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Eviota gunawanae, a new microendemic dwarfgoby from the Fakfak Peninsula, West Papua, Indonesia (Teleostei: Gobiidae)

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Abstract

A new species of dwarfgoby, *Eviota gunawanae*, with a cephalic sensory-canal pore pattern lacking only the IT and NA pores and with the AITO pore positioned far forward and opening anteriorly, is described from the Fakfak Peninsula in the Bird's Head Seascape of western New Guinea, West Papua Province, Indonesia. It has a dorsal/anal-fin-ray formula of 8/7, 16 unbranched pectoral-fin rays, the fifth pelvic-fin ray present, very long anterior tubular nares, a distinctive double black spot at the caudal-fin base, and no narrow horizontal line of melanophores crossing the pectoral-fin base. In life, it has a maroon stripe down the midline of the body, with elongate white spots above it posteriorly and two white lines over the abdomen. *E. gunawanae* is most closely related to *E. tetha*. The new species appears to represent the eighth known microendemic fish species from this remote reef location in West Papua, highlighting the biodiversity conservation importance of the Fakfak Peninsula's reefs.

Key words: taxonomy, systematics, ichthyology, coral-reef fishes, gobies, endemism, microendemism, phylogenetics, Bird's Head Seascape, conservation, *Eviota tetha*.

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Introduction

In 2014, Greenfield & Erdmann described *Eviota tetha* from Cenderawasih Bay, West Papua Province, Indonesia. The species was distinctive in lacking only the IT and NA cephalic sensory-canal pores and having the AITO pore positioned far forward and opening anteriorly, characters shared only with *Eviota infulata* (Smith, 1956). While conducting a reef fish biodiversity survey in the Fakfak Peninsula, West Papua Province, Indonesia, in March 2018, the third and fourth authors collected a single individual of a species looking similar to *E. tetha*, but with a different live coloration. Later, in July 2018, they were able to return to the same location (Karas Island) and collect 7 formalin-fixed as well as 2 ethanol-fixed specimens for DNA analyses. The specimens were determined to represent a new species and it is described here, adding to the two species described since the 113 species reviewed in Greenfield & Winterbottom (2016) and Greenfield (2017), resulting in a total of 116 valid species of *Eviota* described to date.

Materials and Methods

Type specimens are deposited at the Museum Zoologicum Bogoriense, Cibinong, Java, Indonesia (MZB) and the California Academy of Sciences, San Francisco, CA, USA (CAS).

Counts and measurements, descriptions of fin morphology, and the cephalic sensory-canal pore patterns follow Lachner & Karnella (1980) and Jewett & Lachner (1983). Postanal ventral-midline spots begin at the anal-fin origin and extend to a vertical about two or three scale rows anterior to the end of the hypurals, the additional smaller spot posterior to this, if present, is not counted. We follow Lachner & Karnella (1980: 4) in describing the membranes joining the first 4 pelvic-fin rays, which "…are considered to be well developed when the membranes extend beyond the bases of the first branches; they are considered to be reduced when they are slightly developed, not extending to the bases of the first branches". Dorsal/anal fin-ray formulae (eg. 8/7) only include segmented rays. Measurements were made to the nearest 0.1 mm using an ocular micrometer or dial calipers, and are presented as percentage of standard length (SL). Lengths are given as standard length (SL), measured from the median anterior point of the upper lip to the base of the caudal fin (posterior end of the hypural plate); origin of the first dorsal fin is measured from the median anterior point of the upper lip to the anterior base of the first dorsal-fin spine; origin of the second dorsal-fin is measured from the median anterior point of the upper lip to the anterior base of its spine; origin of the anal fin is measured from the median anterior point of the upper lip to the anterior base of its spine; body depth is measured at the center of the first dorsal fin; head length is from the upper lip to the posterior end of the opercular membrane; orbit diameter is the greatest fleshy diameter; snout length is from the median anterior point of the upper lip to the nearest fleshy edge of the orbit; upper jaw length is the straight-line distance from the anterior tip of the premaxilla to the end of the upper margin of the dentary where the maxilla joins behind it; caudal-peduncle depth is the least depth, and caudal-peduncle length the horizontal distance between verticals at the rear base of the anal fin and the caudal-fin base; pelvic-fin length is the length of the longest ray; pelvic-fin length is measured from the base of the pelvic-fin spine to the tip of the longest pelvic-fin soft ray.

