RAFFLES BULLETIN OF ZOOLOGY **62**: 718–725
Date of publication: 5 November 2014
http://zoobank.org/urn:lsid:zoobank.org:pub:07591656-F523-46D1-8AC2-97EF895FC4FB

Mugilogobius hitam, a new species of freshwater goby (Teleostei: Gobioidei: Gobiidae) from Lake Towuti, central Sulawesi, Indonesia

Helen K. Larson[1], Matthias F. Geiger[2], Renny Kurnia Hadiaty[3] & Fabian Herder[2]

Abstract. A new species of *Mugilogobius* is described from Lake Towuti, central Sulawesi, diagnosed by its possession of a distinct transverse sensory papilla pattern on the cheek, overall blackish colour on head, body and fins and relatively large adult size for the genus. Although it may superficially resemble the black goby *Mugilogobius amadi* from Lake Poso, *M. hitam*, new species, lacks the numerous predorsal scales (22–36 in *M. amadi* versus 17–19), high second dorsal fin ray count (I,9, usually I,10, versus I,7–8) and narrow head and protruding chin of *M. amadi*. Cytochrome *c* oxidase subunit 1 (COI) data provide clear support for the species status of *M. hitam*, new species, indicate that all the Malili Lakes *Mugilogobius* may well represent a species flock and place *M. sarasinorum* from Lake Poso as its most likely sister taxon. In addition to the tectonic lake species, we report the occurrence of *M. latifrons* in streams of the Malili Lakes drainage.

Key words. *Mugilogobius*, Gobiidae, taxonomy, Sulawesi, Lake Towuti, freshwater fish, endemism

INTRODUCTION

Gobies (Gobiidae) are a highly diverse family of mostly benthic, perciform fishes, inhabiting a wide range of habitats from marine deep sea environments to freshwater hill streams (Patzner et al., 2011). Gobies are especially species-rich in the Indo-Pacific region, including freshwaters of the Indo-Malay archipelago (Kottelat et al., 1993; Keith & Lord, 2011). The ancient lakes of the Indonesian island Sulawesi (Fig. 1) harbour endemic lineages and species flocks of various freshwater organisms (Vaillant et al., 2011; von Rintelen et al., 2012; Stelbrink et al., 2012), including freshwater fishes (Kottelat, 1990a, b, c, 1991; Larson, 2001; Kottelat et al., 1993; Parenti & Soeroto, 2004; Herder et al., 2006; Parenti, 2008; Herder & Chapuis, 2010). The Malili Lakes system in Central Sulawesi consists of three main lakes interconnected by rivers, and two smaller satellite lakes (Fig. 1), including the extraordinarily deep graben-lake Matano and Lake Towuti, with approx. 560 km^2 surface area the largest lake of the island (von Rintelen et al., 2012). Two genera of gobies are known from the Malili Lakes, *Glossogobius* (three known species with at least two others being described) and *Mugilogobius* (four species); all of the species are endemic to the lakes system (Weber, 1913; Aurich, 1938; Larson, 2001; Hoese et al., in prep.). Two of the *Mugilogobius* are endemic to single lakes (*M. adeia* to Lake Matano; *M. lepidotus* to Lake Towuti), whereas *M. rexi* occurs in Lakes Mahalona and Towuti; and *Mugilogobius latifrons* has been reported from the shallows of all three lakes (Larson, 2001). Here, we describe a new species of *Mugilogobius* known so far only from a single site in Lake Towuti, add records of *M. latifrons* from stream habitats of the drainage (Figs. 2, 3) and provide COI data for the *Mugilogobius* species endemic to Sulawesi.

[1]Museum and Art Gallery of the Northern Territory, P.O. Box 4646, Darwin, Northern Territory 0801, Australia; Museum of Tropical Queensland, 102 Flinders Street, Townsville, Queensland 4810, Australia; School of Marine and Tropical Biology, James Cook University, Townsville, Queensland 4811, Australia; Email: helen.larson@nt.gov.au (*corresponding author)

[2]Zoologisches Forschungsmuseum Alexander Koenig, Sektion Ichthyologie, Adenauerallee 160, D-53113 Bonn, Germany; Email: m.geiger@zfmk.de (MFG); f.herder@zfmk.de (FH)

[3]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

ISSN 2345-7600 (electronic) | ISSN 0217-2445 (print)

MATERIAL AND METHODS

Material. Specimens for morphological examination were initially preserved in 70% ethanol; four of the specimens were transferred into 4 % formalin for fixation. Later, all specimens were transferred into 80% ethanol for long-term storage. Specimens are deposited in the collections of Research Centre for Biology, Indonesian Institute of Sciences, Cibinong (LIPI, formerly the Museum Zoologicum Bogoriense – MZB), Zoological Reference Collection, Lee Kong Chien Museum of Natural History, Singapore (ZRC), the Zoologisches Forschungsmuseum Alexander Koenig, Bonn (ZFMK) and the Queensland Museum, Brisbane (QM). Individuals of both sexes were photographed in the aquarium to document live coloration. The habitat information is based on photographs and descriptions by H.-G. Evers (pers. comm.).

Morphology. Morphometric measurements and meristics follow Larson (2001). All measurements are taken from point to point, recorded to the nearest 0.1 mm with a digital calliper. Abbreviations used: 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). Scale and fin ray counts follow Larson (2001).

