



## Two new pygmygobies (Percomorpha: Gobiidae: *Trimma*) from French Polynesia

JEREMIE VIVIANI

*Département de Biologie, École Normale Supérieure de Lyon,  
Université de Lyon, UCB Lyon 1, 46 Allée d'Italie, Lyon, France  
National Center for Scientific Research, CRIOBE USR 3278 CNRS-EPHE-UPVD  
Laboratoire d'Excellence CORAIL, CRIOBE, 98729 Moorea, French Polynesia*

JEFFREY T. WILLIAMS

*Division of Fishes, Department of Vertebrate Zoology,  
National Museum of Natural History, 4210 Silver Hill Road, Suitland, MD 20746, USA  
corresponding author, E-mail: williamsjt@si.edu*

SERGE PLANES

*4EPHE, PSL Research University, UPVD, CNRS, USR 3278 CRIOBE,  
Université de Perpignan, 52 Av. Paul Alduy, F-66860, Perpignan, France  
Laboratoire d'Excellence CORAIL, CRIOBE, 98729 Moorea, French Polynesia*

### Abstract

Two new species of pygmygobies of *Trimma* with barred color patterns are described from French Polynesia. *Trimma erwani*, n. sp., is described based on two specimens collected at Fatu Hiva, Marquesas Islands. It is distinguished by its unique color pattern within the genus consisting of diagonally slanting grey-and-yellow bars on the body, 5 or 6 predorsal scales, and 16–17 unbranched pectoral-fin rays. *Trimma lutea*, n. sp., is described based on specimens collected from the Austral Islands in French Polynesia, as well as from Rarotonga, Cook Islands. It is distinguished by its color pattern consisting of alternating grey-and-yellow to reddish-yellow vertical bars on the head and body and scale margins outlined with melanophores, 4–7 predorsal scales, and 17–18 unbranched pectoral-fin rays. A mtDNA COI analysis, including all available sequences on the mtDNA-barcode project BOLD, shows a well-supported genetic divergence between each of the new species and among previously described congeners with sequences available.

**Key words:** taxonomy, systematics, phylogenetics, coral-reef fishes, gobies, ichthyology, Pacific Ocean.

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## Introduction

An extensive biodiversity survey of French Polynesia, organized primarily by the CRIOBE Laboratory (Moorea), has been ongoing since 2006. The goal of the project is to obtain genetic samples (linked to preserved museum-vouchered specimens) for genetic barcoding of as many fish species as possible from the different geographic regions of French Polynesia. Results from the first survey conducted at Moorea were used in a discussion of cryptic diversity in coral reef fishes (Hubert *et al.* 2012). Several new species have been described previously based on samples collected during these surveys (Williams *et al.* 2012, Tornabene *et al.* 2013, Williams *et al.* 2013, Delrieu-Trottin *et al.* 2014). A recent publication on the Marquesas Islands discusses the samples taken from that region and reviews the origin of endemic species of the Marquesas (Delrieu-Trottin *et al.* 2015). Our preliminary analysis of the specimens collected in our French Polynesia surveys to date indicates the presence of over 140 probable new species (including the two described herein) of marine shorefishes based on the results of mtDNA COI barcoding combined with morphological examination of the preserved voucher specimens.

Genetic and morphological analysis of the *Trimma* species collected in French Polynesia led to the discovery of several complexes of species forming distinct genetic lineages. We describe herein two new species of barred *Trimma* based on specimens collected from Rimatara, Rurutu, and Rarotonga in the Austral Islands chain and the Marquesas Archipelago.

In an analysis of the mtDNA cytochrome c oxidase subunit I (COI) gene, Winterbottom *et al.* (2014) discovered 94 haplogroups within 54 morphologically recognizable species at that time. They extrapolated from that ratio and said the total number of species may range from “...about 110 to nearly 200 (versus the 73 valid described species currently recognized)” at that time. Winterbottom *et al.* (2015) note that at that time there were 95 (including the three new species they described) named species recognized as valid in the genus *Trimma*. Suzuki *et al.* (2015) subsequently described *T. yoshinoi* from the Ryukyu Islands. Winterbottom (2016) recently described three additional new species. The two new species described herein increase the count to 101 named *Trimma* species currently recognized as valid.