Cyanine Blue 5R (acid blue 113) stain and an airjet were used to make the cephalic sensory-canal pores more obvious (Akihito et al. 1993, 2002, Saruwatari et al. 1997). We sequenced a segment of the mitochondrial gene cytochrome c oxidase subunit I (COI), using the primers GobyL6468 and GobyH7696 (Thacker 2003), and the nuclear gene Protease III (Ptr), using the primers PtrF2 and PtrR2 (Yamada et al. 2009). The PCR conditions follow that of Tornabene et al. (2016). Sequences for the new species were combined with new or existing sequences (Tornabene et al. 2013, 2015, 2016) of *E. tetha* from the type locality (Cenderawasih Bay) and Raja Ampat (Wayag Lagoon), as well as specimens from closely related species (*Eviota cometa* Jewett & Lachner, 1983 and *Eviota zebrina* Lachner & Karnella, 1978) and more distant outgroups from the two main clades of *Eviota* (those with branched and unbranched pectoral-fin rays, respectively). Sequences were aligned in Geneious v.6.0.6 (Biomatters; www.geneious.com). New sequences generated in this study were deposited on GenBank (accession numbers in Appendix). The final alignment consisted of 1173 bp of COI and 614 bp of Ptr. A phylogenetic analysis of the concatenated alignment was done using Bayesian Inference in the software MrBayes v.3.2 (Ronquist et al. 2012), partitioning by gene. Substitution models were chosen using PartitionFinder2 (Lanfear et al. 2016). The analysis was run for 10^6 generations, discarding the first 10% of trees as burn-in.

Eviota gunawanae, n. sp. Greenfield, Tornabene & Erdmann

Tiene's Dwarfgoby

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Figures 1–3, 5 & 6.

Holotype. MZB 24002, 15.9 mm SL, male, Indonesia, West Papua, Fakfak Peninsula, northeast Karas Island, -3.4175°, 132.6783°, 45 m, clove oil & hand net, field number MVE-18-057, M.V. Erdmann & R. Mambrasar, 11 July 2018.

Paratypes. CAS 246233, 5 males 12.1–14.0 mm SL & 1 female 12.7 mm SL, taken with holotype; CAS 246234, 13.1 mm SL male, same location as holotype, 45 m, clove oil & hand net, field number MVE 18-023, M.V. Erdmann & D.N. Pada, 15 March 2018; CAS 246254, 2 specimens (in 95% ethanol), DNA label TET3 and TET4, taken with holotype.

Diagnosis. A species of *Eviota* with a cephalic sensory-canal pore pattern lacking only IT and NA pores and with AITO pore positioned far forward and opening anteriorly; very long anterior tubular nares; dorsal/anal-fin-ray formula 8/7; 16 unbranched pectoral-fin rays; fifth pelvic-fin ray about 10% length of the fourth pelvic-fin ray; a black spot at caudal-fin base in two joined parts extending anteriorly past end of hypural plate; top of head with scattered melanophores, sometimes arranged in lines, but not as a single line of melanophores extending posteriorly from PITO pore back onto nape. In life, a maroon stripe down midline of body with elongate white spots above stripe posteriorly and two white lines over abdomen.

Description. Dorsal-fin elements VI+I,8 (one paratype I,7); first dorsal fin triangular, first three spines filamentous, second or third longest, reaching past end of second dorsal fin when adpressed; all second-dorsal-fin soft rays branched, last branched to base; anal-fin elements I,7, all soft rays branched, last branched to base; pectoral-fin rays 16, all unbranched, pointed, reaching to below second dorsal fin; fifth pelvic-fin ray length about 10% of fourth ray, 3 or 4 branches on fourth ray in paratypes (broken in holotype), 2 segments between consecutive branches of fourth pelvic-fin ray, pelvic-fin membrane reduced, no basal membrane; caudal fin with 11 branched and 17 segmented rays; lateral-line scales 24; transverse scale rows 7; urogenital papilla of male smooth, long, and narrow, expanded into two lateral horn tips, extending past anal-fin spine; female papilla smooth, bulbous, with short finger-like projections on end.

Front of head rounded, profile an angle of about 60° from horizontal axis; mouth slanted obliquely upwards, forming an angle of about 55° to horizontal axis of body, lower jaw not projecting; maxilla extending posteriorly

Figure 1. *Eviota gunawanae*, n. sp., underwater photograph, Fakfak, West Papua Province, Indonesia (M.V. Erdmann).

