THE RAFFLES BULLETIN OF ZOOLOGY 2010 **58**(2): 269–280
Date of Publication: 31 Aug.2010

ORYZIAS HADIATYAE, A NEW SPECIES OF RICEFISH (ATHERINOMORPHA: BELONIFORMES: ADRIANICHTHYIDAE) ENDEMIC TO LAKE MASAPI, CENTRAL SULAWESI, INDONESIA

Fabian Herder
Zoologisches Forschungsmuseum Alexander Koenig, Sektion Ichthyologie,
Adenauerallee 160, D-53113 Bonn, Germany
Email: f.herder.zfmk@uni-bonn.de (Corresponding author)

Simone Chapuis
Zoologisches Forschungsmuseum Alexander Koenig, Sektion Ichthyologie,
Adenauerallee 160, D-53113 Bonn, Germany
Email: sichapuis@t-online.de

***ABSTRACT.* –** A new species of ricefish is described from Lake Masapi, a small satellite lake of the Malili Lakes system in Central Sulawesi, Indonesia. *Oryzias hadiatyae*, new species, is known only from this single lake. It differs from all other adrianichthyids in Sulawesi in having a well marked concavity on the snout, a slender but relatively wide body with elongated snout and slightly upwardly directed mouth, pelvic fins with 5–6 fin rays and anal fin with 19–22 fin rays, both inserting relatively close to the rear end of the body, dorsal fin with 8–10 rays inserted above 10–12th anal fin ray, 28–30 vertebrae, only 27–31 lateral scales, dark brown blotches on the lateral body in adult males, and no blotches in females. This brings the number of ricefish species in Sulawesi to 16 (four *Adrianichthys*, 12 *Oryzias*), with four endemic lacustrine *Oryzias* in the Malili Lakes system. In addition, the riverine ricefish *Oryzias celebensis*, known so far only from Sulawesi's southwestern arm and a single river in East Timor, is here reported for the first time from a drainage in Central Sulawesi.

***KEY WORDS.* –** *Oryzias*, taxonomy, Sulawesi, Malili Lakes, freshwater fish, endemism.

INTRODUCTION

Ricefishes (Adrianichthyidae) are mostly small, beloniform fishes inhabiting fresh and brackish waters from Japan to India and Timor (Indonesia) (Rosen & Parenti, 1981; Nelson, 2006; Parenti, 2008). The most well-known species of the family is the medaka, *Oryzias latipes* (Temminck & Schlegel, 1846), an important vertebrate model organism for genomic and developmental research (Ishikawa, 2000; Kasahara et al., 2007, Kinoshita et al. 2009). A recent revision of Adrianichthyidae (Parenti, 2008) recognized a total of 28 valid ricefish species in two genera (24 *Oryzias* sp., four *Adrianichthys* sp.), and highlighted the still "under-described" (Roberts, 1998: 213) status of this group. Accordingly, the recent discovery of a spectacular small and extremely colourful stream-dwelling *Oryzias* from an island off southeastern Sulawesi (Parenti & Hadiaty, 2010) was not extremely surprising. Including this species, nine *Oryzias* and all four *Adrianichthys* are endemic to Sulawesi (Parenti & Soeroto, 2004; Parenti, 2008; Parenti & Hadiaty, 2010), where most species are restricted to single or adjacent freshwater lakes (Naruse et al., 1993; Kottelat, 1990a, 1990b; Parenti & Soeroto, 2004; Parenti, 2008). Three *Oryzias* inhabit predominantly streams (*O. celebensis*, *O. woworae*) or brackish waters (*O. javanicus*) of the island. *Oryzias celebensis* has so far been reported only from Sulawesi's southwestern arm and from a single river in East Timor (Naruse et al., 1993; Parenti & Soeroto, 2004; Larson & Pidgeon, 2004; Parenti, 2008). In southwestern Sulawesi, it inhabits coastal and inland rivers, streams and Lake Tempe (Parenti, 2008). Phylogenetic analyses based on nuclear and mitochondrial DNA markers concordantly support monophyly of Sulawesi's ricefish (Takehana et al., 2005), yet conflict, in part, with morphological data (Parenti, 2008).

Lake endemics or lacustrine radiations of ricefish in Sulawesi are known from lakes Poso, Lindu and the Malili Lakes system in Central Sulawesi (Kottelat, 1990a, 1990b; Parenti & Soeroto, 2004; Parenti, 2008). Lake Poso harbors the endemic *Adrianichthys* radiation with partially highly derived ecology and brooding modes, and three endemic *Oryzias* (Weber, 1913; Kottelat, 1990b; Parenti & Soeroto, 2004; Parenti,

2008). Three closely related lake-dwelling *Oryzias* species have been described from the Malili Lakes in south-eastern Central Sulawesi (Kottelat, 1990a; Takehana, 2005; Parenti, 2008), consisting of the three cascading main lakes Matano, Mahalona and Towuti, and the two small satellite lakes Lontoa (or Wawontoa; local spelling Lantoa) and Masapi (Fig. 1). *Oryzias matanensis* (Aurich, 1935) is endemic to L. Matano, the uppermost and deepest lake of the system. *Oryzias marmoratus* (Aurich, 1935) occurs in Lakes Towuti, Mahalona and Lontoa as well as in some adjacent streams and creeks; *O. profundicola* Kottelat, 1990 is endemic to Lake Towuti. The Malili Lakes are well known for their high levels of endemism, and for harboring lacustrine radiations of crustaceans, gastropods and fishes (reviewed in von Rintelen et al., in press).

Here, we report *O. celebensis* from a neighbouring river system west of the Malili Lakes (Larona River) drainage, leading to the same estuary, and describe a new species of *Oryzias* endemic to satellite lake Masapi, located in the hills west of L. Towuti. Lake Masapi is the smallest and most remote lake of the Malili Lakes system, drained by Pongkeru River to the effluent of the Malili Lakes (Larona River) close to its mouth. The new species is compared to all ricefish known from Sulawesi, with focus on lacustrine and stream-dwelling *Oryzias*.

MATERIALS AND METHODS

Specimens of the new *Oryzias* were obtained from the southern shore of Lake Masapi (Figs 1 & 2; between 2°50.837'S 121°21.116'E and the lake's outlet, approx. 600 m westwards of this position), Central Sulawesi, Indonesia, from 15–16 Apr.2004. Fish were caught either by gillnetting (6 mm mesh size, set along *Pandanus* sp. roots) or by snorkeling using hand nets. Single individuals of both sexes were photographed immediately after catching to record life colouration. Subsequently, fish were preserved in 4% formalin and later transferred to 70% ethanol for storage. Material