## Materials and Methods

Methods of measuring and counting specimen characters (including cyanine blue staining of preserved specimens to detect head papillae) and the presentation format for the descriptions generally follow Winterbottom *et al.* (2015) and references cited therein to facilitate comparisons. Types are deposited in the National Museum of Natural History, Smithsonian Institution (USNM) and the Bernice P. Bishop Museum (BPBM). USNM collection records are available online ([http://vertebrates.si.edu/fishes/fishes\\_collections.html](http://vertebrates.si.edu/fishes/fishes_collections.html)). Other abbreviations used include standard length (SL) and head length (HL). Each of the USNM type specimens was tissue sampled (right pectoral fin removed) for DNA extraction and the entire specimens were preserved in 95% ethanol.

Procedures used for our mtDNA analysis using cytochrome c oxidase subunit I (COI) follow Williams *et al.* (2012) and Delrieu-Trottin *et al.* (2014). We utilized all COI sequences available (513) to us in BOLD (Barcode of Life Database) for our analysis. Neighbor-joining (NJ) analysis (Saitou & Nei 1987) based on the p-distance model (Nei & Kumar 2000) was conducted using the software package MEGA 7 (Kumar *et al.* 2016). Confidence in topologies was evaluated by a bootstrap analysis with 1000 replicates (Felsenstein 1985).



**Figure 1.** *Trimma erwani*, fresh holotype, USNM 409436, 13.9 mm SL, female, Fatu Hiva, Marquesas (J.T. Williams).

***Trimma erwani*, n. sp.**

Slanted Pygmygoby

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Figures 1–2.

**Holotype.** USNM 409436, 13.9 mm SL, female, (tissue number MARQ-436), French Polynesia, Marquesas Islands, Fatu Hiva, south of Baie Hanavave (Baie des Vierges) at tip of Pointe Matautu, on steep rock wall with narrow terraces, depth 20–30 m, 10.47153°S, 138.67794°W, field number MARQ-2011-32, rotenone, J.T. Williams, S. Planes, E. Delrieu-Trottin, J. Mourier, & P. Sasal, 10 November 2011.

**Paratype.** USNM 409435, 13.4 mm SL, female, (tissue number MARQ-435), collected with holotype.

**Diagnosis.** A species of *Trimma* with a unique color pattern within the genus consisting of diagonally slanting grey and yellow bars on body; nape scaled with about 5–6 predorsal scales; pectoral fin with 16–17 unbranched rays; fifth pelvic-fin ray unbranched, about half length of fourth ray; interorbital region with U-shaped trench and no postorbital trenches.

**Description.** Dorsal-fin rays VI + I,8, all segmented rays branched, second spine longest (but not elongated), reaching posteriorly to bases of spine of second dorsal fin when adpressed, longest dorsal-fin ray 45% (SD=0.01) of HL, last dorsal-fin ray reaching posteriorly to midpeduncle; anal-fin rays I,8, most segmented rays branched;