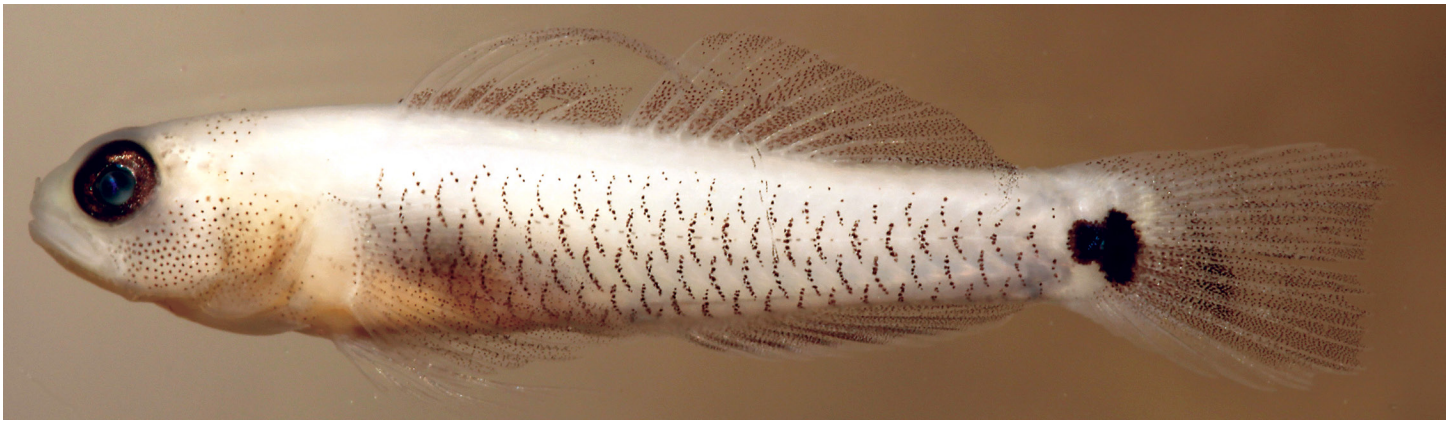

Figure 2. *Eviota gunawanae*, n. sp., preserved holotype, MZB 24002, 15.9 mm SL, male (D.W. Greenfield).

to center of pupil; anterior tubular nares very long, extending past anterior margin of upper lip; gill opening extending forward to below posteroventral edge of preoperculum; cephalic sensory-canal pore system lacking only IT and NA pores and with AITO pore positioned far forward and opening anteriorly, cutaneous sensory-papilla system similar to papilla pattern B-1 of Lachner & Karnella (1980).

Measurements [% SL; based on holotype and 7 paratypes, 12.1–15.9 mm SL; value for holotype (range of all types, mean of all types)]: Head length 28.3 (28.3–32.8, 30.4); origin of first dorsal fin 34.6 (33.1–37.8, 35.1); origin of second dorsal fin 52.8 (52.3–57.0, 55.1); origin of anal fin 59.7 (55.7–60.0, 58.5); caudal-peduncle length 22.0 (22.0–32.8, 26.0); caudal-peduncle depth 12.6 (11.6–13.4, 12.5); body depth 18.9 (18.2–21.4, 19.6); eye diameter 8.8 (8.0–11.0, 9.3); snout length 4.1 (3.7–5.0, 4.4); upper-jaw length 7.9 (6.7–10.0, 8.8); pectoral-fin length 27.4 (26.7–31.4, 28.7); greatest pelvic-fin length 56.7 (most damaged).

Color in life. (Figs. 1 & 6) Background color of body above midline and ventrally posterior to anus translucent grey, grey area above midline with scattered small red spots. Midline of body with maroon stripe, widest at head narrowing to black spot at caudal-fin base. Top of stripe with 7 elongate white spots spread along its length. A white stripe extending from center of eye back across maroon stripe to above anus, second white stripe under maroon stripe over abdomen. Lower portion of abdomen below second white stripe translucent grey. Head bicolored, ventral half below eye translucent grey, dorsal half maroon, a bright white spot under preoperculum, and another white spot at tip of snout between nares, and a white bar crossing pectoral-fin base. Pupil of eye black, iris crossed by four bars, a yellow one directly above the pupil, a brown one above that, a narrow white bar below the pupil with a brown bar below that. Dorsal-fin spines reddish.

Color in preservative. (Figs. 2, 3 & 5) Background color of head and body pale cream. Scale anterior margins on lower half of body outlined with melanophores. A bold black spot at caudal-fin base consisting of two parts, a posterior oval half larger and centered over posterior end of hypural plate, and a smaller anterior half more rounded in shape. Dark internal organs show through body on abdomen under pectoral fin. Side of head with heavy peppering of melanophores from under eye to posterior edge of operculum. Top of head with scattering of melanophores, sometimes arranged in several rows. A line of melanophores extending from posterodorsal portion of eye back above preoperculum. Pelvic fins immaculate, membranes of pectoral fins with peppering of melanophores, more intense ventrally. Anal-fin and second dorsal-fin membranes peppered with melanophores. First dorsal fin with a concentration of melanophores along basal third; distal ends of filamentous first few spines with melanophores. Caudal fin with a peppering of melanophores on membranes, with dark area extending from dark spot at caudal-fin base onto lower half of fin.

Etymology. The species is named in honor of Dr. Tiene Gunawan, one of Indonesia's foremost marine conservationists who has dedicated the past two decades to expanding the marine protected area network of West Papua and formulating policies to protect the biodiverse marine ecosystems contained therein. Dr. Gunawan also helped plan and launch the marine biodiversity survey of the Fakfak coastline that led to the discovery of this species.