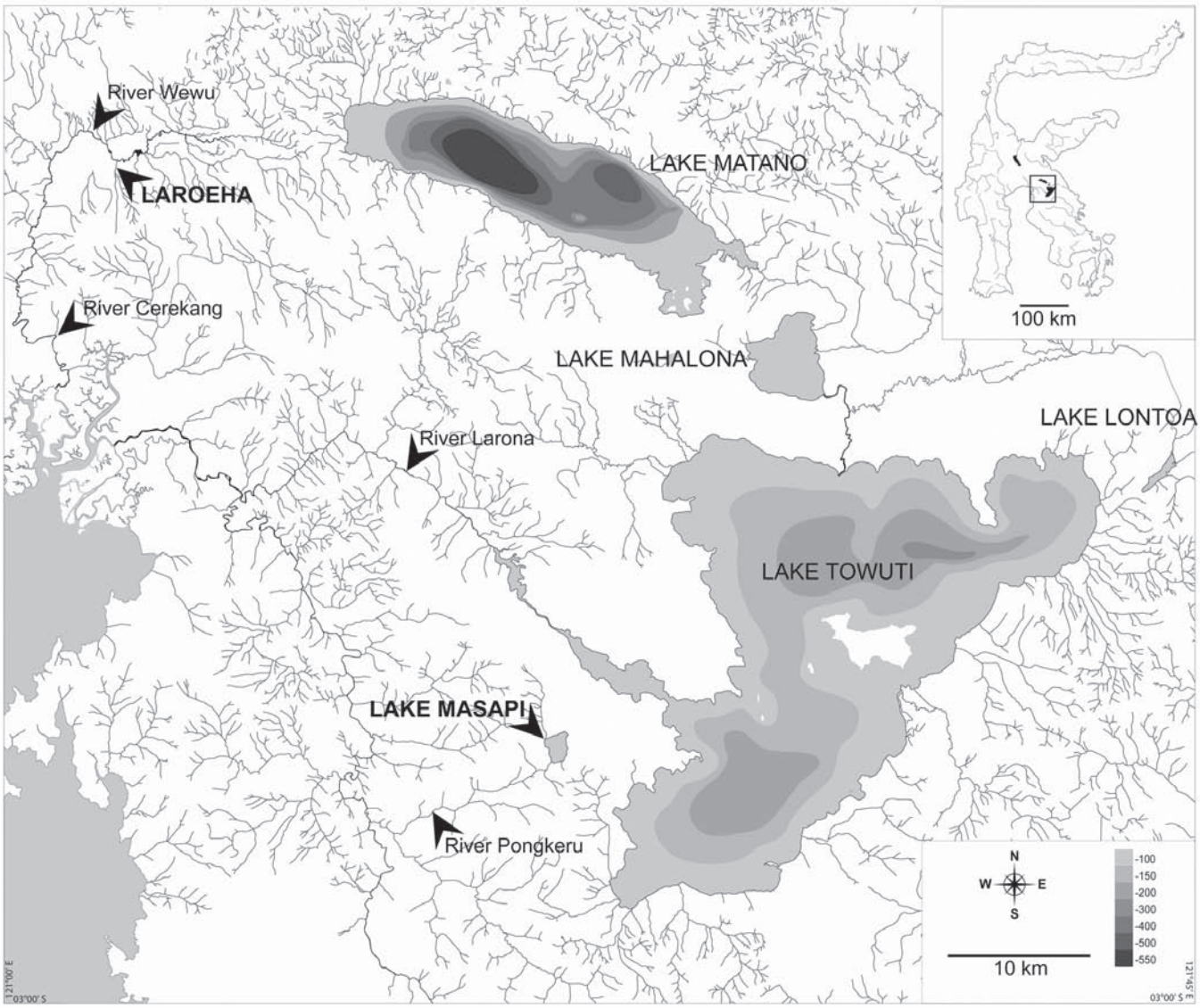

Fig. 1. Map of the Malili Lakes system and adjacent drainages. Arrows highlight Lake Masapi, the type locality of endemic *Oryzias hadiatyae* with River Pongkeru draining the lake to River Larona, and Laroeha, sampling location of *Oryzias celebensis* at a tributary of Rivers Wewu / Cerekang.

examined is deposited in the Research and Development Centre for Biology, the Indonesian Institute of Sciences (LIPI, formerly the Museum Zoologicum Bogoriense – MZB), Cibinong, Indonesia, the Zoologisches Forschungsmuseum Alexander Koenig, Bonn (ZFMK), the Bavarian State Collection of Zoology, Munich (ZSM), and the Zoological Reference Collection (ZRC) of the Raffles Museum for Biodiversity Research, National University of Singapore. Following Parenti (2008), the species described herein is clearly assigned to the genus *Oryzias* (vs. *Adrianichthys*) by combination of the following characters: maximum adult size recorded 46.1 mm SL; only 28–30 vertebrae; pelvic fins in line with pleural rib of the 6th vertebrate; dorsal fin inserted above 19th to 20th vertebrate; absence of a distinct abdominal concavity. Comparative material of lake-dwelling ricefish was collected between 2002 and 2006 from L. Matano (*Oryzias matanensis*), L. Towuti (*O. marmoratus* / *O. profundicola*) and L. Lontoa (*O. marmoratus*) (see Comparative Material for exact sampling locations). *Oryzias celebensis* was collected by electrofishing at a small river approx. 16 km west of Lake Matano, at the Village Laroeha (2°28.226'S 121°04.125'E). Morphometric measurements and meristics follow Kottelat (1990b) and Parenti & Soeroto (2004). All measurements are taken from point to point, recorded to the nearest 0.1 mm with a digital caliper. Abbreviations used are SL – standard length, HL – head length. Counts of the unpaired fins and vertebrae (total = precaudal + caudal) were made from radiographs, using a digital X-ray device (Faxitron LX-60). In the caudal fin, all rays were counted, including unbranched rays in upper and lower lobe (all individuals examined had 3 minor and 2 major simple rays in each lobe). Scale counts follow Kottelat (1990b); the small scales on caudal fin base are not included. Scales in transverse row are counted from origin of dorsal fin to lateral row and continuing to anal fin origin; ½ refers to the scale in front of the dorsal fin. See Appendices 1–3 for meristic and morphometric data on comparative material.

Fig. 2. Lake Masapi, type locality of *Oryzias hadiatyae*. View from southwestern shore across the center of the lake.

TAXONOMY

Oryzias hadiatyae, new species

(English common name: Renny's ricefish)
(Figs 3, 4; Table 1)

***Material examined.* – Holotype -** MZB 18491 (34.2 mm SL), male, Indonesia, Sulawesi: South Sulawesi Province; Larona drainage; Lake Masapi, southern shore between 2°50.837'S 121°21.116'E and the lake's outlet, approx. 600 m westwards of this position; F. Herder, J. Pfaender, J. Schwarzer & R. K. Hadiaty 15–16 Apr.2004.

***Paratypes* –** All collected with the holotype: MZB 18492–18506, 4 males (22.5–30.3 mm SL), 11 females (23–44.6 mm SL), ZFMK 41540–41550, 4 males (31.6–40.3 mm SL), 7 females (32–43.2 mm SL), ZSM 39760–39766, 2 males (28.4 & 31.6 mm SL), 5 females (34.5–43.7 mm SL), ZRC 51984, 2 males (28 & 29.7 mm SL), 2 females (29.3 & 46.1 mm SL).