DNA barcode analyses. Genomic DNA was extracted using Macherey & Nagel NucleoSpin® Tissue kits following the manufacturer′s protocol on an Eppendorf EpMotion® pipetting-roboter with vacuum manifold. The standard vertebrate DNA barcode region COI was amplified using a M13-tailed primer cocktail including in equal concentrations FishF2_t1 (5′ TGTAAAACGA CGGCCAGTCGACTAATCATAAAGATATCGGCAC), FishR2_t1 (5′ CAGGAAACAGCTATGACACTTCAG GGTGACCGAAGAATCAGAA), VF2_t1(5′ TGTAA AACGACGGCCAGTCAACCAACCACAAAGAC ATTGGCAC) and FR1d_t1 (5′ CAGGAAACAGCTATGA CACCTCAG GGTGTCCGAARAAYCARAA) (Ivanova et al., 2007). Sequencing of the ExoSAP-IT (USB) purified PCR product in both directions was conducted at Macrogen Europe Laboratories with forward sequencing primer M13F (5′ GTAAAACGACGGCCAGT) and reverse sequencing primer M13R-pUC (5′ CAGGAAACAGCTATGAC). All generated COI sequences are made publically available via the NCBI GenBank with their respective accession numbers given in Fig. 4.

Data processing and sequence assembly was done in Geneious Pro and the Muscle algorithm (Edgar, 2004) was used to create a DNA sequence alignment including additional COI sequences from GenBank as appropriate outgroups (*Awaous*, *Rhinogobius*). Modeltest (Posada & Crandall, 1998), implemented in the MEGA 5 software (Tamura et al., 2011) was used to determine the most appropriate sequence evolution model for the given data, the model with the lowest BIC scores (Bayesian Information Criterion) considered to best describe the substitution pattern. We generated Neighbour-joining (Saitou & Nei, 1987), Maximum Parsimony (Swofford, 2002; in PAUP4b) and Maximum Likelihood (in MEGA 5) phylogenetic trees with 1000 bootstrap replicates to explore the new species affinities to the other Indonesian *Mugilogobius*. According to Modeltest, the Hasegawa-Kishino-Yano (HKY) model (Hasegawa et al., 1985) with discrete Gamma distribution (3 categories (+G, parameter = 0.5491)) and rate variation for some sites invariable ([+I], 56.97% sites), best represented the COI alignment, and was used to estimate the evolutionary history using Maximum Likelihood and Neighbour-joining methods. Main topological outcomes were identical between the different analysis methods, and only bootstrap support values for important clusters are presented in Fig. 4.

Comparative material. As listed in Larson (2001); also additional material, all from Sulawesi, examined. *Mugilogobius adeia*: MZB 218841–21844, 4 (16.3–23.1 mm SL), South Sulawesi Province; Lake Matano, gravel fields in a few metres depth at small islands at the lake's south-western shore, 2°25.649'S, 121°17.144'E, F. Herder

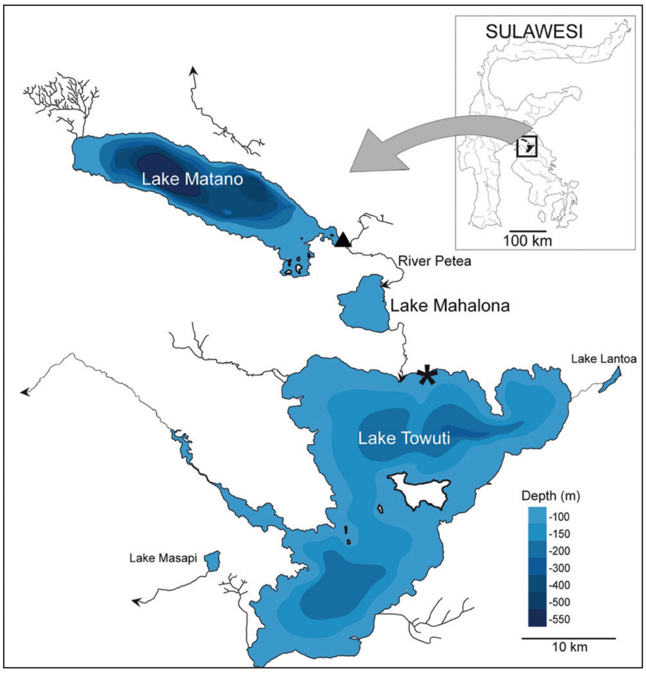

Fig. 1. Map of the Malili Lakes in Sulawesi. The type locality of *Mugilogobius hitam*, new species, is denoted by an asterisk (modified Map © T. von Rintelen).

Fig. 2. Type locality of *Mugilogobius hitam*, new species, at northern Lake Towuti, east of the mouth of Tominanga river (photograph by H.-G. Evers).

Fig. 3. Cobble and gravel substrate at type locality, Lake Towuti (photograph by H.-G. Evers).

& R. K. Hadiaty, December 2002; ZFMK 65004–65006, 3 (17.7–19.7 mm SL), South Sulawesi Province, Lake Matano, gravel fields in a few metres depth at the southern shore, close by Salonsa, 2°30.149'S, 121°19.416'E, F. Herder & R. K. Hadiaty, April 2004. *Mugilogobius latifrons*: MZB 21845–21850, 5 (34.7–39.6 mm SL), South Sulawesi Province, Stream Koro Kodube, between Timampu and Kampung Baru, 300 m upstream of bridge, F. Herder & R. K. Hadiaty, 2 May 2004; ZFMK 65013, 1 (30.3 mm SL), South Sulawesi Province, Lawa River, entering north-western Lake Matano, about 25 m upstream of the lake 2°25.850′S, 121°13.438′E, gravel and leaf litter in shallows, F. Herder & R. K. Hadiaty, 12 November 2006. *Mugilogobius latifrons*: ZFMK 65014–65016, 4 (16.7–25.5 mm SL), South Sulawesi