**Figure 2.** *Trimma erwani*, fresh paratype, USNM 409435, 13.4 mm SL, female, Fatu Hiva, Marquesas (J.T. Williams).

pectoral-fin rays 16–17 (mean = 16.5), all rays unbranched, longest pectoral-fin ray 71–76% of HL (mean=74%), fin reaching posteriorly to above anterior elements of anal fin; pelvic-fin rays I,5, fifth ray unbranched and 44–49% length of fourth, which reaches posteriorly to first element of anal fin, other rays with one sequential branch; frenum absent, basal membrane vestigial. Lateral scales 26–28; transverse scales 7–8 anteriorly, 6 scales posteriorly; opercle and cheek unscaled; three rows of cycloid scales on pectoral-fin base; several scale pockets (scales lost) on midline anterior to pelvic fin with some cycloid scales posterior to pelvic-fin base and on belly; remaining lateral body scales ctenoid (most scales lost); body scales extending anteriorly to nape and across dorsal midline (only scale pockets remain), about 8 predorsal scales (scale pockets counted). Upper jaw with outer row of canine teeth flanked medially by two to three rows of small conical teeth; teeth in lower jaw with five or six enlarged recurved canines on each side of symphysis, 2 rows of small teeth at symphysis and 1 row posteriorly and medial to row of enlarged canine teeth. Tongue rounded. Gill opening extending anteriorly to point below vertical from mid-pupil; inner gill rakers on first arch 4+13. Anterior nares short tube, posterior nares circular pore with raised rim. Epaxialis musculature reaching to above posterior margin of orbit.

Bony interorbital width 63–75% of pupil diameter; interorbital trench U-shaped, broader than deep, no postorbital trenches; peduncle width 32–33% of peduncle length; head length 28–33% of SL; eye diameter 41% of HL; snout length 21–25% of HL; head papillae not apparent (possibly due to preservation in 95% ethanol).

**Color when fresh.** (based on photographs of freshly dead specimens from Fatu Hiva, Marquesas) Head covered with fine melanophores, with yellow on nape posterior to orbits, yellow on opercle and underside of head continuing across pelvic bases, along belly to anal-fin origin, snout yellow with grey area at tip of snout on upper lip and continuing onto anterior tip of lower lip, remainder of lips and chin yellow, suborbital yellow with two narrow grey bars extending ventrally along cheek for about half distance to preopercular angle, third narrow grey bar extending posteroventrally from posterior border of orbit almost to angle of preopercle, narrow yellow bar along posterior margin of preopercle followed by grey bar extending from nape, across opercle; yellow bar extending posteroventrally from nape, across posterior portion of opercle to pelvic bases, followed by six diagonally slanted (anterodorsal to posteroventral) grey bars, the first and second not reaching the ventral midline, each grey bar about the width of three scales; six slanted yellow bars alternating with grey bars, yellow bars about 2–2.5 scales wide with posteriormost yellow bar angling posteriorly onto ventral half of caudal fin and almost reaching posterior tips of caudal rays, bordered ventrally by narrow posterior extension of sixth grey body bar that continues to tips of caudal rays, yellow bar on caudal fin bordered dorsally by grey area then yellow blotch, then grey dorsal border along caudal rays to tips. Pelvic-fin rays yellowish. Anal fin with alternating yellow and grey bands formed by body bars extending onto fin. First dorsal fin with yellow body bar extending onto fin with basal and distal grey regions; second dorsal fin with body bar forming narrow yellow area basally over rays 1–3, followed by diagonal grey area, then distally by broad yellow band extending diagonally from tips of first ray to merge with yellow body bar. Iris of eye with narrow iridescent blue ring around pupil followed by yellow ring broken by several iridescent blue narrow spokes radiating from inner ring.

**Color when preserved.** Preserved specimens retain bar pattern, with yellow areas pale and dark bars consisting of densely clustered melanophores. Lateral scales outlined with melanophores.