Distribution and habitat. Currently known only from Karas Island in the Fakfak Regency, West Papua Province, Indonesia. It is presumably more widespread along the poorly-explored Fakfak coastline, but unlikely to be found in the very well-surveyed Raja Ampat Islands to the north. The species was found in a relatively

unusual deepwater-reef environment consisting of large foliose and plating corals on a gentle slope from 35–55m depth, exposed to moderate currents but otherwise protected from wave energy.

Comparisons. Only two other described species of *Eviota* lack both the IT and NA cephalic-sensory pores with the AITO pore positioned far forward and opening anteriorly: *E. infulata* and *E. tetha*. *Eviota infulata* differs by having a distinctive large dark irregular mark, often W-shaped, on the body just above and posterior to the pectoral-fin base. Both *E. gunawanae* and *E. tetha* have distinctive dark spots on the caudal-fin base (Fig. 3), lacking in *E. infulata*. *Eviota gunawanae* is most similar to *E. tetha*, but differs in several characters: all 10 type specimens of *E. gunawanae* have a pectoral-fin ray count of 16 vs. 14 (6) or 15 (3); the fifth pelvic-fin ray is about 10% of the fourth vs. usually absent or rudimentary; the dark spot at the base of the caudal fin is larger and extends anteriorly as a partially overlapping paired spot vs. restricted to the posterior end of the hypural plate (Fig. 3); only a few scattered melanophores at the pectoral-fin base vs. a narrow horizontal line of melanophores crossing the pectoral-fin base (Fig. 3); the scale anterior margins outlined with melanophores (see Fig. 2) vs. not darkly outlined