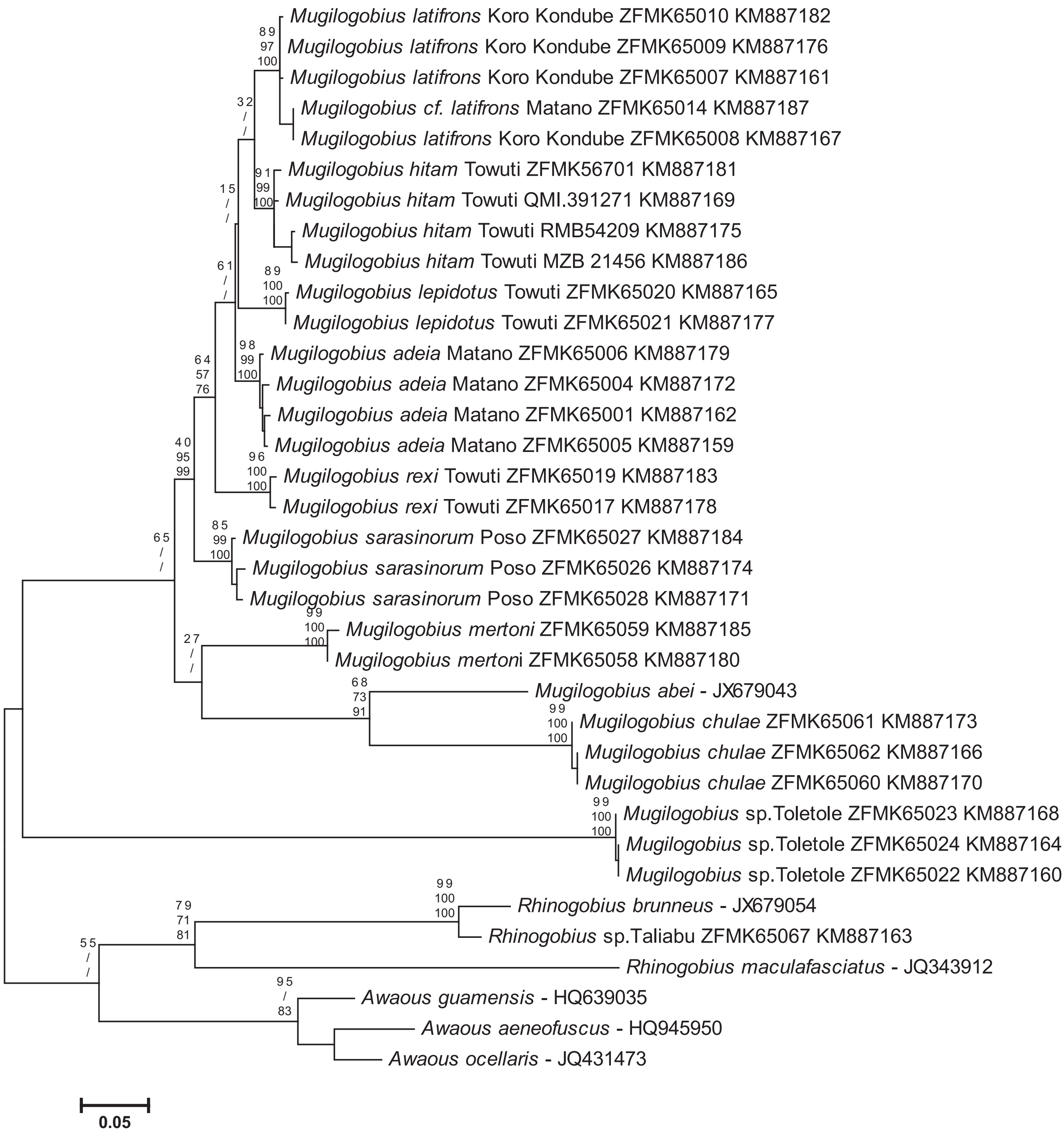

Fig. 4. Maximum Likelihood (ML) estimation of the phylogenetic position of *M. hitam*, new species, based on the mitochondrial COI barcode region. Codon positions with less than 95% site coverage were eliminated resulting in 530 nucleotide positions analysed. Uppermost number above nodes depicts ML bootstrap support, followed by Maximum Parsimony and Neighbour-joining bootstrap support values. Branch lengths represent the number of substitutions per site. Numbers following species names refer to museum collection vouchers, followed by NCBI GenBank numbers.

Province: Lawa River, entering north-western Lake Matano, about 25 m upstream of the lake, 2°25.850'S, 121°13.438'E, gravel and leaf litter in shallows, F. Herder & R. K. Hadiaty, 22 November 2006. *Mugilogobius lepidotus*: MZB 21839, 10 (11.1–23.9 mm SL), South Sulawesi Province, north-western Lake Towuti, 1 km north of Kampung Baru, shallow shore with gravel and small rocks, F. Herder & R. K. Hadiaty, 22 March 2004; ZFMK 65020–65021, 2 (24.1–27.2 mm SL), South Sulawesi Province, north-western Lake Towuti, 1 km north of Kampung Baru, shallow shore with gravel and small rocks, F. Herder & R. K. Hadiaty, 22 March 2004; ZFMK 65055–65056, 2 (27.8–29 mm SL), South Sulawesi Province, north-western Lake Towuti, 1 km north of Kampung Baru, shallow shore with gravel and small rocks, F. Herder & R. K. Hadiaty, 22 March 2004; ZSM 42895, 1 (25.2 mm SL), South Sulawesi Province, north-western Lake Towuti, 1 km north of Kampung Baru, shallow shore with gravel and small rocks, F. Herder & R. K. Hadiaty, 22 March 2004. *Mugilogobius rexi*: MZB 21840, 10 (11.1–23.9 mm SL), South Sulawesi Province, north-western Lake Towuti, 1 km north of Kampung Baru, shallow shore with gravel and small rocks, F. Herder & R. K. Hadiaty, 22 March 2004; MZB 21851, 3 (21.5–21.7 mm SL), South Sulawesi Province, north-western Lake Towuti, 1 km north of Kampung Baru, shallow shore with gravel and small rocks, F. Herder & R. K. Hadiaty, 22 March 2004; MZB 21852, 1 (17.7 mm SL), South Sulawesi Province, north-western Lake Towuti, 1 km north of Kampung Baru, shallow shore with gravel and small rocks, F. Herder, A. Nolte & R. K. Hadiaty, December 2002; ZFMK 65045–65054, 10 (10.1–23.5 mm SL), South Sulawesi Province, north-western Lake Towuti, 1 km north of Kampung Baru, shallow shore with gravel and small rocks, F. Herder & R. K. Hadiaty, 22 March 2004; ZSM 42894, 3 (21.6–22.9 mm SL), South Sulawesi Province, north-western Lake Towuti, 1 km north of Kampung Baru, shallow shore with gravel and small rocks, F. Herder & R. K. Hadiaty, 22 March 2004. *Mugilogobius sarasinorum*: MZB 21854, 2 (19.4–20.5 mm SL), Central Sulawesi Province, north-east Lake Poso, muddy, shallow beach west of outlet to Poso River, 1°46.101'S, 120°37.860'E, F. Herder, J. Pfaender & B. Stelbrink, 10 September 2012; ZFMK 65026, 1 (19.4 mm SL), Central Sulawesi Province, north-east Lake Poso, muddy, shallow beach west of outlet to Poso River, 1°46.101'S, 120°37.860'E, F. Herder, J. Pfaender & B. Stelbrink, 10 September 2012. *Mugilogobius* sp.: MZB 21853, 3 (22.1–23.3 mm SL), South Sulawesi Province, Toletole River at Toletole village, at truck washing place about 150 m upstream of large river bridge at road to Wasaponda, 2°31.664'S, 121°06.726'E, F. Herder & R. K. Hadiaty, 4 May 2004; ZFMK 65039–65041, 3 (18.9–23.3 mm SL), South Sulawesi Province, north-western Lake Towuti, 1 km north of Kampung Baru, shallow shore with gravel and small rocks, F. Herder & R. K. Hadiaty, 15 May 2004. *Redigobius* cf. *penango*: ZFMK 65038, 1 (28.3 mm SL), South Sulawesi Province, Salo Saluro, small hill stream leading to Petea River, Malili Lakes drainage, 2°31.842'S, 121°30.006'E, F. Herder, J. Frommen & R. K. Hadiaty, 2 November 2002; MZB 21855, 3 (18.4–31.4 mm SL), South Sulawesi Province, stream near Lake Lontoa, 2°37.987'S, 121°44.208E, F. Herder & R. K. Hadiaty, 17 November 2006.