Diagnosis. – *Oryzias hadiatyae* is distinguished from all other Adrianichthyidae in Sulawesi by combination of a well marked concavity on the snout (Fig. 5), a slightly upwards directed mouth, a slender but relatively wide body (body depth 18.2–25.7% SL, body width 10.9–14.5% SL), pelvic fins with 5–6 fin rays inserting relatively close to the rear end of the body (prepelvic length >47.7% SL), anal fin with 19–22 fin rays inserting relatively close to the rear end of the body (preanal length >63% SL), dorsal fin with 8–10 rays inserted above 10–12th anal fin ray, 28-30 vertebrae, large eyes (30–39.8% HL), 27–31 lateral scales, ½ 10–14 transversal scale rows, absence of dark blackish, dark bluish, or steel blue body colouration or brilliant red marks in both sexes, presence of dark brown blotches on the lateral body in adult males, and absence of these blotches in females.

***Comparisons.* –** Compared to other lacustrine Adrianichthyidae from Sulawesi, *O. hadiatyae* is characterized by having conspicuously few large, lateral scales [27–31 vs. >62 in *Adrianichthys* (including "*Xenopoecilus*" *oophorus* and "*X.*" *poptae*; see Parenti, 2008), >40 in *O. orthognathus*, and 32–34 in *O. profundicola*, 36–39 in *O. bonneorum*, 32–36 in *O. nebulosus*, 34–37 in *O. nigrimas*, >44 in *O. orthognathus*, 70–75 in *O. sarasinorum* (see Kottelat 1990b; Parenti, 2008)]. In addition to non-overlapping lateral scale

Fig. 3. A: *Oryzias hadiatyae*, new species, MZB 18491, holotype, male, 34.2 mm SL, male; B: ZFMK 41544, paratype, female,

counts, *O. hadiatyae* is distinguished from *O. orthognathus* in L. Poso, sharing a similar concavity on the snout, by having a deeper caudal peduncle (1.1–1.6 vs. 1.7–1.9 times longer than deep), larger eyes (8.8–14% SL vs. 7.6–8.7% SL), a longer snout (8.2–11.8% SL vs. 7–8% SL), the dorsal fin inserted less anterior (origin above 10–12th vs. 13–16th anal ray), a smaller size (up to 46.1 mm SL vs. 51.5 mm SL), less anal fin rays (19–22 vs. 23–25) and only 5–6 (vs. 7) pelvic fin rays; the last pelvic ray is connected to the body by a membrane on half to whole length in females and to half length in males, vs. not connected in *O. orthognathus* (Kottelat, 1990b; Parenti, 2008). Lateral scale counts overlap with *O. marmoratus* (having 31–32 lateral scales), which are however arranged in ½ 13–15 (vs. ½ 10–14 in *O. hadiatyae*) transversal rows (see also Kottelat, 1990a).

In contrast to other lacustrine *Oryzias* from L. Poso and the Malili Lakes, the origin of anal and pelvic fins is conspicuously far from the caudal fin base in *O. hadiatyae* and can be used to clearly distinguish the species (preanal length: 63.3–83.6% SL vs. <63% SL in *O. nebulosus*, *O. nigrimas*, *O. orthognathus*, *O. matanensis*, *O. marmoratus* and *O. profundicola*; prepelvic length: >47.7% SL vs. <47.7% SL in *O. orthognathus*, *O. profundicola* and *O. marmoratus*). *Oryzias nigrimas* and *O. matanensis* can, like *O. orthognathus*, be distinguished from *O. hadiatyae* by their more posterior position of the dorsal fin origin relative to the anal fin origin (dorsal fin origin above the >12th anal ray in contrast to the 10–12th anal ray in *O. hadiatyae*). Adult male *O. hadiatyae* do not show dark blackish or bluish body colouration as in males of *O. nigrimas* or *O. nebulosus*; both species have moreover a shorter snout than *O. hadiatyae* (8.2–11.8% SL vs. 6–8% SL in *O. nebulosus* and *O. nigrimas*). *Oryzias hadiatyae* has fewer anal fin rays than *O. orthognathus*, *O. profundicola*, *A. kruyti*, *A. poptae* and *A. roseni* (19–22 vs. >22; Kottelat, 1990a, 1990b; Parenti & Soeroto, 2004), and a relatively shorter caudal peduncle compared to *O. orthognathus*. Compared to *A. kruyti*, *A. poptae*, *A. roseni* and *O. sarasinorum*, *O. hadiatyae* has less (8–10 vs. >10) rays in dorsal fin. Likewise, it is distinguished from *O. bonneorum* by having fewer dorsal fin rays (12–13 in *O. bonneorum*) and relatively larger eyes (8.8–14% SL vs. 9–10% SL). It differs from *O. celebensis* in head shape (Fig. 5), reflected by higher relative snout length (8.2–11.8% SL vs. 5.7–8.1% SL) and

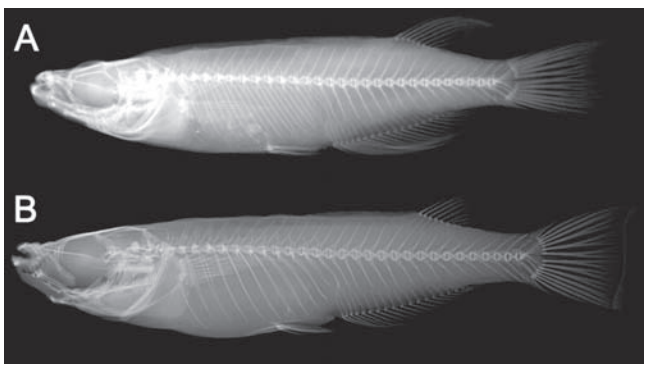

Fig. 4. Radiograph of *Oryzias hadiatyae*. A: *Oryzias hadiatyae*, MZB 18491, holotype, male, 34.2 mm SL, male; B: ZFMK 41544, paratype, female, 43.2 mm SL.

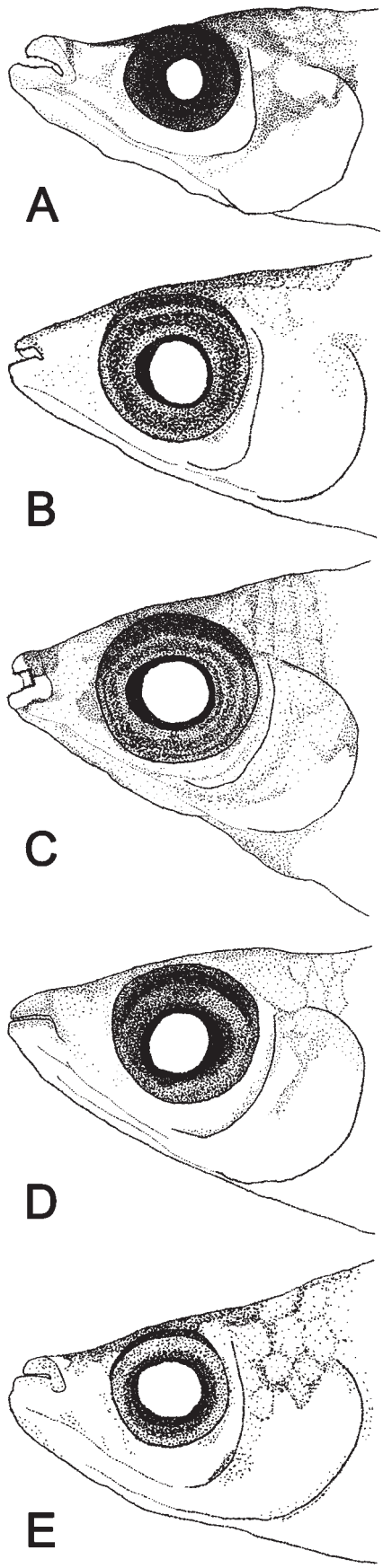

Fig. 5. Diagrammatic representation of the head of (A) *Oryzias hadiatyae*, new species, paratytype ZFMK 41540, compared to the other lacustrine *Oryzias* species of the Malili Lakes system: (B) *O. marmoratus* (ZFMK 41562), (C) *O. profundicola* (ZFMK 41555), (D) *O. matanensis* (ZFMK 41551), and (E) stream-dwelling *O. celebensis* (MZB 18518).