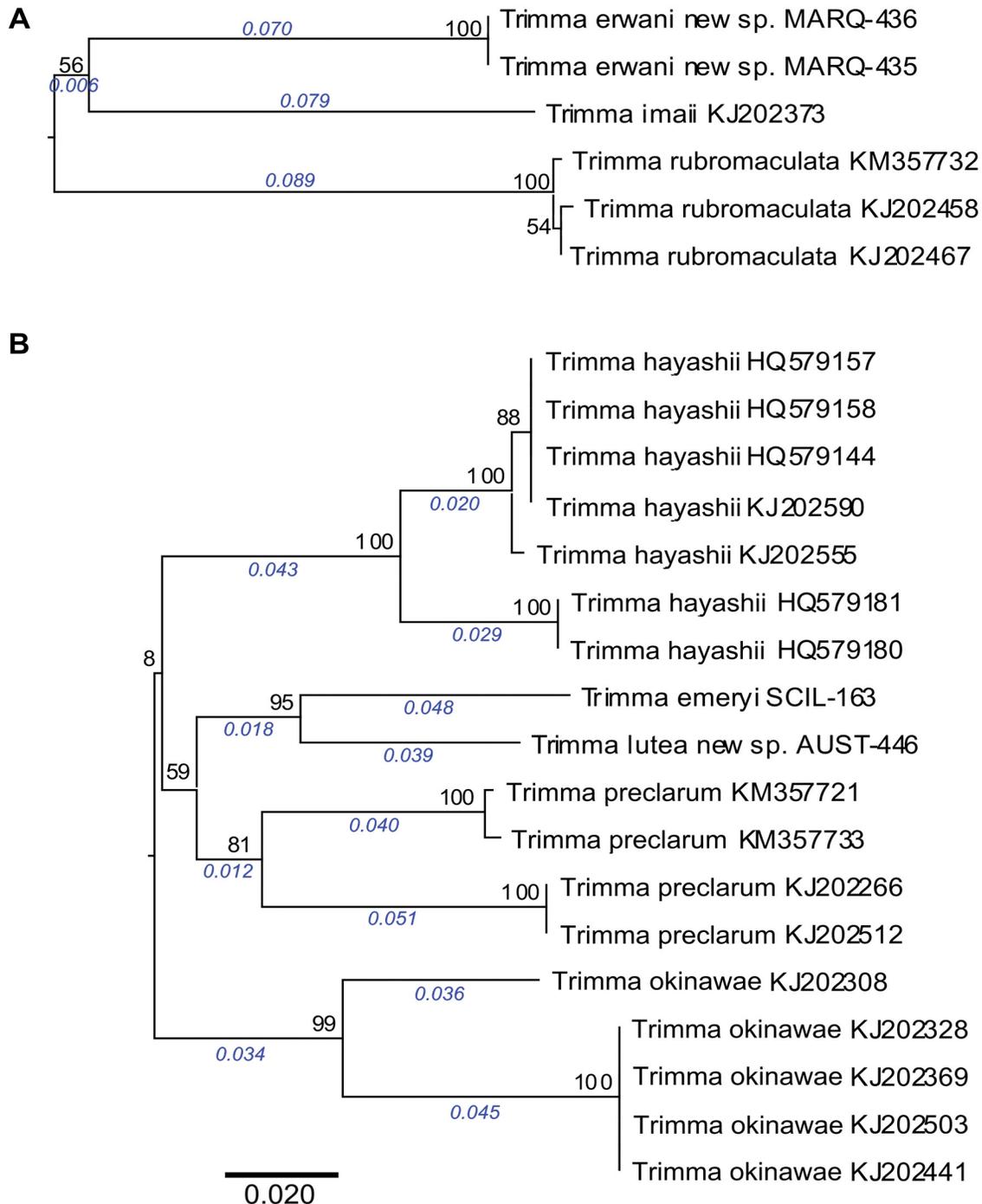
**Etymology.** The species is named *erwani* in recognition of Erwan Delrieu-Trottin, who assisted in the collecting of these specimens in the Marquesas (as well as on other French Polynesia expeditions) and who worked late into the night with one of us (JTW) to take tissue samples and to help with processing of specimens.

**Remarks.** *Trimma erwani* is known from only two specimens collected at Fatu Hiva, Marquesas Islands, but is likely to occur at other islands in the Marquesas group. Its cryptic habits, depth of occurrence (20–30 m), and small size (under 14 mm SL) make it difficult to observe or collect.

**Comparisons.** *Trimma erwani* shares the combination of having predorsal midline scales, unbranched pectoral-fin rays and an unbranched fifth pelvic-fin ray with *T. habrum* Winterbottom, 2011; *T. helenae* Winterbottom, Erdmann & Cahyani, 2014; *T. imaii* Suzuki & Senou, 2009; *T. kitrinum* Winterbottom & Hoese, 2015; and the *T. tevegae* Cohen & Davis, 1969 group of species (including *T. caudomaculatum* Yoshino and Araga in Masuda *et al.*, 1975; *T. burridgeae* Winterbottom, 2016; *T. corerefum* Winterbottom, 2016; and *T. hollemani* Winterbottom, 2016). *Trimma erwani* differs from all of these by its distinctively angled yellow bars on the dark gray body,

interorbital trench present, vestigial pelvic basal membrane, no scales on the cheek, pectoral-fin rays 16–17 (*T. imaii* has 16, others with fewer), and more (26–28) lateral scale rows (versus 23–24).