TAXONOMY

Mugilogobius hitam, new species

(English common name: Black Towuti Goby)
(Figs. 5–9; Tables 1, 2)

Material examined. Holotype: MZB 21456, 43 mm SL male, shallow gravel habitats of Lake Towuti, east of mouth of Tominanga River, Central Sulawesi, Indonesia (3°02.126'S, 119°53.232'E), August 2011, coll. H.-G. Evers, hand nets. Paratypes: MZB 21457, 3(26–35.3); ZRC 54209, 2(32.5–42.5); QM I.39127, 1(36.5); ZFMK 56701, 1(26); all with same data as holotype.

Diagnosis. A large *Mugilogobius* with second dorsal rays I,7–8, usually I,8; anal rays I,7–8, usually I,8; pectoral rays 15–16, usually 15; longitudinal scales 31–35; transverse scales backward 9–12; circumpeduncular scales 12–14; predorsal scales small, 17–21, reaching to slightly anterior of rear preopercular margin; ctenoid scales on sides of body extending forward in wedge to behind pectoral fin; sensory papillae on head in distinct transverse pattern; numerous short papilla rows along side of body; gill opening oblique, shoulder girdle smooth; first spine of dorsal fin longest in males, second spine longest in females, no spines elongate; head, body and fin rays plain dark brown to blackish; known only from Lake Towuti, central Sulawesi, Indonesia.

Relative to its congeners *M. abei*, *M. adeia*, *M. latifrons*, *M. lepidotus*, *M. rexi* and *M. sarasinorum*, the new species is characterised by seven fixed nucleotide substitutions in the 652 bp long mtDNA COI barcode region studied (Table 1). Based on the complete COI fragment analysed, the mean smallest K2P distances to a congener is 4.7% to *M. latifrons*.

Description. Based on eight specimens, 25.6–42.5 mm SL. An asterisk indicates counts of holotype (Figs. 5, 6) if differing from paratypes.

First dorsal VI; second dorsal I,7–I,8 (nearly always I,8*); anal I,7–8 (nearly always I,8*), pectoral rays 15; segmented caudal rays 15–16; caudal ray pattern 8/7* (in 7) or 9/7 (in 1); total branched caudal rays usually 15; unsegmented (procurrent) caudal rays 5/5* (in 5), 6/5 (in 1), 6/6 (in 1); longitudinal scale count 31–33; transverse scales backward 11–12; predorsal scales 17–19; circumpeduncular scales 12. Gill rakers on outer face of first arch 3+5* (in 1), 2+7 (in 1). Pterygiophore formula 3-12210. Vertebrae 11+16 (in 7), 10+17 (in 1). Neural spines of anterior vertebrae narrow and pointed, or second and third spine slightly broadened (first neural spine bifid in one). Two epurals present. Three anal pterygiophores anterior to haemal spine of first caudal vertebra (Fig. 6).

Body rounded to slightly compressed anteriorly, compressed posteriorly. Body depth at anal-fin origin 19.0–22.0% (mean 20.7%) of SL (Table 2). Head depressed anteriorly, HL 33.5–37.0% (mean 35.2%) of SL. Head width greater than head depth at posterior preopercular margin; depth 46.0–53.5% (mean 49.5%) of HL, width at posterior preopercular margin 61.2–68.7% (mean 65.9%) of HL; cheeks somewhat rounded. Mouth terminal, oblique, forming angle of about

Table 1. List of the seven diagnostic nucleotide substitutions found in the 652 base pairs long mtDNA COI barcode region. Nucleotide position is given with reference to the complete mitochondrial genome of *Oryzias latipes* (GenBank accession number AP004421).