Table 1. Meristic and morphometric data of *Oryzias hadiatyae* (38 specimens).

	Holotype MZB 18491	Paratypes (males, n=12)				Paratypes (females, n=25)			
		Min.	Max.	Mode		Min.	Max.	Mode	
Standard length (mm)	34.2	22.5	40.3			23	46.1		
Anal fin rays (total)	20	19	22	19/21		19	22	20	
Dorsal fin rays (total)	9	8	10	9		8	10	9	
Pelvic fin rays	6	5	6	6		6	6	6	
Pectoral fin rays	11	10	11	10		10	11	10	
Caudal fin rays (total)	3/2/4+5/2/3	3/2/4+5/2/3	3/2/4+5/2/3	3/2/4+5/2/3		3/2/4+5/2/3	3/2/4+5/2/3	3/2/4+5/2/4	
Scales in lateral row	29	28	31	28		27	31	28	
Scales in transverse row	12	11	13	13		10	14	11	
Vertebrae	28	28	29	29		28	30	29	
% Standard length		**Min.**	**Max.**	**Mean**	**SD(±)**	**Min.**	**Max.**	**Mean**	**SD(±)**
Total length	127.3	126.9	131.4	129	1.5	123.9	163.7	129.5	7.25
Head length	28	27.2	29.7	28.8	0.8	27.6	37.1	29.8	1.70
Head depth	14	13.5	15.1	14.1	0.6	13.5	19.4	15.3	1.23
Head width	13.5	15.1	16.8	16	0.5	15.7	19.9	16.5	0.80
Predorsal length	77.4	75.7	79.3	77.9	1.1	76.2	100.7	79.5	4.67
Prepelvic length	53.3	47.8	56.3	52.3	2.2	48.7	67.6	54.3	3.22
Preanal length	65.9	63.4	68.3	65.8	1.7	63.3	83.6	66.3	3.88
Body depth	23.8	18.2	22.6	20	1.2	19.3	25.7	20.8	1.33
Body width	12.7	10.9	14.4	12.4	1.1	12.4	14.5	13.4	0.58
Length of caudal peduncle	11.7	9.7	12.9	11.6	0.8	9.5	13.4	11.5	0.92
Depth of caudal peduncle	8.9	7.5	9.7	8.4	0.6	7.5	10.5	8.5	0.65
Length of dorsal fin	29.6	21.1	31.1	27.8	3.3	14.5	20.2	16.6	19
Length of dorsal fin base	10	7.8	11.1	9.9	0.9	8.1	11.7	9.8	0.78
Length of anal fin base	27.3	24.4	27.8	26.7	0.9	24.2	34.9	26.2	2.14
Length of pectoral fin	23.4	20	23.3	21.7	1.2	17.5	27.1	20.8	1.77
Length of pectoral fin base	6.3	5.3	6.9	5.9	0.4	5.1	7.9	6	0.57
Length of pelvic fin	11.9	10.2	12.5	11.5	0.7	9.8	15.4	12	1.28
Length of pelvic fin base	1.9	1.4	2.4	1.9	0.4	1.4	2.7	2	0.30
% Head length									
Interorbital width	30.1	23.8	35.8	31.1	3.9	21.9	39.3	32.3	4.39
Eye diameter	35.6	35.5	39.8	37.5	1.6	30	39.8	33.5	2.12
Snout lenght	33	30.4	35	31.6	1.4	27.8	36.3	31.9	27

higher relative head length (27.2–37.1% SL vs. 22.7–28.5% SL). Furthermore, it does not show the pattern of stripes on the posterior flank and on caudal fin characteristic for *O. celebensis* (Parenti, 2008; Kottelat et al., 1993), but has a faint black lateral stripe along lateral line. *Oryzias hadiatyae* is distinguished from *O. woworae* by colour pattern, most conspicuously the absence of steel blue body colouration and of brilliant red colouration in ventral surface of head and body anterior to pelvic fins, dorsal portion of pectoral fins, bases of dorsal and anal fin, and margins of caudal fin in both sexes, vs. presence of dark brown blotches on the lateral body in adult males, and absence of these blotches in females. *Oryzias hadiatyae* grows larger than *O. woworae* (SL up to 46.1 mm vs. 28 mm), and is characterized by the concavity on its more prominent snout (vs. dorsal surface of head slightly convex; relative snout length 8.2–11.8% SL vs. 6–8% SL; Parenti & Hadiaty 2010).

Besides meristic differences, head shape and colouration, *O. hadiatyae* differs from the Malili Lakes *Oryzias* by its more slender body [body depth 18.2–25.7% SL vs. 24.7–31.8% SL (Kottelat, 1990a) / 26–30.72% SL (present study; Appendices 1, 2) in *O. marmoratus*, 26–31% SL (Kottelat, 1990a) / 24.8–28.6 (present study) in *O. matanensis*, 30.4–35.2% SL in *O. profundicola* (Kottelat, 1990a) / 28.3–39.1% SL in *O. profundicola/O. marmoratus* (present study)], and laterally wider body [body width 10.9–14.5% SL vs. 10.5–13.5% in *O. matanensis*, 9.3–12.5% in *O. profundicola*, and 8.4–11% in *O. marmoratus* (Kottelat 1990a)]. *Oryzias hadiatyae* has a more slender caudal peduncle than *O. matanensis* (depth 7.5–10.5% vs. 10.6–12.8% SL), *O. profundicola* (10.6–13% SL) and, with some overlap, also than *O. marmoratus* (9.8–11.9% SL). In addition to meristic and morphometric characters, *O. hadiatyae* differs from *O. matanensis* in fin colouration (life: male dorsal and anal fin blackish brown, with a narrow blackish margin in anal fin, vs. male dorsal and anal fin blackish; preserved: dorsal and anal fin dusky grey hyaline to light brown with narrow blackish anal fin margin, vs. dusky blackish with hyaline margins), body colouration with small irregular blackish blotches or spots scattered around axial stripe in males and no blotches or spots in females, vs. a row of black vertical elongate blotches along axial stripe plus several smaller black blotches distributed irregularly on lateral body (blackish pigmentation most conspicuous in males) in *O. matanensis*. In terms of meristics and morphometrics, *O. hadiatyae* is among the Malili Lakes ricefish most similar to *O. marmoratus*. From that species it is clearly distinguished by presence (vs. absence) of the well marked concavity on the snout. Furthermore, the orientation of the mouth differs (slightly upwards vs. almost horizontal; see Fig. 5), as well as the greater preanal length [>63.2% SL vs. 54.1–60.8% SL (Kottelat 1990a) / 56.1–62.7% SL, present study] and prepelvic length (47.8–67.6% SL vs. 42.2–47.6% SL (Kottelat 1990a) / 44.3–48.9% SL, present study). In addition, *O. hadiatyae* does not show distinct margins and purple (life) or blackish (preserved) longitudinal stripes in male caudal fin as in *O. marmoratus*; females do not show lateral blotches, and have a darker brown lateral body than males (vs. lateral body lighter brown in females than in males).

