2001), 22 females, 37.6–69.9 mm SL, 14 males, 36.4–45.6 mm SL). – *Nomorhamphus brembachi* Indonesia, Sulawesi Selatan: Highlands of South Sulawesi, smaller mountain streams; D. Vogt May 1978: ZMH 7166, 2 ex (paratypes, 1 female, 35.5 mm SL, 1 male, 38.7 mm SL). – *Nomorhamphus brembachi* Indonesia, Sulawesi Selatan: Highlands of Maros; M. Brembach August 1978: ZMH 7160, 13 ex. (paratypes of *Nomorhamphus ravnaki ravnaki*, synonym of *N. brembachi* (Meisner, 2001), 5 females, 55.8–77.0 mm SL, 4 males, 35.0–37.8 mm SL, 4 undet., 18.0–23.8 mm SL). – *Nomorhamphus megarrhamphus* Indonesia, Sulawesi Selatan: Lake Towuti, inlet of River Tominanga; F. Herder & A. Nolte 28 November 2002: ZFMK 44923, 1 ex. (female, 77.3 mm SL). Towuti, 02°41.335'S, 121°25.897'E; F. Herder & A. Nolte 29 November 2002: ZFMK 44928–44931, 4 ex. (females, 61.2–65.6 mm SL). Towuti, Timampu, fish market: Catch of commercial fishermen collecting small fishes in the pelagic areas of L. Towuti; F. Herder 15 April 2004: ZFMK 44936–44937, 2 ex. (females, 73–75.7 mm SL). – *Nomorhamphus weberi* Indonesia, Sulawesi Selatan: Lake Matano, 02°30.149'S, 121°19.416'E; F. Herder October 2002: ZFMK 44924–44927 and 44932–44935, 8 ex. (females, 64.1–73.4 mm SL).

#### ACKNOWLEDGEMENTS

We would like to thank to Research Centre for Biology-LIPI and RISTEK for the supporting & research permits in Indonesia. We wish to thank Indonesian-ICBG Project Mekongga leaders Rosichon Ubaidillah and Elizabeth A. Widjaja (LIPI) and Andrew Engilis Jr (University of California, Davis). Alan Hitch (University of California, Davis) helped coordinate the research expedition to the region. Fish were collected under the ICBG Indonesia project. This project was partly supported by Grant #U01TW008160 from the Fogarty International Center, the Office of Dietary Supplements, the National Science Foundation, and the Department of Energy. This project was supported by the Agricultural Food Research Initiative of the National Institute of Food and Agriculture, USDA, Grant #35621-04750. The

content is solely the responsibility of the authors and does not necessarily represent the official views of the Fogarty International Center or the National Institutes of Health, the Office of Dietary Supplements, the National Science Foundation, the Department of Energy, or the Department of Agriculture. Work in Indonesia was also supported by a grant from the Deutsche Gesellschaft für Ichthyologie (GfI). Ralf Thiel kindly provided access to specimens under his care. Thanks to Jörg Huylebrouck for preparing Figs. 2, 3, 8, and 9. We also thank K. W. Conway, B. B. Collette and V. Sant'Anna for their comments on the manuscript. We also wish to thank Pratini Sudarmanu and her family for housing and hospitality, and Daisy Wowor, Sopian Sauri and Arief Aditya Hutama for strongly supporting JH during his work in Indonesia.