	Nucleotide position						
	5	5	5	5	5	5	6
	4	4	4	4	7	8	0
	7	9	9	9	6	5	8
	7	0	3	6	9	0	4
codon position	2	3	3	3	3	3	3
M. sarasinorum	T	G	G	G	G	G	T
M. rexi	T	G	G	G	G	G	T
M. lepidotus	T	G	G	G	G	G	T
M. abei	T	G	G	G	G	G	T
M. adeia	T	G	G	G	G	G	T
M. latifrons	T	G	G	G	G	G	T
M. hitam n. sp.	A	C	A	C	C	C	C

30–40° with body axis; jaws reaching to below anterior part of eye. Upper jaw 31.5–41.4% (mean 35.0% in both sexes (two males, six females)) of HL. Lips smooth, moderately thick, with row of fine low fimbriae present on inner edges of both lips; lower lip free at sides, fused across front. Eyes relatively small, lateral, high on head, top forming part of dorsal profile, 18.1–23.0% (mean 20.5%) of HL. Snout blunt in dorsal view, flattened toward centre, not fleshy or overhanging, 25.8–30.6% (mean 28.8%) of HL. Interorbital broad and flat to slightly concave between bulges of eyes, 28.2–37.8% (mean 32.8%) of HL. Top of head anterior to nape scales with small, sparsely scattered villi, densest on interorbital area. Caudal peduncle compressed, length 22.2–24.5% (22.8%) of SL. Caudal peduncle depth 10.4–13.1% (mean 11.6%) of SL.

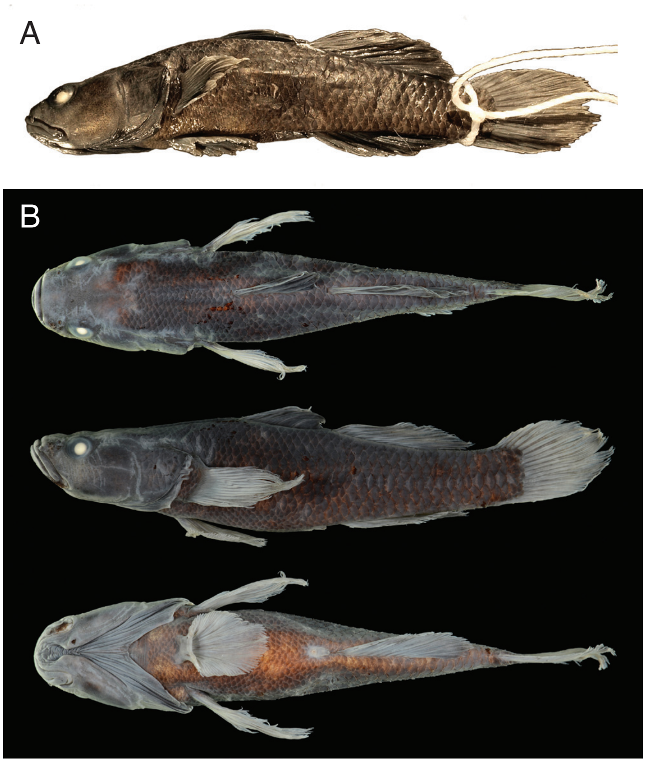

Fig. 5. *Mugilogobius hitam*, new species. A, MZB 21456, holotype, 43 mm SL male (photograph by S. Hüllen); B, ZRC 54209, paratype, 42.5 mm SL female (right side reversed) (photograph by H. H. Tan).

First dorsal fin low, triangular, tips of spines free, first spines longest in males (and two females), second spine longest in four females, but longest spine never much longer than others and never filamentous; fin falling short of second dorsal fin origin when depressed; longest spine 12.9–16.7% (mean 14.6%) of SL. Second dorsal and anal fins low, rounded posteriorly, anterior and posterior rays of about equal length; rays falling well short of caudal fin base when depressed. Pectoral fin pointed, central rays longest, 21.4–25.0% (mean 23.1%) of SL; uppermost ray shortest and unbranched. Pelvic fins short, oval; reaching somewhat more than half distance to anus, 17.8–20.2% (mean 19.3%) of SL; pelvic frenum edge irregular. Caudal fin rounded posteriorly, central rays longest, 17.2–26.2% (mean 21.0%) of SL.

No mental frenum, chin smooth. Anterior naris short, in thin tube, placed just behind upper lip, and oriented down and forward; preorbital slightly produced forward to accommodate naris tube. Posterior naris in small, round to oval pore, placed just above front centre margin of eye. Gill opening extending forward to under opercle, just behind preopercular rear margin. Inner edge of pectoral girdle smooth with low irregular fleshy ridge. Gill rakers on upper limb of outer face of first arch short and stubby (in one) or short and pointed (in one), unspined; rakers on ventral arm of arch low, short and slightly pointed (anteriormost rakers more blunt). Tongue tip blunt in two specimens. Outer row teeth in upper jaw moderately large, sharp and curved, largest teeth toward side of jaw; inner two to three rows of evenly sized, very small sharp teeth; rows narrowing at side of jaw. Lower jaw with outer row of slightly enlarged curved teeth and about four to five rows of evenly sized small sharp, curved teeth behind; rows narrowing toward side of jaw. Teeth size similar in male and female.

Predorsal scales small, cycloid, evenly sized, reaching anteriorly past preopercular margin in curved irregular pattern. Operculum covered with small cycloid scales; scales not always overlapping. Cheek naked. Pectoral base covered with small cycloid scales. Prepelvic area covered with small cycloid scales. Belly scales cycloid. Ctenoid scales on side of body in wedge extending up to behind pectoral fin, wedge narrowing in gap between dorsal fins; remainder of scales cycloid.

Genital papilla in male elongate, slightly rounded basally, becoming more flattened toward narrowly blunt tip; in female, papilla rounded, slender and bulbous.

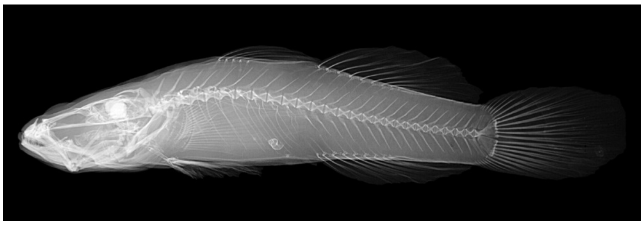

Fig. 6. *Mugilogobius hitam*, new species, radiograph of MZB 21456, holotype.