***Description.* –** See Fig. 3 for general appearance in lateral view, Fig. 4 for radiographs of the male holotype and a female paratype, and Table 1 for morphometric data. Body laterally compressed, elongated. Snout slightly elongated, mouth terminal, upwardly directed, with a pharyngeal knob at ventral profile of head. No external teeth. Dorsal head profile concave on snout. Dorsal body profile almost straight from a small hump at nape to dorsal fin. Ventral body profile convex from snout to anal fin origin in females, only slightly convex to almost straight from posterior ventral head to anal fin in males. Caudal peduncle 1.1–1.6 times longer than deep; caudal peduncle length 9.5–13.4% SL, caudal peduncle depth 7.5–10.5% SL. Genital papilla small and tubular in males, large, bilobed and rounded in females. Eye relatively large, diameter 8.8–14% SL. Orbits meet or slightly project beyond dorsal surface of head.

Scales: 27–31 cycloid scales along lateral midline, ½ 10–14 transversal rows at dorsal fin origin. Dorsal fin origin above 10–12th anal ray, with 8–10 rays; pointed but small, not reaching caudal base in females, fin filamentous, elongated with tip reaching or extending past caudal base in adult males; rays 2–5 are the longest. Anal fin with 19–22 rays, straight to slightly concave in females, convex with slightly elongated, filamentous rays in males. Pelvic fin with 5–6 rays (5 in just one specimen), small, the last ray connected to the body by a membrane along its proximal half to its whole length. Pectoral fin with 10–11 rays, falcate, reaching slightly beyond pelvic origin. Caudal fin truncate to slightly emarginate, with two simple rays at upper and lower margin respectively and nine (3/2/4+5/2/3) branched rays. Vertebrae number 28–30.

***Live colouration*. –** Body yellowish brown to grey. Belly and throat white to light yellowish. Lateral body of males covered with pattern of small irregular blackish blotches or spots scattered around a faint, narrow brownish axial stripe. Dorsal surface of head blackish to brown, extending posteriorly as narrow black dorsal stripe to dorsal and caudal fin. Dorsal surface of snout dark brown, side of snout brownish grey. From eye to anus, ventral body and head white to light yellowish. Opercle with silver bluish sheen. Iris iridescent blue. Fins yellowish hyaline, with brownish rays. In males, dorsal and anal fin blackish brown; male anal fin with a narrow blackish margin. In some adult males, small blackish spots are present on anal-fin.

***Preserved colouration*. –** See Fig. 3 for preserved pigmentation. Body yellowish brown to grey. Faint black lateral stripe present on lateral midline, extending from uppermost posterior extremity of opercle to caudal base. In males, the light brown lateral body is covered with a pattern of up to 14 small blackish blotches or spots, distributed mainly along and around lateral midline. In females, the lateral body is dark brown, a faint blackish axial stripe is present but blackish lateral spots or blotches are absent. Belly blackish grey; ventral body above anal fin and at caudal peduncle light yellowish brown. Dorsal surface of head blackish, extending posteriorly as narrow black dorsal stripe to dorsal- and caudal fin. Throat light yellowish brown. Fins dusky grey hyaline to

light brown, with narrow blackish anal fin margin in males. A single blackish blotch or short bar is present on anterior upper opercle in males and females.

Sexual dimorphism. **–** Females grow larger than males (maximum SL recorded: 40.3 mm in males, 46.1 mm in females) and differ in colouration as described above. Males have elongated dorsal and anal fins which are dark with blackish margins in life.

Distribution and habitat. **–** *Oryzias hadiatyae* is known exclusively from Lake Masapi, westwards of Lake Towuti in Central Sulawesi, Indonesia. This blackwater lake is almost circular and only a few meters deep, surrounded by rain forest. *Oryzias hadiatyae* has been collected from the southern shore to the lake's outlet area in its southwestern corner, including areas of gentle current. This species appeared to be associated with roots of the *Pandanus* sp. vegetation characteristic of the lake's shallow shoreline habitats. As Pongkeru River, the lake's only tributary, has not yet been sampled, it remains unknown if the distribution of *O. hadiatyae* extends downstream. The only other native fish known from the lake is a species of *Anguilla*, which is exploited occasionally and gave the lake its local name, Masapi, Bahasa for Eel.

Like in the other lakes of the Malili lakes system, Lake Masapi has not remained unaffected by increasing population density (see Herder et al. 2006a for comments). While its distant location prevented, at least to date of the present collection, permanent settlements and water management activities, massive logging activities in areas close by are expected to affect the lake in the near future. Moreover, predatory snakeheads (*Channa striata*) were introduced, which use the same shallow shoreline habitats as *O. hadiatyae* and appear likely also to affect the endemic ricefish population.

Etymology. **–** The specific name, *hadiatyae*, honors Renny Kurnia Hadiaty who contributed significantly to the exploration of fish diversity in the Malili Lakes area. Renny also discovered this endemic ricefish in remote Lake Masapi.