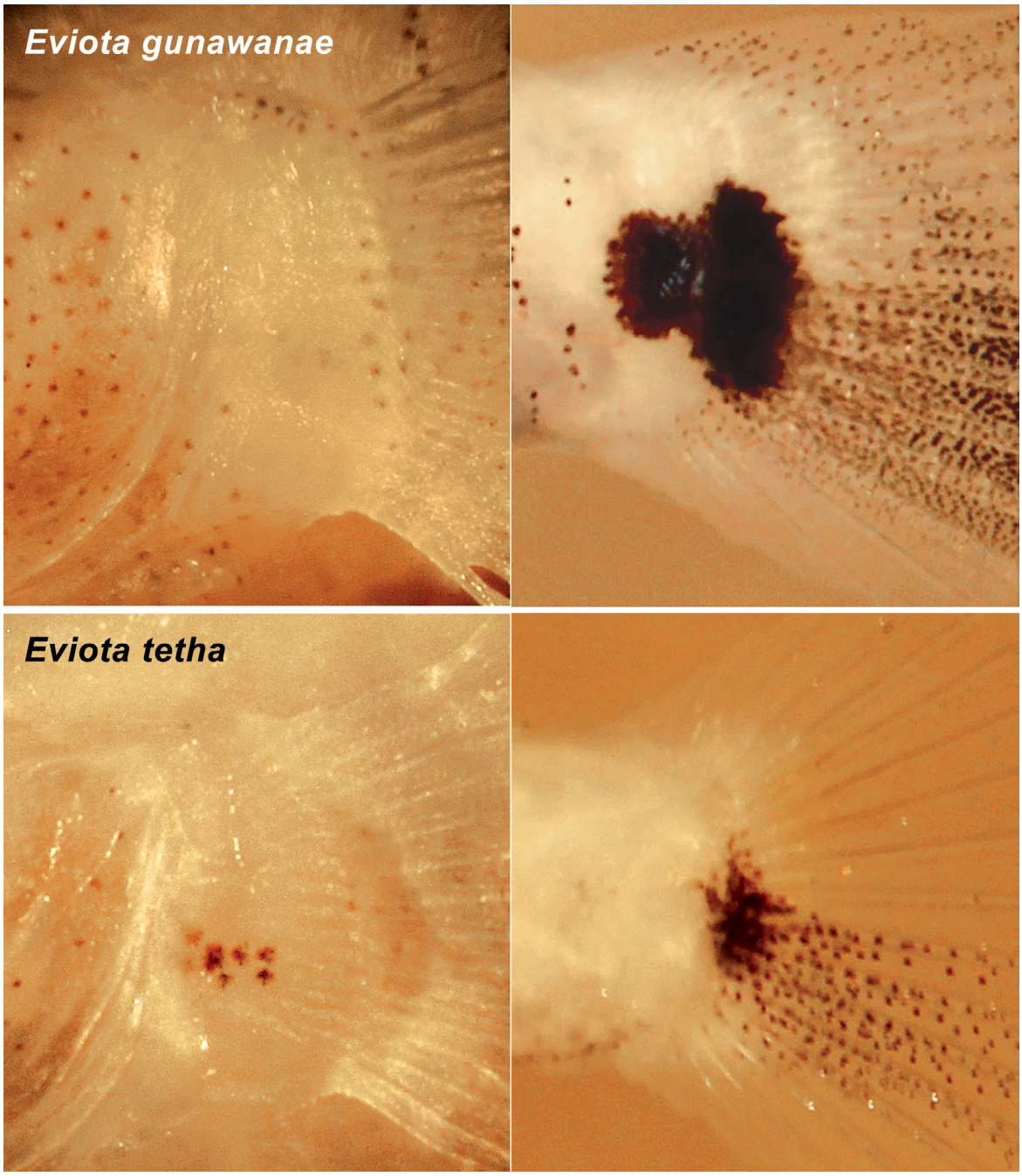

Figure 3. Comparison of pectoral-fin base (left) and caudal-fin base (right) markings in preserved holotype of *Eviota gunawanae*, MZB 24002, 15.9 mm SL, male vs. *E. tetha*, CAS 246235 (D.W. Greenfield).

Figure 4. *Eviota tetha*, preserved, CAS 246235, 11.9 mm SL, female, Cenderawasih Bay, West Papua Province, Indonesia (D.W. Greenfield).

(Fig. 4), and finally the top of the head has scattered melanophores, sometimes arranged in lines, but not a single line of melanophores extending posteriorly from the PITO pore vs. a single line of melanophores extending posteriorly from the PITO pore back onto the nape (Fig. 5).

The two species also differ in live coloration (Figs. 1 & 6 vs. 7): *E. gunawanae* is overall a darker maroon whereas *E. tetha* is mostly bright red-orange; the white spots extending the length of the line above the vertebral column are large and elongate in *E. gunawanae* vs. small and rounder in *E. tetha*; and, although both have a yellow bar crossing the eye above the pupil, the other bars crossing the eye are darker, almost brown, in *E. gunawanae* vs. red-orange in *E. tetha*.

The distinctively shaped dark mark at the caudal-fin base of *E. gunawanae*, and the dark area on the lower portion of the caudal fin, is most similar to that found in *E. cometa* (Fig. 8). *Eviota cometa* also has a reddish stripe down the midline of the body with white marks spaced along its dorsal surface, similar to *E. gunawanae*, leading to possible

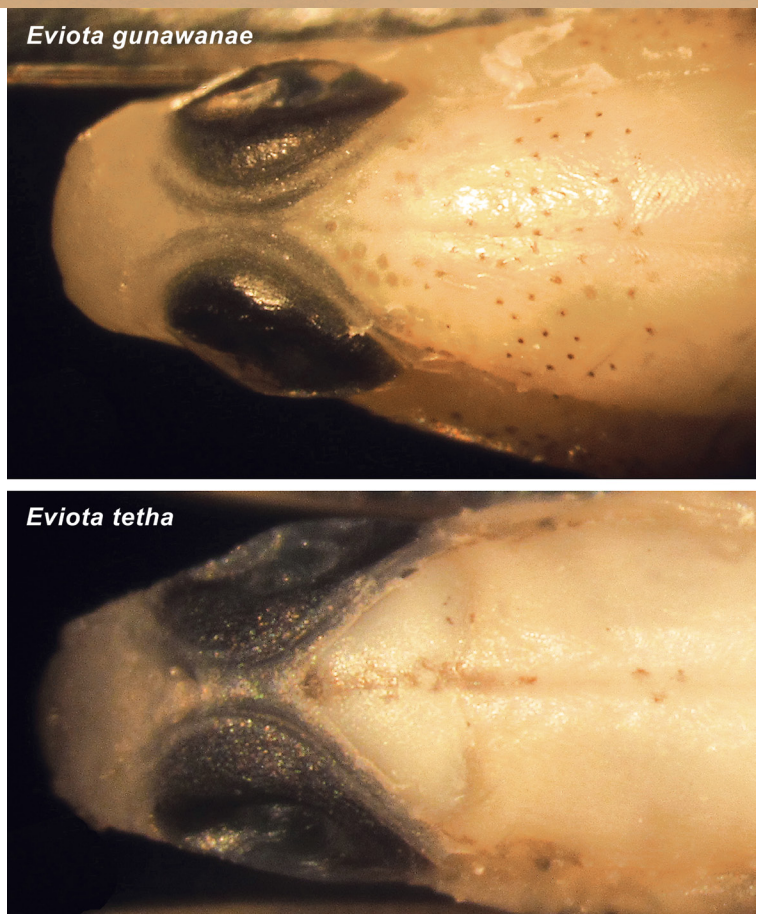

Figure 5. Comparison of dorsal head markings in preserved holotype of *Eviota gunawanae*, MZB 24002 vs. *E. tetha*, CAS 246235 (D.W. Greenfield).