Table 2. Morphometrics of *Mugilogobius hitam*, new species, expressed as percentage of standard length (SL) or head length (HL).

Character	Holotype	Males Minimum	Males Maximum	Males Mean	Females Minimum	Females Maximum	Females Mean
Head length in SL	35.4	35.4	37.0	36.2	33.5	35.9	34.9
Head depth in HL	51.7	48.7	51.7	50.2	46.0	53.5	49.3
Head width in HL	64.2	64.2	66.1	65.1	61.2	68.7	66.2
Body depth in SL	20.6	20.6	22.0	21.3	19.0	21.7	20.4
Body width in SL	18.4	18.4	19.4	18.9	16.8	21.6	19.4
Caudal ped. l. in SL	22.2	22.2	23.7	23.0	22.2	24.5	22.8
Caudal ped. d. in SL	12.6	12.6	13.1	12.8	10.4	12.0	11.1
Snout length in HL	29.7	25.8	29.7	27.8	28.3	30.6	29.1
Eye width in HL	20.3	18.5	20.3	19.4	18.1	23.0	20.8
Jaw length in HL	35.5	34.7	35.5	35.1	31.5	41.4	35.0
Interorbital in HL	35.8	34.7	35.8	35.2	28.2	37.8	31.9
Pectoral length in SL	23.2	23.2	25.0	24.1	20.4	24.5	22.7
Pelvic length in SL	19.3	19.3	20.1	19.7	17.8	20.2	19.2
Caudal length in SL	26.2	22.1	26.2	24.1	17.2	22.1	20.0
Longest first dorsal fin spine in SL	16.7	14.7	16.7	15.7	12.9	15.0	14.3

Head pores absent as in all *Mugilogobius*.

Sensory papillae pattern transverse (Fig. 7). Vertical cheek papilla rows numerous (and variable), probably resulting from proliferation of vertical rows *c* and *a*; two short *s* rows on snout, with longitudinal rows joining them; short curved row *f* of about six papillae on chin. Body with distinctive rows of vertical papillae on scale row along mid-side, with several similar short rows above and below mid-lateral scales anteriorly and near caudal fin base (Fig. 8). Caudal fin with two longitudinal papilla rows and two short rows ventrally (Fig. 8).

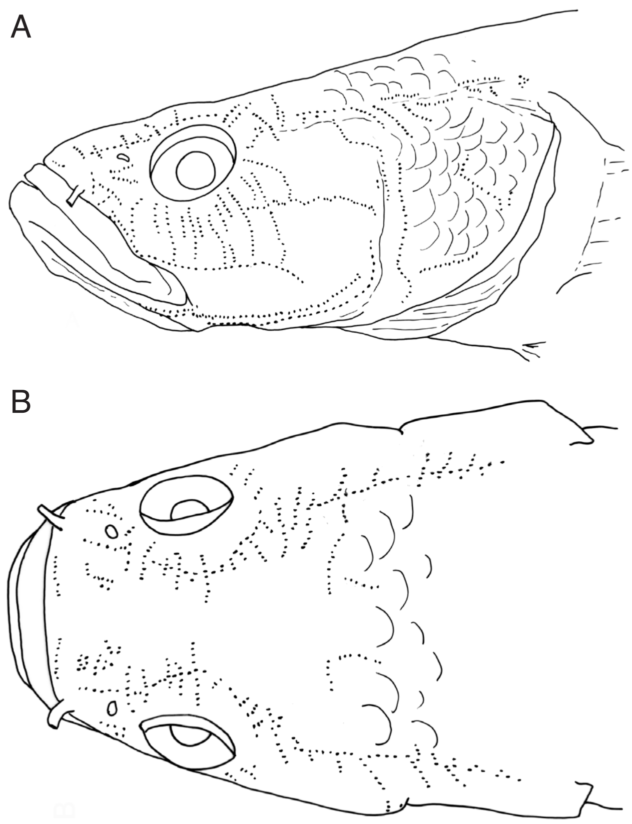

Fig. 7. Sensory papillae rows on head of *Mugilogobius hitam*, new species, ZRC 54209, 42.5 mm SL female paratype (scales indicated only). A, lateral view; B, dorsal view.

Live coloration. Body blackish brown to black; head reddish brown (Fig. 9). Unpaired fin membranes blackish hyaline. Fin rays in first and second dorsal fin blackish to black, fin rays in caudal and anal fin reddish brown to blackish brown. Dorsal and anal fins with diffuse paler margin. Pelvic fin hyaline blackish. Pectoral fin membranes hyaline, pectoral rays light reddish brown.

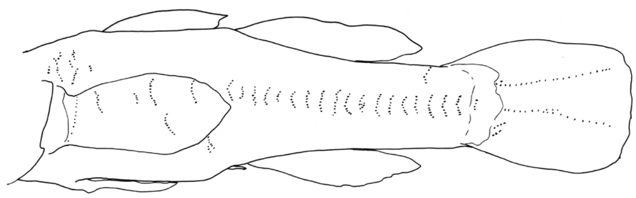

Fig. 8. Diagram of papillae rows on body and caudal fin of *Mugilogobius hitam*, new species, QM I.391271, 36.5 mm SL male paratype (scales omitted).

Fig. 9. *Mugilogobius hitam*, new species, captive specimen (photograph by H.-G. Evers).

Preserved coloration. Head and body plain blackish to brownish black, paler on belly (Fig. 5). First dorsal fin dark grey to blackish, with first spine white and other spines usually darker than membrane; tips of spines white to dusky; one female with two dark-margined oval translucent spots at edge of fin between third and fourth spines and fourth and fifth spines respectively. Second dorsal fin plain dark grey to blackish. Anal fin plain dark grey to blackish; spines darker than membrane. Caudal fin dusky to dark grey, spines blackish. Pectoral fin membrane translucent to whitish, with dusky to dark grey rays. Pelvic fins with membrane translucent to pale dusky, with dusky to dark grey rays; base of fin darker than remainder.