**Genetic analysis.** Our analysis of 513 available mtDNA COI sequences (see linked resource file at <http://doi.org/10.5281/zenodo.159613>) yields a NJ network that places *T. erwani* phenetically closest (although with a bootstrap value of only 56) to *T. imaii* from the Izu Islands, Japan, with about 14.9% sequence divergence pairwise (the relevant portion of the NJ network is extracted and presented in Fig. 3A). These two species both have slightly darkened scale margins, but are easily distinguished by the lack of bars on the pale yellow body of *T. imaii* and the other characters discussed above. It is likely that an as-yet unsequenced (possibly undescribed) species of *Trimma* will be more similar to *T. erwani* given the high level of genetic divergence from other known *Trimma* species.



**Figure 3.** Neighbor-Joining networks based on p-distance model of sequence evolution (with 1,000 bootstrap replicates) for available members of the genus *Trimma* on BOLD. Bootstrap values are shown in black and genetic distance values from each branch are shown in blue. The scale bar at left represents a 2% sequence divergence. The entire 513-sequence NJ network from which these sub-networks were extracted is available at <http://doi.org/10.5281/zenodo.159613>



**Figure 4.** *Trimma lutea*, fresh holotype, USNM 422899, 23.4 mm SL, Rimatara Island, Austral Islands (J.T. Williams).

***Trimma lutea*, n. sp.**

**Yellow Barred Pygmygoby**

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Figures 4–6.

**Holotype.** USNM 422899, 23.4 mm SL, (tissue number AUST-445), French Polynesia, Austral Islands, Rimatara Island, outer reef slope with dead coral structure but little live coral, dead coral-reef channel on outer slope, depth 20–26 m, 22.6406°S, 152.8223°W, field number AUST-2013-17, rotenone, J.T. Williams, E. Delrieu-Trottin, & P. Sasal, 18 April 2013.

**Paratypes.** USNM 422870, 21.8 mm SL, (tissue number AUST-444), collected with holotype; USNM 422880, 19.7 mm SL, (tissue number AUST-447), collected with holotype; USNM 422908, 21.4 mm SL, (tissue number AUST-446), collected with holotype; BPBM 13699, 4 (14–23 mm SL), Rurutu, Austral Islands, west side off Areva; steep coral slope, depth 46–58 m, rotenone, J. Randall, D. Cannoy, R. McNair, J. Haywood, & D. Devanay, 28 February 1971; BPBM 13966, 7 (15.5–22 mm SL), Rarotonga, Cook Islands, off oil tanker buoy near harbor entrance, small pocket of coarse sand and surrounding coral, depth 15 m, rotenone, J. Randall & D.B. Connoy, 10 March 1971.