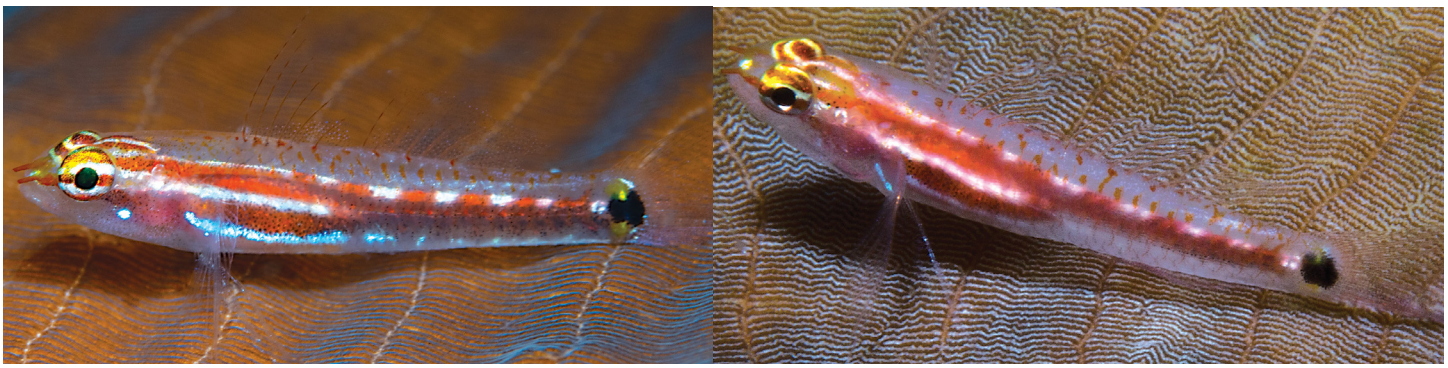

Figure 6. *Eviota gunawanae*, n. sp., Fakfak, West Papua Province, Indonesia (M.V. Erdmann).

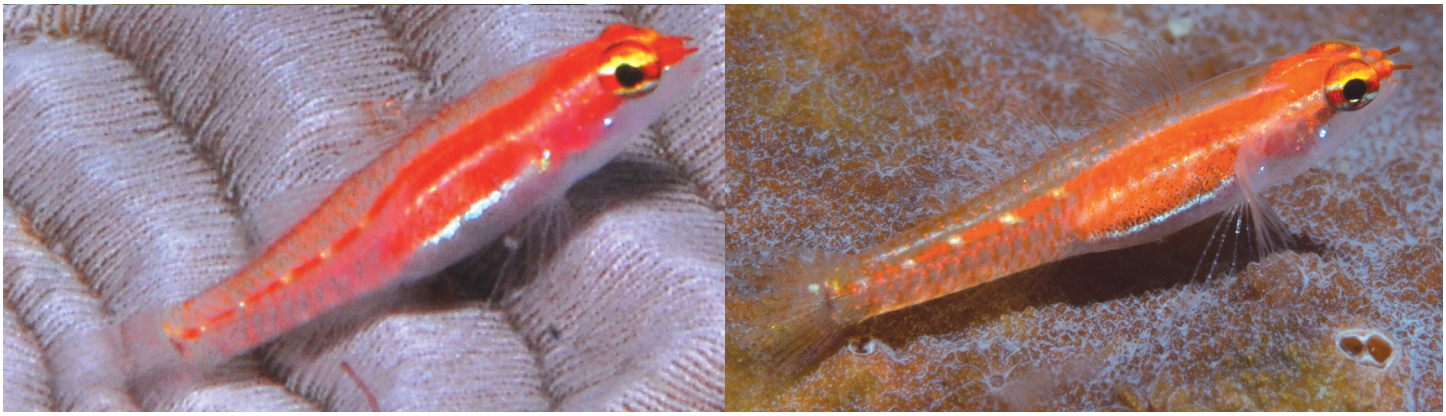

Figure 7. *Eviota tetha*, Cenderawasih Bay, West Papua Province, Indonesia (M.V. Erdmann).

confusion between the two; however, *E. cometa* has a different cephalic-sensory pore pattern, lacking only the IT pore (pattern 2) and the AITO pore not placed anteriorly and facing forward. The two species are not sympatric; the cryptic species complex comprising *E. cometa* is widespread in the region, but not present in Indonesia.

Figure 8. *Eviota cometa*, Vatu-i-Ra, Fiji (Rudy Whitworth).