Distribution. This species is so far known only from Lake Towuti, near Tominanga in central Sulawesi, Indonesia (Figs. 1–3).

Ecology. This species hides in the warm shallows, deep among coarse gravel substrate (see Fig. 3). It was recorded down to 2 m depth, where it was rare during fieldwork in 2011. In contrast to other *Mugilogobius* species of the Malili Lakes, *M. hitam* is very shy, and difficult to find and collect (H.-G. Evers, pers. comm.). Syntopic goby species in its shallow gravel habitats are *M. latifrons* and *Glossogobius flavipinnis*. It is uncertain if this species is restricted to this depth and habitat; an extended focus in sampling effort in suitable areas within Lake Towuti is required to answer this question.

Etymology. The specific name, *hitam*, is the Bahasa Indonesia word for black.

Comparisons. *Mugilogobius hitam* differs from all other known species of the genus other than *M. rexi* by having rows of transverse papillae on the cheek. It is easily distinguished from *M. rexi* by its larger size, complex transverse sensory papillae pattern and having uniformly plain brownish black colouring; *M. rexi* is small, has only short transverse papillae rows under the eye and is pale in colour, yellow to yellowish grey with darker reticulate pattern on scale margins when alive. *Mugilogobius hitam* could possibly be confused with the large plain dark (and possibly extinct) *Mugilogobius amadi* from Lake Poso, but has far fewer lateral line scales (31–34), while *M. amadi* has 52–65 (Larson, 2001).

Remarks. This species has successfully been kept in aquaria and has reportedly spawned several times in captivity (H.-G. Evers, pers. comm.). Like other closely related species of the genus, *M. hitam* deposits and guards its small eggs on hard substrates. The larvae are minute, and have so far not been successfully reared. Photographs on an aquarium website show this species spawning in captivity (http://www.aqualifestyle-france.com/t8498p15-reproduction-mugilogobius-cf-amadi). The species has apparently been traded in Europe as *Mugilogobius amadi* (see http://photobucket.com/images/mugilogobius?page=1 and http://www.aqualifestyle-france.com/t8498p15-reproduction-mugilogobius-cf-amadi).

DISCUSSION

All of the Malili Lakes *Mugilogobius* species, as distinguished by morphological characters, are recovered as monophyletic clades by COI barcodes. This applies also to *M. hitam*, which forms a monophyletic group nested within the clade of other *Mugilogobius* from the Malili Lakes. The resolution of the mitochondrial COI gene fragment does not, however, allow for unequivocal inference of sister species relationships and the restricted outgroup sampling available for this study sets clear constraints on the phylogenetic interpretation of the results.

Sulawesi's endemic freshwater lake *Mugilogobius* share a number of characters, and form a separate clade in phylogenetic analyses based on morphology (Larson, 2001). The hypothesis that the Malili Lakes *Mugilogobius* similarly form a monophyletic clade in the present analyses highlights their close relationship and indicates that these small gobies may well represent a species flock with common ancestry, as do other fish and invertebrate flocks of this ancient lakes drainage (von Rintelen et al., 2012). Not surprisingly, and in agreement with morphological data (Larson, 2001), *M. sarasinorum*, the single endemic species reported from the similarly ancient Lake Poso, is here supported as the most likely sister taxon to all the Malili Lakes species. Detailed phylogenetic studies, incorporating the remaining species diversity of the genus, are required to test the hypothesis of a monophyletic lakes flock. These studies may also allow a tracing back to the biogeographic history of the Sulawesi endemics, an issue of substantial current interest (e.g., de Bruyn et al., 2012, Stelbrink et al., 2012, von Rintelen et al., 2012).

The unusually large *Mugilogobius amadi* (Weber, 1913), endemic to Lake Poso, is possibly extinct and was therefore not available for our barcoding study. Despite its size and its derived ecology, *M. amadi* shares a number of morphological characters with the other species of the genus from Sulawesi (Larson, 2001). Available data indicate that *M. amadi* is most likely a pelagic deep-water-dweller which had previously been placed in its own genus, *Weberogobius* Koumans, 1953 (see Larson, 2001 for discussion) due to its unusual appearance. *Mugilogobius amadi* was important to local fisheries in this extraordinarily deep lake (see Kottelat, 1990a), but it has not been recorded since the early 1980s, and is considered extinct (Whitten et al., 1987, 1988). Impacts by volcanic activity and the introduction of alien fish species and their parasites have been hypothesised as the most likely causes of the species' disappearance (Larson, 2001). However, local people at Lake Poso reported in late 2012 and in late 2013 that the "bungu" (*M. amadi*'s local name), as well as species of the equally vanished "bunting" (the large ricefishes endemic to L. Poso: *Adrianichthys kruyti*, *A. poptae* and *A. roseni*), are occasionally still to be found in the lake, but at low abundances. Further fieldwork is required to shed light on the possibility that these comparatively large endemic species of Lake Poso might in fact still exist.

Our finding that the new species' congener *Mugilogobius latifrons* is not restricted to lake habitats, but also occurs in streams of the lakes system, is attributed to the lack of long-term attention paid to the riverine habitats of the area, when compared to the conspicuous lakes. *Mugilogobius latifrons* was not rare at the time of sampling at the riverine sites. Its distribution corresponds to the lack of divergence in COI barcodes among specimens from a stream draining to Lake Towuti (Koro Kondube) and from the mouth of a stream entering the north-western tip of Lake Matano (Lawa). The lake habitats preferred by this species, reported earlier (Larson & Kottelat, 1992) and confirmed by the present observations, are all very shallow (lake edges). Most of these habitats are greatly affected by wave action, usually during the afternoon, and are mostly dominated by gravel, submerged wood, and leaf litter. They thus appear similar to the habitat composition typical for the riverine habitats of *M. latifrons*.