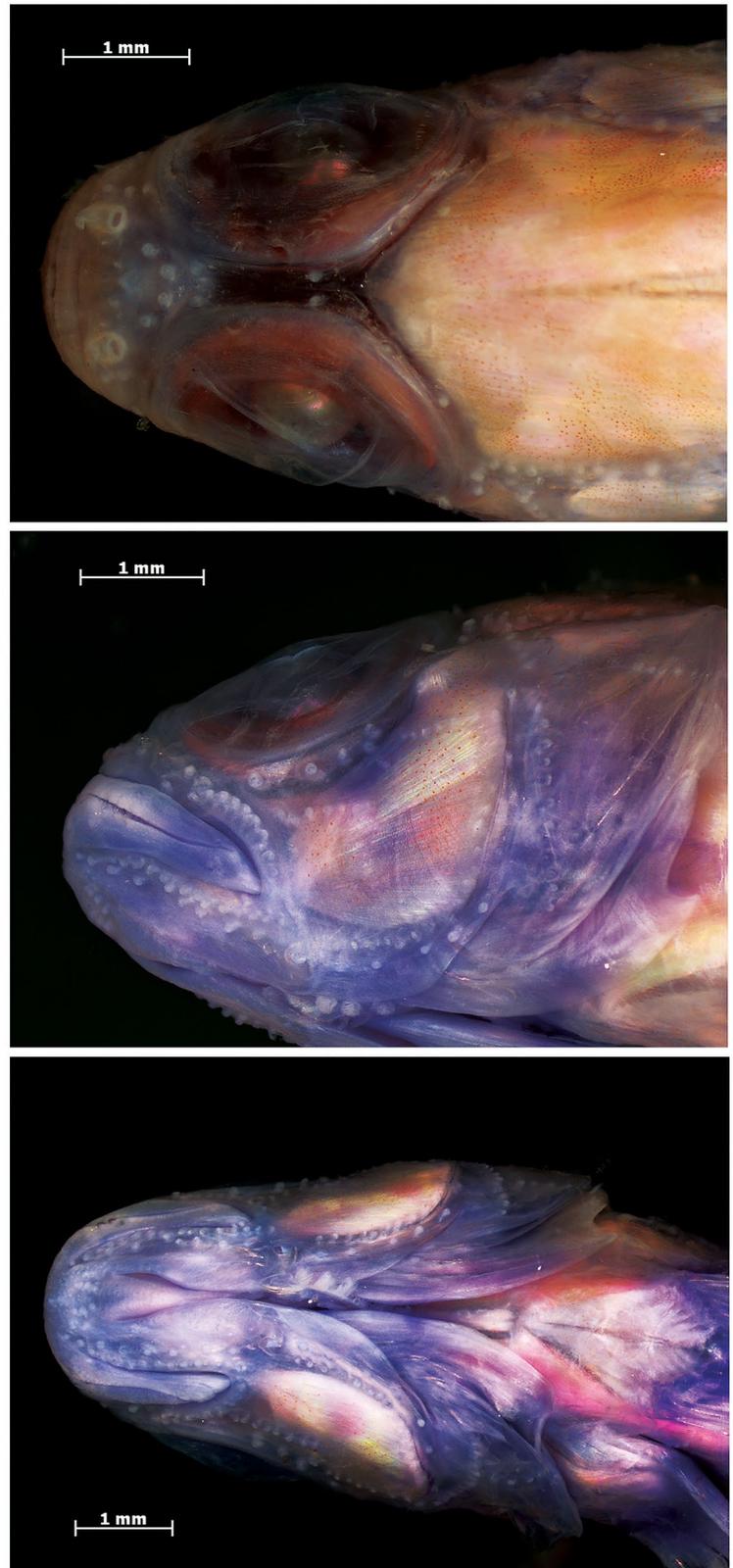
**Diagnosis.** A species of *Trimma* with a unique color pattern within the genus consisting of alternating grey or reddish grey and yellow bars on head and body; nape half to completely scaled with about 4–7 predorsal scales; pectoral fin with 18 rays, 8 unbranched rays; fifth pelvic-fin ray unbranched, about 50% to 80% length of fourth ray; interorbital region with well-developed U-shaped trench and postorbital trenches.

**Description.** Dorsal-fin rays VI + I, 10, first segmented ray branched or unbranched, others branched, first spine longest (but not elongated), reaching posteriorly to base of spine of second dorsal fin when adpressed, anal-fin rays I, 9–10, first segmented ray branched or unbranched, others branched; pectoral-fin rays 18, dorsalmost 4 and ventralmost 4 rays unbranched, 10 middle rays branched, fin reaching posteriorly to above anterior elements of anal fin; pelvic-fin rays I, 5, fifth ray unbranched and about 50%–80% length of fourth, which reaches posteriorly to bases of anterior elements of anal fin, other rays with one sequential branch; frenum absent, basal membrane vestigial. Vertebrae 10+17. Lateral scales 25–27; transverse scales 7–8 anteriorly and 6–7 posteriorly; opercle and cheek unscaled; 1–3 rows of scales on pectoral-fin base; 4–6 scales on midline anterior to pelvic fin; scales on nape, breast anterior to pelvics, belly just posterior to pelvics, and pectoral base cycloid; others ctenoid; body