Discussion. The molecular phylogeny shows *Eviota gunawanae* as part of a complex that also includes *E. tetha*, *E. cometa*, and *E. zebrina* (Fig. 9). Our analysis also reveals that *E. cometa* and *E. zebrina*, like many other nominal species of *Eviota*, appear to comprise multiple cryptic species and are thus in need of a robust integrative taxonomic analysis that incorporates live photos and genetic data from their respective type localities. Within this large species complex, *E. gunawanae* is sister to *E. tetha* with strong support (posterior probability 1.0). The two species show approximately 10–12% divergence in COI (Table 1), whereas the mean genetic distance within each species is less than 1.2%. Within *E. tetha*, the specimen from Wayag Lagoon (Raja Ampat) is approximately 5% divergent from specimens of *E. tetha* from Cenderawasih Bay, the type locality. In addition to this genetic variation, there appears to be some geographic variation in *E. tetha* in live coloration. The white spots along the lateral midline that interrupt the red-orange lateral stripe are less distinct or absent in *E. tetha* from Wayag versus those at the type locality in Cenderawasih Bay (Fig. 10). There are no obvious differences in morphology or in preserved pigmentation between these two populations. Additional specimens and photographs from Wayag and localities around Raja Ampat may confirm that this variation is indicative of multiple species, and that *E. tetha* is actually restricted to Cenderawasih Bay. Such a finding would not be surprising, as Cenderawasih Bay has previously been shown to be hotspot of endemism, with at least 15 species of reef fish and up to 18 species of hard coral known only from within the bay (Allen et al. 2015).

Importantly, the Fakfak coastline has also been shown to host an unusual number of microendemic species (Allen et al. 2018a, 2018b); *Eviota gunawanae* appears to represent the seventh such microendemic fish described from Fakfak since 2007. Other described microendemics include *Manonichthys jamali* Allen & Erdmann, 2007

TABLE 1

Genetic distances between species in the *Eviota tetha* complex (mtDNA COI)

Numbers above diagonal are average pairwise genetic distances, below the diagonal are average Kimura 2-parameter distances, on the diagonal are average within-group p-distances

	Eviota gunawanae	*Eviota tetha* Cenderawasih	*Eviota tetha* Wayag	*Eviota* cf. *zebrina*
Eviota gunawanae	0.006	0.113	0.103	0.135
Eviota tetha Cenderawasih	0.126	0.012	0.048	0.128
Eviota tetha Wayag	0.113	0.050	n/a	0.140
Eviota cf. *zebrina*	0.152	0.143	0.158	n/a