Comparative material. **–** *Oryzias matanensis* Indonesia, Sulawesi: South Sulawesi Province, Larona drainage, Lake Matano: southwestern shore at 02°30.149'S 121°19.416'E; F. Herder, R. K. Hadiaty & J. Schwarzer coll., Oct.2002: MZB 18509, 1 ex. (43.4 mm SL); ZFMK 41551–41552, 2 ex. (39.5–40.2 mm SL); ZSM 39767–39768, 2 ex. (both 39.9 mm SL); southwestern shore at 02°28.458'S 121°15.570'E; F. Herder & R. K. Hadiaty coll., 8 Nov.2002: MZB 18511, 1 ex. (41.5 mm SL); northern shore at 02°27.342'S 121°21.624'E; F. Herder, R. K. Hadiaty, J. Pfaender & J. Schwarzer coll., 5 Nov.2004: 2 ex., MZB 18507 & MZB 18510 (36.4–37 mm SL); ZFMK 41553–41554, 2 ex. (37.8–37.87 mm SL); ZSM 39769, 1 ex. (36.1 mm SL); northwestern shore at 02°25.649'S 121°17.144'E; F. Herder, R. K. Hadiaty & J. Schwarzer coll., Oct.2002: 1 ex., MZB 18508 (45.6 mm SL).
Oryzias marmoratus, Indonesia, Sulawesi: South Sulawesi Province; Larona drainage, Lake Lontoa: southwestern shore at 02°40.474'S 121°43.068'E; F. Herder, R. K. Hadiaty, J. Pfaender & J. Schwarzer coll., 3 May 2004: MZB 18512–18513, 2 ex. (29.2–23.8 mm SL); ZFMK 41560–41564, 5 ex. (26–35.4 mm SL); Lake Towuti: northwestern shore at 02°41.335'S, 121°25.897'E; F. Herder & A. Nolte coll., 30 Nov.2002: MZB 18514–18515, 2 ex. (34.2–40.9 mm SL).
Oryzias cf. *marmoratus*, Indonesia, Sulawesi: South Sulawesi Province, Larona drainage, Lake Towuti: northwestern shore at 02°41.335'S 121°25.897'E; F. Herder & A. Nolte coll., 30 Nov.2002: ZSM 39770–39771, 2 ex. (36–39.9 mm SL).
Oryzias profundicola, Indonesia, Sulawesi: South Sulawesi Province, Larona drainage, Lake Towuti: northwestern shore at 02°41.335'S 121°25.897'E; F. Herder & A. Nolte coll., 30 Nov.2002: ZFMK 41555–41556, 2 ex. (39.7–47.5 mm SL).
Oryzias celebensis, Indonesia, Sulawesi: South Sulawesi Province: Bantimurung Karst of Maros, Patunuang; J. Harun, 10 Jun.2006: MZB 18518, 15 ex. (32.2–38.7 mm SL); R. K. Hadiaty coll., 20 Jul.2007; ZFMK 41565–41592, 28 ex. (28.6–38.1 mm SL); S. Rumbia; R. K. Hadiaty coll., 27 Jul.2007 ZFMK 41593–41612, 20 ex. (22.8–26.6 mm SL).

First record of* Oryzias celebensis *in Central Sulawesi. **–** *Oryzias celebensis* was recorded in a small river approximately 16 km west of Lake Matano, at Village Laroeha (2°28.226'S 121°04.125'E). Few hundred meters downstream of the sample site, the river connects to Wewu River, which is in turn a headwater of the Cerekang River drainage (Fig. 1). The Cerekang drainage shares the estuary region with the Malili Lakes (Larona River) drainage. The population is identified as *O. celebensis* following Parenti (2008) (MZB 18516–18517; ZFMK 41557–41559; morphometrics and meristics presented in Appendix 3), including typical pigmentation. This species was previously only known from the south-western arm of Sulawesi and from East Timor (Parenti, 2008), and is here – to our knowledge - reported for the first time from Central Sulawesi. We did not record the species so far within the comparatively well-sampled Malili Lakes drainage, but tentatively assume in the light of limited sampling activity in most remaining streams of Central Sulawesi that *O. celebensis* might be more widely distributed in the area. At Laroeha, *O. celebensis* co-occurs with a yet undescribed *Telmatherina* species (*T.* cf. *bonti* "West"; see Herder et al. 2006a, 2006b for pictures and genetics), a *Nomorhamphus* species, and three introduced fish species widespread in the area (*Anabas testudineus*, *Channa striata*, *Trichopodus pectoralis*). The river is a few meters wide and partially covered by forest canopy; riffles and small rapids alternate with pools.

***Notes on* Oryzias marmoratus *vs.* O. profundicola.** **–** *Oryzias marmoratus* and *O. profundicola* show at least some overlap in diagnostic meristic and morphometric characters (dorsal and anal fin ray counts, relative body depth; Kottelat, 1990a). In contrast to *Oryzias* from L. Lontoa, which can clearly be assigned to *O. marmoratus* (Appendix 1), determination of sympatric *O. marmoratus* vs. *O. profundicola* in L. Towuti was accordingly not unequivocally straightforward in the sample we examined (see Appendix 2 for individual morphometric and meristic

data). Two out of the six specimens examined in detail here show character states conflicting with a clear assignment to either of the two species, and determination of three additional individuals is based solely on anal fin ray counts. The same applies to pigmentation characters, which are—at least in preserved individuals—not unequivocally diagnostic in all specimens. Occasional hybridization (Parenti, 2008) or early stages of divergence, in this case shallow-water dwelling *O. marmoratus* vs. clearly lacustrine *O. profundicola*, are among the most likely explanations for this phenomenon. Both are predicted for evolving radiations, and occur in another radiation of freshwater atherinomorph fishes in the Malili Lakes area (Herder et al. 2006b, 2008; Schwarzer et al. 2008). Given the additional complexity due to significant geographic variation within *O. marmoratus* (Kottelat, 1990a), we stress that focus studies incorporating additional material will be required to solve this issue.

ACKNOWLEDGEMENTS

We thank the Indonesian Institute of Sciences (LIPI) for the permit to conduct research in Indonesia. We are especially grateful to R. K. Hadiaty for strongly supporting our work. PT. INCO provided outstanding logistic support in Sulawesi. F. H. is grateful to U. K. Schliewen for the opportunity to conduct the relevant fieldwork in Indonesia and for his strong support in many ways. For assistance in the field we thank R. K. Hadiaty, J. Pfaender, J. Schwarzer and A. Nolte. Fieldwork greatly benefited from logistic support in Indonesia by T. von Rintelen. Thanks to D. Schaller for inspiring ricefish discussions. Comments by Tan Heok Hui and two anonymous referees helped improve the manuscript. Fieldwork was supported by research grants from the Deutsche Forschungsgemeinschaft to U. K. Schliewen (DFG SCHL 567/2).

LITERATURE CITED

Aurich, H. J., 1935. Mitteilungen der Wallacea-Expedition Woltereck. Mitteilungen XIII. Fische I. *Zoologischer Anzeiger*, **112**: 97–107.

Herder, F., J. Schwarzer, J. Pfaender, R. K. Hadiaty & U. K. Schliewen, 2006a. Preliminary checklist of sailfin silversides (Pisces: Telmatherinidae) in the Malili Lakes of Sulawesi (Indonesia), with a synopsis of systematics and threats. *Verhandlungen der Gesellschaft für Ichthyologie*, **5**: 139–163.

Herder, F., A. Nolte, J. Pfaender, J. Schwarzer, R. K. Hadiaty & U. K. Schliewen, 2006b. Adaptive radiation and hybridisation in Wallace´s Dreamponds: evidence from sailfin silversides in the Malili Lakes of Sulawesi. *Proceedings of the Royal Society of London Series B-Biological Sciences*, **273**: 2209–2217.

Herder, F., J. Pfaender & U. K. Schliewen, 2008. Adaptive sympatric speciation of polychromatic "roundfin" sailfin silverside fish in Lake Matano (Sulawesi). *Evolution*, **62**: 2178–2195.

Ishikawa, Y., 2000. Medakafish as a model system for vertebrate developmental genetics. *BioEssays*, **22**: 487–495.