scales extending anteriorly on either side of midline to middle of nape or to anterior part of nape; 4–7 predorsal scales. Upper jaw with outer row of canine teeth flanked medially by two to three rows of small conical teeth; lower jaw with five or six enlarged canine teeth on each side of symphysis, 2 rows of small teeth at symphysis, and 1 row posteriorly and medial to row of large canine teeth. Tongue rounded. Gill opening extending anteriorly to point below vertical from mid-pupil; gill rakers on first arch 4–5 + 14–15. Anterior nares short tube, posterior nares circular pore with raised rim. Epaxialis musculature reaching to above posterior margin of orbit.

Bony interorbital width 29–39% of eye diameter; well-developed postorbital and interorbital trenches (latter U-shaped), both deeper than wide; peduncle width 37–42% of peduncle length; head length 28–29% of SL; eye diameter 41–43% of HL; snout length 19–22% of HL; head papillae (based on two specimens, see Fig. 5): row *a* 5–6, row *b* 7, row *c* 6, row *cp* 1, row *d* 7–8, row *d'* 9–10, row *e*-anterior 14–15, row *e*-posterior 14, row *f* 3, row *i*-anterior 6–8, row *i*-posterior 11, row *p* 6, row *r* 2, row *cs* 3, row *g* 5–7, row *n* 1, row *u* 5, row *x* 6, row *z* 4, row *ot* 12–13, row *os* 5, row *oi* 4; transverse: line 1 2, line 2 1, line 3 1, line 4 0–1, line 5 2–3, line 6 1.

**Color when fresh.** (based on photographs of freshly dead specimens from the Austral Islands, French Polynesia and Rarotonga, Cook Islands) Head covered with fine melanophores, reddish brown on cheeks, snout and chin, encircled with five alternating narrow yellow bars on reddish brown background, first yellow bar on snout, two yellow bars beneath eye, one yellow bar posterior to orbits and one yellow bar running from nape across opercle to pelvic bases; upper lip with alternating red and yellow spots; body encircled with six or seven narrow yellow bars (each about 1–2 scales wide) alternating with broader reddish brown to brown bars (each about 3 scales wide) with first yellow bar at insertion of first dorsal fin, fourth and fifth bars usually slightly oblique (from dorsal profile angling slightly to terminate at base of anal fin slightly anterior to vertical from dorsal origin of respective bar), sixth and seventh bars on caudal peduncle usually broken into cluster of 2–4 yellow blotches at base of caudal fin; scales on nape and body outlined with melanophores; caudal fin with three yellow spots at base followed by three or four vertical rows of small yellow spots on dusky background; dorsal fins dusky with small yellow spots; anal fin yellow with dusky stripe basally and narrow dusky border distally; pectoral fins translucent with reddish rays; pelvic fins yellow with brown border from base to distal tip along outer edge; iris of eye reddish with yellow bars roughly continuous with yellow bars on head.



**Figure 5.** *Trimma lutea*, head papillae pattern, BPBM 13966, stained with cyanine blue: dorsal view (top), lateral view (middle), ventral view (bottom)(A. Nonaka).



**Figure 6.** *Trimma lutea*, fresh paratype, BPBM 13699, 22 mm SL, Rurutu Island, Austral Islands (J.E. Randall).

**Color when preserved.** Preserved specimens retain bars with yellow areas pale and dark bars consisting of densely clustered melanophores. Lateral scales outlined with melanophores. BPBM specimens have almost all melanophores completely faded and are pale overall.