#### LITERATURE CITED

- Anderson WD & Collette BB (1991) Revision of the freshwater halfbeaks of the genus *Hemirhamphodon* (Teleostei, Hemiramphidae). *Ichthyological Exploration of Freshwaters*, 2: 151–176.
- Brembach M (1976) Anatomische Beiträge zur Systematik lebendgebärender Halbschnäbler (Hemiramphidae, Pisces). *Zeitschrift für zoologische Systematik und Evolutionsforschung*, 14: 169–177.
- Brembach M (1991) Lebendgebärende Halbschnäbler. Untersuchungen zur Verbreitung, Morphologie, Systematik und Fortpflanzungsbiologie der lebendgebärenden Halbschnäbler der Gattungen *Dermogenys* und *Nomorhamphus* (Hemiramphidae: Pisces). Verlag Natur und Wissenschaft, Solingen, Germany, 201 pp.
- Collette BB (2004) Annotated checklist of fishes, family Hemiramphidae Gill 1859. *California Academy of Sciences*, 22: 1–35.
- Herder F & Chapuis S (2010) *Oryzias hadiatyae*, a new species of ricefish (Atherinomorpha: Beloniformes: Adrianichthyidae) endemic to Lake Masapi, Central Sulawesi, Indonesia. *Raffles Bulletin of Zoology*, 58: 269–280.
- Herder F, Hadiaty RK & Nolte AW (2012) Pelvic-fin brooding in a new species of riverine ricefish (Atherinomorpha: Beloniformes: Adrianichthyidae) from Tana Toraja, Central Sulawesi, Indonesia. *The Raffles Bulletin of Zoology*, 60: 467–476.
- Huylebrouck J, Hadiaty RK & Herder F (2012) *Nomorhamphus rex*, a new species of viviparous halfbeak (Atherinomorpha: Beloniformes: Zenarchopteridae) endemic to Sulawesi Selatan, Indonesia. *The Raffles Bulletin of Zoology*, 60: 477–485.
- Kottelat M, Whitten T, Kartikasari SN & Wirjoatmodjo S (1993) *Freshwater Fishes of Western Indonesia and Sulawesi*. Periplus Editions, Hong Kong, 344 pp.
- Lovejoy NR, Iranpour M & Collette BB (2004) Phylogeny and jaw ontogeny of beloniform fishes. *Integrative and Comparative Biology*, 44: 366–377.
- Meisner AD & Burns JR (1997) Testis and andropodial development in a viviparous halfbeak, *Dermogenys* sp. (Teleostei: Hemiramphidae). *Copeia*, 1997: 44–52.
- Meisner AD & Louie KD (2000) *Nomorhamphus kolonodalensis*, a new species of viviparous halfbeak from Sulawesi (Teleostei: Hemiramphidae). *Ichthyological Exploration of Freshwaters*, 11: 361–368.
- Meisner AD (2001) Phylogenetic systematics of the viviparous halfbeak genera *Dermogenys* and *Nomorhamphus* (Teleostei: Hemiramphidae: Zenarchopterinae). *Zoological Journal of the Linnean Society*, 133: 199–283.
- Mohr E (1936a) Hemirhamphiden-Studien IV. Die Gattung *Dermogenys* van Hasselt. *Mitteilungen aus dem Zoologischen Museum in Berlin*, 21: 34–55.
- Mohr E (1936b) Hemirhamphiden-Studien V. Die Gattung *Nomorhamphus* Weber & de Beaufort 1922. *Mitteilungen aus dem Zoologischen Museum in Berlin*, 21: 55–58.
- Mohr E (1936c) Hemirhamphiden-Studien VI. Die Gattung *Hemirhamphodon* Bleeker 1866. *Mitteilungen aus dem Zoologischen Museum in Berlin*, 21: 59–64.
- Nelson JS (2006) *Fishes of the World*. John Wiley & Sons, USA, 624 pp.
- Parenti LR & Hadiaty RK (2010) A new, remarkably colorful, small ricefish of the genus *Oryzias* (Beloniformes, Adrianichthyidae) from Sulawesi, Indonesia. *Copeia*, 2010: 268–273.
- Parenti LR, Hadiaty RK, Lumbantobing D & Herder F (2013) Two new ricefishes of the Genus *Oryzias* (Atherinomorpha: Beloniformes: Adrianichthyidae) augment the endemic freshwater fish fauna of southeastern Sulawesi, Indonesia. *Copeia*, 2013: 403–414.
- Weber M & de Beaufort LF (1922) *The fishes of the Indo-Australian Archipelago IV. Heteromi, Solenichthyes, Synentognathi, Percosoces, Labyrinthici, Microcyprini*. E. J. Brill, Leyden, 410 pp.