Kasahara, M., K. Naruse, S. Sasaki, Y. Nakatani, W. Qu, B. Ahsan, T. Yamada, Y. Nagayasu, K. Doi, Y. Kasai, T. Jindo, D. Kobayashi, A. Shimada, A. Toyoda, Y. Kuroki, A. Fujiyama, T. Sasaki, A. Shimizu, S. Asakawa, N. Shimizu, S.-I. Hashimoto, J. Yang, Y. Lee, K. Matsushima, S. Sugano, M. Sakaizumi, T. Narita, K. Ohishi, S. Haga, F. Ohta, H. Nomoto, K. Nogata, T. Morishita, T. Endo, T. Shin-I., H. Takeda, S. Morishita & Y. Kohara, 2007. The medaka draft genome and insights into vertebrate genome evolution. *Nature*, **447**: 714–719.

Kinoshita, M., Murata, K., Naruse, K. & M. Tanaka, 2009. Medaka: Biology, Management, and experimental Protocols. Wiley-Blackwell, Ames.

Kottelat, M., 1990a. The ricefishes (Oryziidae) of the Malili Lakes, Sulawesi, Indonesia, with description of a new species. *Ichthyological Exploration of Freshwaters*, **1**: 151–166.

Kottelat, M., 1990b. Synopsis of the endangered buntingi (Osteichthyes: Adrianichthyidae and Oryziidae) of Lake Poso, Central Sulawesi, Indonesia, with a new reproductive guild and descriptions of three new species. *Ichthyological Exploration of Freshwaters*, **1**: 49–67.

Kottelat, M., T. Whitten, S. N. Kartikasari & S. Wirjoatmodjo, 1993. *Freshwater fishes of Western Indonesia and Sulawesi*. Periplus Editions, Hong Kong.

Larson, H. K. & B. Pidgeon, 2004. New records of freshwater fishes from East Timor. The Beagle. *Records of the Museum and Art Gallery of the Northern Territory*, **20**: 195–198.

Naruse, K., A. Shima, M. Matsuda, M. Sakaizumi, T. Iwamatsu, B. Soeroto & H. Uwa, 1993. Distribution and phylogeny of rice fish and their relatives belonging to the suborder Adrianichthyoidei in Sulawesi, Indonesia. *The Fish Biology Journal Medaka*, **5**: 11–15.

Nelson, J. S., 2006. *Fishes of the World*. 4th ed, New Jersey.

Parenti, L. R., 2008. A phylogenetic analysis and taxonomic revision of ricefishes, *Oryzias* and relatives (Beloniformes, Adrianichthyidae). *Zoological Journal of the Linnean Society*, **154**: 494–610.

Parenti, L. R. & R. K. Hadiaty, 2010. A New, Remarkably Colorful, Small Ricefish of the Genus *Oryzias* (Beloniformes, Adrianichthyidae) from Sulawesi, Indonesia. *Copeia*, **2010**: 268–273.

Parenti, L. R. & B. Soeroto, 2004. *Adrianichthys roseni* and *Oryzias nebulosus*, two new ricefishes (Atherinomorpha: Beloniformes: Adrianichthyidae) from Lake Poso, Sulawesi, Indonesia. *Ichthyological Research*, **51**: 10–19.

Roberts, T. R., 1998. Systematic observations on tropical Asian medakas or ricefishes of the genus Oryzias, with descriptions of four new species. *Ichthyological Research*, **45**: 213–224.

Rosen, D. E. & L. R. Parenti, 1981. Relationships of *Oryzias*, and the group of atherinimorph fishes. *American Museum Novitates*, **2719**: 1–25.

Schwarzer, J., Herder, F., Misof, B., Hadiaty, R. K. & U. K. Schliewen, 2008. Gene flow at the margin of Lake Matano's adaptive sailfin silverside radiation: Telmatherinidae of River Petea in Sulawesi. *Hydrobiologia*, **615**: 201–213.

Takehana, Y., Naruse, K. & M. Sakaizumi, 2005. Molecular phylogeny of the medaka fishes genus Oryzias (Beloniformes: Adrianichthyidae) based on nuclear and mitochondrial DNA sequences. *Molecular Phylogenetics and Evolution*, **36**: 417–428.

Temminck, C.J. & H. Schlegel, 1846. Pisces. In: *Fauna Japonica, sive descriptio animalium quae in itinere per Japoniam suscepto annis 1823–30 collegit, notis observationibus et adumbrationibus illustravit P. F. de Siebold*. Leiden, parts 10–14: 173–269.

von Rintelen, T., von Rintelen, K., Glaubrecht, M., Schubart, C. D. & F. Herder. Aquatic biodiversity hotspots in Wallacea – the species flocks in the ancient lakes of Sulawesi, Indonesia. In: Gower, D. J., Johnson, K. G., Richardson, J. E., Rosen, B. R., Rüber, L. & S. T. Williams (eds.), Biotic evolution and environmental change in southeast Asia. Cambridge University Press, Cambridge, in press.

Weber, M., 1913. Neue Beiträge zur Kenntnis der Süsswasserfische von Celebes. Ergebnisse einer Reise von E.C. Abendanon in Celebes. *Bijdragen tot de Dierkunde*, **19**: 197–213.

Appendix 1. Meristics and morphometrics of comparative material: *Oryzias matanensis* and *O. marmoratus* (Lake Lontoa)

	***Oryzias matanensis* (n=12)**				***Oryzias marmoratus* Lake Lontoa (n=7)**			
	Min.	**Max.**	**Mode**		**Min.**	**Max.**	**Mode**	
Standard length (mm)	36.1	45.6			23.8	35.4		
Anal fin rays (total)	21	23	22		21	24	24	
Dorsal fin rays (total)	8	9	8		9	10	10	
Pelvic fin rays	6	6	6		6	6	6	
Pectoral fin rays	10	12	11		10	10	10	
Caudal fin rays (total)	19	19	19		19	19	19	
Scales in lateral row	41	46	41		28	34	30	
Scales in transverse row	11	15	15		10	14	11	
Vertebrae	30	30	30		29	30	29	
% Standard length	**Min.**	**Max.**	**Mean**	**SD(±)**	**Min.**	**Max.**	**Mean**	**SD(±)**
Total length	126.4	133.7	130.2	2.4	128.9	134.4	131.7	2.1
Head length	25.8	27.6	26.8	0.5	25.9	29.2	27.5	1.1
Head depth	14.6	18	15.8	0.9	14.7	16.6	15.3	0.6
Head width	15.7	17.5	16.3	0.4	14.7	16.4	15.5	0.6
Predorsal length	78.8	82	80.6	1.2	75.4	79.7	77.3	1.7
Prepelvic length	45.3	48.7	47.2	1.2	44.3	48.9	46.2	1.6
Preanal length	59.8	63.1	61.2	1	56.1	62.7	59.4	2.1
Body depth	24.8	28.6	26.7	1.2	26	29.7	28.1	1.4
Body width	10.7	14.2	13.3	1	10.7	12.6	11.8	0.7
Length of caudal peduncle	10.1	14	12	1.1	9.6	12.9	11.2	1.3
Depth of caudal peduncle	9.8	12	11.2	0.7	8.8	11.3	9.9	0.8
Length of dorsal fin	12	24.3	17.5	4	16.5	39.3	27.9	8.4
Length of dorsal fin base	7.1	10.8	8.7	1	11.7	13.2	12.2	0.7
Length of anal fin base	29	35.2	31.6	1.8	32.9	38.1	35.3	1.8
Length of pectoral fin	22.1	24.8	23.6	0.8	16.8	28.5	24.2	4.2
Length of pectoral fin base	5.5	7.6	6.7	0.6	5.5	8.2	6.2	1
Length of pelvic fin	10.8	14.9	12.9	1.3	11.8	14.4	13	0.8
Length of pelvic fin base	2.1	3.8	2.5	0.5	1.5	2.2	2	0.2
% Head length								
Interorbital width	23.2	41.8	35.4	4.8	32.9	40.8	36.5	3.1
Eye diameter	34.9	44	40	2.8	40.5	46.7	43	2
Snout lenght	28.2	35.2	31.4	2.2	23.8	31.2	27.9	2.3