ACKNOWLEDGEMENTS

Our thanks to INCO / PT. VALE Indonesia Tbk., for providing outstanding logistic support in Sulawesi. We are grateful to Hans-Georg Evers for providing the specimens of the species described herein and for information on habitat and reproductive biology. We thank Sebastian Hüllen and Friedrich Wilhelm Miesen for measuring and documenting specimens, and Serkan Güse for technical assistance.

LITERATURE CITED

Aurich HJ (1938) Mitteilung XXVIII der Wallacea-Expedition Woltereck. Die Gobiiden. (Ordnung: Gobioidea). Internationale Revue der gesamten Hydrobiologie und Hydrographie, 38(1/2): 125–183.

De Bruyn M, von Rintelen T, von Rintelen K, Mather PB & Carvalho GR (2012) Molecular biogeography and phylogeography of the freshwater fauna of the Indo-Australian Archipelago. In: Gower DJ, Johnson KG, Richardson JE, Rosen BR, Rüber L & Williams ST (eds.), Biotic Evolution and Environmental Change in Southeast Asia. Cambridge University Press, Cambridge. Pp. 316–347.

Edgar RC (2004) MUSCLE: multiple sequence alignment with high accuracy and high throughput. Nucleic Acids Research, 32(5): 1792–1797.

Hasegawa M, Kishino K & Yano T (1985) Dating the human-ape splitting by a molecular clock of mitochondrial DNA. Journal of Molecular Evolution, 22: 160–174.

Herder F & Chapuis S (2010) *Oryzias hadiatyae*, a new species of ricefish (Atherinomorpha: Beloniformes: Adrianichthyidae) endemic to Lake Masapi, Central Sulawesi, Indonesia. The Raffles Bulletin of Zoology, 58: 269–280.

Herder F, Schwarzer J, Pfaender J, Hadiaty RK & Schliewen UK (2006) 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.

Ivanova NV, Zemlak TS, Hanner RH & Hebert PDN (2007) Universal primer cocktails for fish DNA barcoding. Molecular Ecology Notes, 7: 544–548.

Keith P & Lord C (2011) Tropical freshwater gobies: amphidromy as a life cycle. In: Patzner R, Van Tassell JL, Kovacic M & Kapoor BG (eds) The Biology of Gobies. Science Publishers, Jersey, Channel Islands. Pp 243–277.

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 (1990c) Sailfin silversides (Pisces: Telmatherinidae) of Lakes Towuti, Mahalona and Wawontoa (Sulawesi, Indonesia) with descriptions of two new genera and two new species. Ichthyological Exploration of Freshwaters, 1: 227–246.

Kottelat M (1991) Sailfin silversides (Pisces: Telmatherinidae) of Lake Matano, Sulawesi, Indonesia, with descriptions of six new species. Ichthyological Exploration of Freshwaters, 1: 321–344.

Kottelat M, Whitten AJ, Kartikasari SN & Wirjoatmodjo S (1993) Freshwater Fishes of Western Indonesia and Sulawesi. Perpiplus Editions Limited, Hong Kong. Pp 221.

Koumans FP (1953) X. Gobioidea. In: Weber M & Beaufort LF de (eds) The Fishes of the Indo-Australian Archipelago. E.J. Brill, Leiden. Pp 423.

Larson H (2001) A revision of the gobiid fish genus *Mugilogobius* (Teleostei: Gobioidei), and its systematic placement. Records of the Western Australian Museum Supplement, 62: 1–233.

Larson HK & Kottelat M (1992) A new species of *Mugilogobius* (Pisces: Gobiidae) from Lake Matano, central Sulawesi, Indonesia. Ichthyological Exploration of Freshwaters, 3(3): 225–234.

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

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

Patzner RA, Van Tassell JL, Kovacic M & Kapoor BG (eds.) (2011) The Biology of Gobies. Science Publishers, Enfield, NH, 650 pp.

Posada D & Crandall KA (1998) Modeltest: testing the model of DNA substitution. Bioinformatics, 14: 817–818.

Saitou N & Nei M (1987) The Neighbor-Joining Method—a new method for reconstructing phylogenetic trees. Molecular Biology and Evolution, 4: 406–425.

Stelbrink B, Albrecht C, Hall R & von Rintelen T (2012) The biogeography of Sulawesi revisited: is there evidence for a vicariant origin of taxa on Wallace's "anomalous island"? Evolution, 66: 2252–2271.

Swofford D (2002) PAUP*: Phylogenetic analysis using parsimony (and other methods) 4.0 beta. Version 3.0s. Champaign, Illinois.

Tamura K, Peterson D, Peterson N, Stecher G, Nei M & Kumar S (2011) MEGA5: Molecular Evolutionary Genetics Analysis using Maximum Likelihood, Evolutionary Distance, and Maximum Parsimony Methods. Molecular Biology and Evolution, 28(10): 2731–2739.

Vaillant JJ, Haffner GD & Cristescu ME (2011) The Ancient Lakes of Indonesia: Towards Integrated Research on Speciation. Integrative and Comparative Biology, 51: 634–643.

Von Rintelen T, von Rintelen K, Glaubrecht M, Schubart CD & Herder F (2012) Aquatic biodiversity hotspots in Wallacea: the species flocks in the ancient lakes of Sulawesi, Indonesia. In: Gower DJ, Johnson KG, Richardson JE, Rosen BR, Rüber L & Williams ST (eds.), Biotic Evolution and Environmental Change in Southeast Asia. Cambridge University Press, Cambridge. Pp. 290–315.

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

Whitten T, Nash SV, Bishop KD & Clayton L (1987) One or more extinctions from Sulawesi, Indonesia? Conservation Biology, 1: 42–48.

Whitten AJ, Henderson GS & Mustafa M (1988) The Ecology of Sulawesi. Periplus Editions, Indonesia, 777 pp.