**Etymology.** The species name *lutea* is derived from the Latin *luteus* meaning yellow, in reference to the yellow bars on the body and is treated as a noun in apposition. The common name, Yellow Barred Pygmygoby, refers to the distinctive yellow bars on the head and body.

**Remarks.** *Trimma lutea* is known from specimens collected at the Austral Islands and the southern Cook Islands, but is likely to occur at other islands in the Austral group. Its cryptic habits, depth of occurrence (20–58 m), and small size (under 24 mm SL) make it difficult to observe or collect. This species was first discovered by John E. Randall when he collected the four BPBM specimens reported here in 46–58 m.

**Comparisons.** *Trimma lutea* differs from all known *Trimma* species by its unique color pattern of yellow and brown bars. It is most similar in color pattern to *T. cana* Winterbottom, 2004 (Fig. 7), with some similarity to the patterns of *T. sostra* Winterbottom, 2004 (Fig. 8), and *T. squamicana* Winterbottom, 2004. *Trimma lutea* has eight yellow bars on a brown background, no elongate dorsal-fin spines, 4–7 predorsal scales, and 25–27 lateral



**Figure 7.** *Trimma cana*, USNM 432613, 22 mm SL, Luzon, Philippines (J.T. Williams).



**Figure 8.** *Trimma sostra*, USNM 365598, 19.5 mm SL, Solomon Islands (J.T. Williams).

scale rows on body, while *T. cana* has eight red bars on a white background, an elongate second dorsal-fin spine, no predorsal scales, and 23–24 lateral scale rows. *Trimma sostra* has seven broad red blotches midlaterally from the head to peduncle on a white background, an elongate second dorsal-fin spine, no predorsal scales, and 22–25 (usually 24) lateral scale rows. *Trimma squamicana* has eight red saddles dorsally (some corresponding with ventral saddles, but not forming complete bars) on a white background, a variably elongate second dorsal-fin spine, 0–9 predorsal scales, and 23–26 (usually 24) lateral scale rows.

**Genetic analysis.** Our analysis of 513 available mtDNA COI sequences (see linked resource file at <http://doi.org/10.5281/zenodo.159613>) yields a NJ network that places *T. lutea* phenetically closest (bootstrap value of 95) in our NJ network to a member of the *T. emeryi* Winterbottom, 1985 species complex from Mopelia, French Polynesia, with about 8.7% divergence pairwise (the relevant portion of the NJ network is extracted and presented in Fig. 3B). These two species both have slightly dark scale margins, but are easily distinguished by the lack of bars or stripes on the body of the Mopelia *T. cf emeryi* (Fig 9), 8 second dorsal-fin rays (versus 10 for *T. lutea*), and a short basal membrane connecting the fifth pelvic-fin rays (versus vestigial in *T. lutea*).

The next branch in the network is weakly supported (bootstrap value of 59) and contains two haplotypes of *Trimma* “*preclarum*” with 10.9% divergence. *Trimma preclarum* Winterbottom, 2006 is easily distinguished from *T. lutea* by having three narrow yellow stripes on the body (versus bars), 9 second dorsal-fin rays (versus 10), and a short basal membrane connecting the fifth pelvic-fin rays (versus vestigial).



**Figure 9.** *Trimma cf. emeryi*, USNM 435052, 19.5 mm SL, Scilly Atoll, French Polynesia (J.T. Williams).

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Specimens examined for this study were collected by JTW and SP during expeditions to French Polynesia organized primarily by SP. The Pakaihi I Te Moana expedition to the Marquesas was funded by the Agence des Aires Marines Protégées in France and organized by the CRIOBE. We thank the Centre Plongée Marquises (Xavier (Pipapo) and Marie Curvat), the Fondation TOTAL, the Ministère de l’Environnement de Polynésie, the Délégation à la Recherche Polynésie, the Mairie of Nuku-Hiva, and the people of the Marquesas Islands for their kind and generous support of the project as we traveled throughout the islands. The Austral Islands expedition was part of the Global Reef Expedition and the work presented here is based in part on specimens collected in the Austral Islands made possible due to the support of the Khaled bin Sultan Living Oceans Foundation.

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