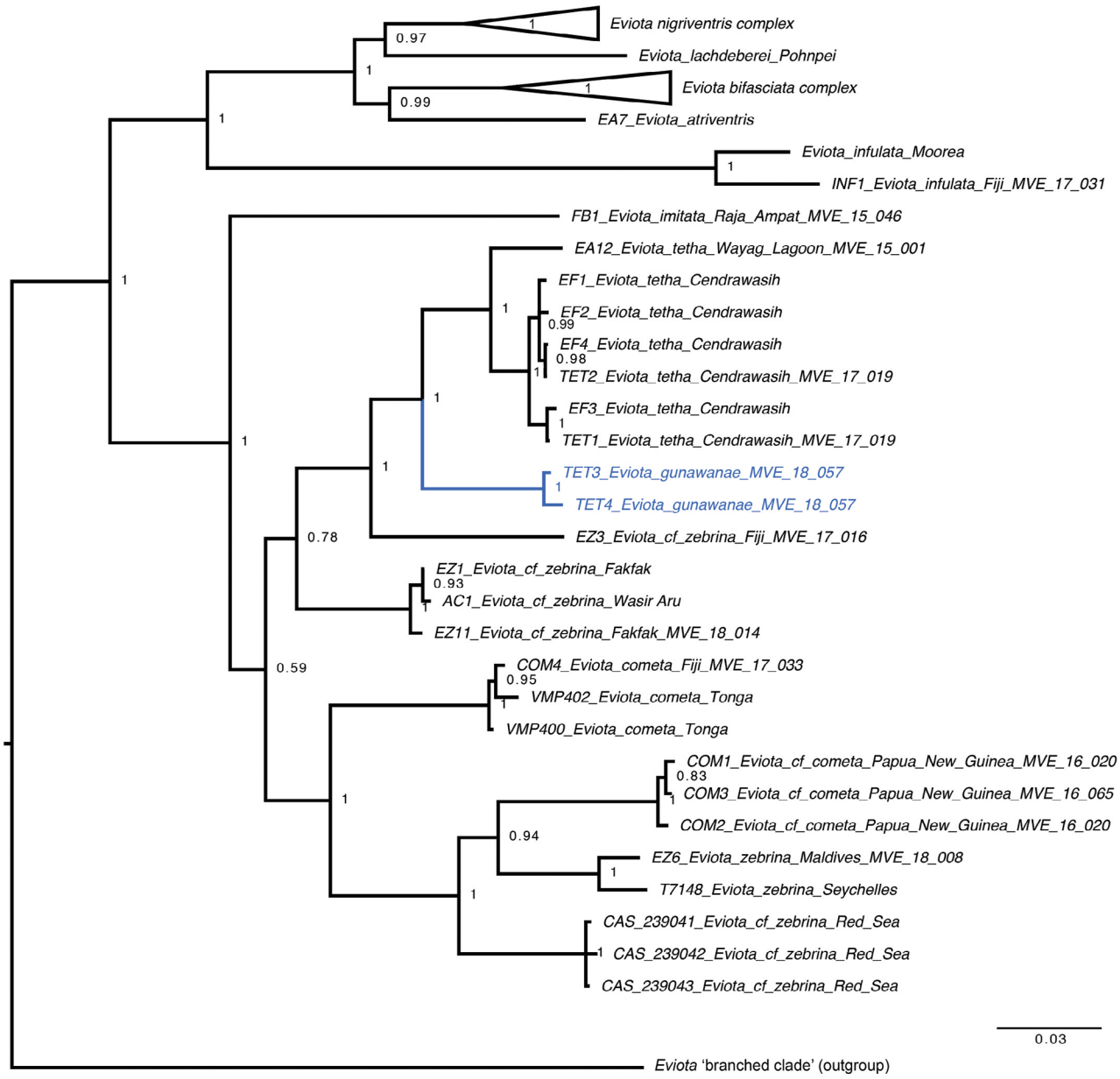

Figure 9. Molecular phylogeny based on COI and Ptr sequences. Branch lengths are subsitutions/site, node labels are Bayesian posterior probabilities.

Figure 10. A. *Eviota tetha*, Cenderawasih Bay, Papua Province, Indonesia (type locality); B. *Eviota tetha,* Wayag Lagoon, Raja Ampat, West Papua Province, Indonesia (M.V. Erdmann).

(Pseudochromidae); *Chrysiptera giti* Allen & Erdmann, 2008; *Chrysiptera uswanasi* Allen, Erdmann & Cahyani, 2018; *Pomacentrus bellipictus* Allen, Erdmann & Hidayat, 2018; and *Pomacentrus fakfakensis* Allen & Erdmann 2009 (Pomacentridae); and *Paracheilinus nursalim* Allen & Erdmann, 2008 (Labridae). Moreover, we are currently in the process of describing an eighth local microendemic, a new species of *Ecsenius* (Blenniidae). As noted by Allen et al. (2018a), the reefs of the Fakfak Peninsula, though existing in relative proximity to extensive reef systems to the north in Raja Ampat and to the west in the Maluku Spice Islands, are seemingly quite isolated in the north by Bintuni Bay and in the south by Arguni and Etna Bays, which are characterized by large freshwater plumes, heavy siltation, and large tidal fluctuations– all of which appear to form a barrier to planktonic dispersal of reef-fish larvae. As such, Fakfak's reefs appear to show limited connectivity to adjacent reefs in Raja Ampat and Maluku, and consequently host a variety of microendemic species. This unusual degree of microendemism highlights the biodiversity conservation value of the Fakfak Peninsula, where two new marine protected areas (MPAs) have recently been gazetted by the Fakfak government and local communities.

Comparative material. *Eviota tetha*: holotype, CAS 237105; paratypes CAS 237106, MZB 22099, ROM 94929, USNM 427308, WAM 34021-001; non-types CAS 243541, CAS 246235, CAS 237517 (DNA samples EF1–4), CAS 246252 (DNA samples TET1–2), CAS 246247 (DNA samples EA11–12). *Eviota cometa*: CAS 228703.

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Appendix

DNA label	Species	Catalog Number	GenBank COI	GenBank Ptr
239041	*Eviota* cf. *zebrina*	CAS 239041	MK712442	MK712461
239042	*Eviota* cf. *zebrina*	CAS 239042	MK712443	MK712462
239043	*Eviota* cf. *zebrina*	CAS 239043	MK712444	MK712463
COM1	*Eviota cometa*	CAS 246244	MK712445	MK712464
COM2	*Eviota cometa*	CAS 246244	MK712446	MK712465
COM3	*Eviota cometa*	CAS 246245	MK712447	MK712466
COM4	*Eviota cometa*	CAS 246246	MK712448	MK712467
EA12	*Eviota tetha*	CAS 246247	MK712449	MK712468
EZ1	*Eviota* cf. *zebrina*	CAS 246248	MK712450	MK712469
EZ11	*Eviota* cf. *zebrina*	CAS 246249	MK712451	MK712470
EZ2	*Eviota* cf. *zebrina*	CAS 246248	MK712452	MK712471
EZ3	*Eviota* cf. *zebrina*	CAS 246250	MK712453	MK712472
EZ6	*Eviota zebrina*	CAS 246251	MK712454	MK712473
TET1	*Eviota tetha*	CAS 246252	MK712455	MK712474
TET2	*Eviota tetha*	CAS 246252	MK712456	MK712475
TET3	*Eviota gunawanae*	CAS 246254	MK712457	MK712476
TET4	*Eviota gunawanae*	CAS 246254	MK712458	MK712477
VMP400	*Eviota cometa*	UW 158711	MK712459	MK712478
VMP402	*Eviota cometa*	UW 158711	MK712460	MK712479