Appendix 2: Meristics and morphometrics of comparative material: *Oryzias* from Lake Towuti

Sex	MZB 18514 male	MZB 18515 female	ZSM 39770 male	ZSM 39771 male	ZFMK 41555 male	ZFMK 41556 female
Standard length (mm)	40.9	34.2	36	39.9	47.5	39.7
Anal fin rays (total)	24	24	28	28	29	27
Dorsal fin rays (total)	10	10	13	13	13	11
Pelvic fin rays	6	6	6	6	6	6
Pectoral fin rays	10	10	10	10	10	10
Caudal fin rays (total)	19	19	19	19	20	19
Scales in lateral row	32	32	31	31	32	32
Scales in transverse row	15	13	15	13	15	15
Vertebrae	29	30	29	29	29	29
% Standard length						
Total length	130.3	132.8	132	134.2	137	133.4
Head length	25	25.3	24.6	23.8	24	24.8
Head depth	13.9	14.6	15.2	15.2	15.5	14.6
Head width	15.2	15.1	14.5	14.4	14.9	15.5
Predorsal length	74.7	76.6	71.3	75.9	76.3	74
Prepelvic length	46.1	47	43.5	45.8	46.3	48.3
Preanal length	61.8	59.9	59.4	59.9	61.8	61
Body depth	30.7	28.3	30.9	36.2	39.1	33
Body width	11.6	12.9	11.6	12.3	13.2	13
Length of caudal peduncle	8.4	9.2	8	8.3	8.5	8.7
Depth of caudal peduncle	10.8	10.6	10.2	12.2	13.6	11.7
Length of dorsal fin	23.3	18.2	22.6	30.2	36.4	19.4
Length of dorsal fin base	11.2	11.5	13.1	14.6	18.5	12.5
Length of anal fin base	36.8	34.1	39.9	41.3	45.6	38.5
Length of pectoral fin	22.9	23.6	24.3	26.2	29.3	25
Length of pectoral fin base	6.2	6.1	5.1	6.5	6.3	6.4
Length of pelvic fin	11.7	12.8	14	16.1	15.3	15.4
Length of pelvic fin base	2	2.1	2	2.4	2	2.4
% Head length						
Interorbital width	35.4	36.1	48	40.1	41.4	42.9
Eye diameter	43.2	42	46.4	47.4	44.2	48.9
Snout lenght	31	27.9	26.7	28.7	32.5	29.3
Species determination*	*O. marmoratus*	*O. marmoratus*	conflicting	conflicting	*O. profundicola*	*O. profundicola*

* Ranges of meristic and morphometric characters diagnostic for *Oryzias marmoratus* or *O. profundicola* partially overlap. In the sample available from Lake Towuti, species determination was hence not unequivocal in all cases. Results of tentative determination following Kottelat 1990a are *O. marmoratus*, *O. profundicola*, or conflicting character states ("conflicting"). Diagnostic meristic and morphometric characters to distinguish both species (*O. marmoratus* / *O. profundicola*) are 20–26 vs. 26–29anal rays; (8)9–12 vs. 10–14 dorsal rays; body depth 25–31 vs. 30–35% SL; lateral scale counts are 31–32 vs. 32–34).

Appendix 3: Meristics and morphometrics of *Oryzias celebensis* Laroeha, and comparative material from Maros.

	***Oryzias celebensis* Laroeha (n=5)[a]**				***Oryzias celebensis* Maros (n=22)[b]**			
	Min.	**Max.**	**Mode**		**Min.**	**Max.**	**Mode**	
Standard length (mm)	21.9	29.3			22.8	38.7		
Anal fin rays (total)	18	19	18		18	22	21	
Dorsal fin rays (total)	9	9	9		8	9	8	
Pelvic fin rays	6	7	7		6	6	6	
Pectoral fin rays	10	10	10		10	13	11	
Caudal fin rays (total)	19	20	19		19	19	19	
Scales in lateral row	33	35	34		30	32	32	
Scales in transverse row	12	12	12		13	17	16	
Vertebrae	30	31	31		29	32	31	
% Standard length	**Min.**	**Max.**	**Mean**	**SD(±)**	**Min.**	**Max.**	**Mean**	**SD(±)**
Total length	125.5	129	127.2	1.4	108	133	127.5	4.9
Head length	26.6	28	27.3	0.6	22.7	28.5	26	1.4
Head depth	14.6	23.3	17.7	3.5	12.8	22.2	16	1.9
Head width	15.1	16.1	15.5	0.4	14.4	20.2	16.8	1
Predorsal length	76.6	81.1	78.5	1.8	70.7	86	82.9	3.1
Prepelvic length	47.4	62.8	52.3	6.5	34.9	48.9	43.9	3.3
Preanal length	48.2	64	58.3	6.3	53.1	66.8	62.6	2.8
Body depth	22.5	24.4	23.4	0.8	15.3	26.3	23.4	2.3
Body width	10.3	12.8	11.8	1	11.8	17.7	14.4	1.4
Length of caudal peduncle	14.8	16.2	15.5	0.6	9.2	16.3	12.8	1.4
Depth of caudal peduncle	9.3	10.1	9.7	0.3	9	12.8	10.9	0.8
Length of dorsal fin	27.6	28.4	27.9	0.4	12.9	32.5	21.3	6.3
Length of dorsal fin base	11.5	13.1	12.2	0.6	6.4	11.9	9.2	1.2
Length of anal fin base	23	28	25.7	1.9	24.1	31.5	28.4	1.6
Length of pectoral fin	15.2	23.9	20.4	3.5	19.4	26.7	23.8	1.8
Length of pectoral fin base	6.8	7.4	7.1	0.2	5.7	8.4	6.9	0.7
Length of pelvic fin	11.9	12.7	12.4	0.3	14.8	23.2	17.8	2.1
Length of pelvic fin base	2.3	2.9	2.6	0.3	2.7	7.2	4.2	1.2
% Head length								
Interorbital width	29.5	37.2	33.4	3.7	25.9	51.5	35.6	7.8
Eye diameter	36.1	42.8	39.7	2.5	36.7	45.9	40	2.3
Snout lenght	27.1	29.7	28.5	1.1	24.7	33.3	28.5	2.6

[a] MZB 18516–18517, ZFMK 41557–41559; [b]including material from all three populations incorporated (8 ex. MZB 18518; 8 ex. ZFMK 41565–41592; 6 ex. ZFMK 41593–41612)