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Eviota erdmanni (Teleostei: Gobiidae), a new dwarfgoby from the Savu Sea, Flores, Indonesia

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Abstract

A uniquely colored dwarfgoby, *Eviota erdmanni* n. sp., with a cup-like urogenital papilla in males, a cephalic sensory-canal pore system lacking only the IT pore (pattern 2), some branched pectoral-fin rays, and a dorsal/anal fin-ray formula of 9/8 is described from south Flores, Indonesia. We use molecular data from both mitochondrial and nuclear genes to infer the phylogenetic relationship of the new species with respect to its congeners, with specific emphasis on species with uniquely shaped urogenital papillae.

Key words: taxonomy, systematics, phylogenetics, coral-reef fishes, gobies, Pacific Ocean, urogenital papilla, molecular data.

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Introduction

The goby genus *Eviota*, commonly known as dwarfgobies, has 105 currently described species and several more species descriptions are currently submitted and in review, making it the most taxonomically diverse genus of marine fishes in the world. In recent years, there has been an abundance of undescribed gobiid diversity discovered from the region known as the Coral Triangle– a marine biodiversity hotspot in the western Pacific Ocean that broadly straddles the Indo-Australian Archipelago and is home to more than 2600 species of reef fishes (Allen & Erdman 2012). Many of the new species belong to the genera *Eviota* (e.g. Greenfield & Tornabene 2014; Tornabene *et al.* 2015, 2016; Greenfield & Erdmann 2014a, 2014b; and Greenfield & Jewett 2014a, 2014b) and *Trimma* (e.g. Winterbottom *et al.* 2014a, 2014b, 2014c; Winterbottom & Erdmann 2015; and Allen 2015a), however the Coral Triangle also harbors new species in other gobioid genera as well (e.g. *Navigobius*, Allen *et al.* 2015a; *Tomiyamichthys* and *Cryptocentrus*, Allen 2015b; *Lubricogobius*, Allen 2015c; *Acentrogobius*, Allen 2015d; and Allen *et al.* 2015b).

Here we describe another new species of dwarfgoby from the Coral Triangle. Mark V. Erdmann discovered the species from south Flores, Indonesia while assessing marine biodiversity and eco-tourism potential of sites around the Savu Sea, travelling aboard the *True North* expedition vessel from Australia. The new species can be distinguished from all other species of *Eviota* by a combination of its cup-shaped male urogenital papillae and its unique color pattern. We use molecular data from mitochondrial and nuclear genes to infer the phylogenetic position of the new species with respect to congeners, specifically those with similar urogenital papilla morphology.

Materials and Methods

Counts and measurements, descriptions of fin morphology and the cephalic sensory-canal pore patterns follow Lachner & Karnella (1980) and Jewett & Lachner (1983). Postanal midline spots, along the posterior ventral midline of the body begin at the anal-fin origin and extend to a vertical drawn 2 to 3 scale rows anterior to the ends of the hypurals where they articulate with the caudal-fin ray bases, the additional smaller spot posterior to this, if present, is not counted. "The membranes joining the first four [pelvic] fin rays 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" (Lachner & Karnella 1980, p. 4). Dorsal/ anal fin-ray formulas only include segmented rays. Measurements were made to the nearest 0.1 mm using both an ocular micrometer and dial calipers, and are presented as percentage of standard length (SL). All specimen lengths are SL in mm. Cyanine Blue 5R (acid blue 113) stain was used to make pores more obvious (Akihito *et al.*1993, 2002, Saruwatari *et al.* 1997), and an airjet used to observe them. For counts and measurements, values for the holotype are given first followed by values for the paratype in parentheses, if they differ from that of the holotype. The caudal, pectoral, and pelvic fins are badly damaged on the paratype and thus counts for these fins are omitted.

We sequenced a segment of the mitochondrial cytochrome c oxidase subunit I gene (COI) and the nuclear gene *Ptr* from the paratype using methods described by Greenfield & Tornabene (2014). Sequences from the new species were aligned with those from Tornabene *et al.* (2013, 2015), as well as sequences from several newly-collected species. Outgroups included several species from the 'unbranched' clade of *Eviota sensu* Tornabene *et al.* (2013), *Gobiodon*, and *Bryaninops*. Substitution models for each gene were determined using the Akaike Information Criterion scores generated using the software Jmodeltest v0.1.1 (Posada 2008). Phylogenetic analysis for the concatenated dataset was performed using Bayesian Inference in MrBayes v3.2 (Ronquist *et al.* 2012). For each analysis we implemented two parallel metropolis-coupled Markov chain Monte Carlo (MCMC) runs, each with four chains run for 10,000,000 generations sampling trees every 1000 generations after a burn-in period of 1,000,000 generations. Stationarity and convergence were evaluated by inspecting the standard deviation of split frequency statistic in MrBayes and by visualizing log-likelihood versus generation plots in Tracer v1.5 (Rambaut & Drummond 2007). A consensus tree with a posterior probability cutoff of 0.50 percent was generated from 9000 post-burn-in trees.



Figure 1. Eviota erdmanni, fresh holotype, CAS 238221, 11.8 mm SL, Ende, Flores, Indonesia (M.V. Erdmann).

Eviota erdmanni, n. sp.

Erdmann's Dwarfgoby

urn:lsid:zoobank.org:act:0D608671-3A39-4B08-A5AE-855BB4E3A8AE

Figures 1–2.

Holotype. CAS 238221, 11.8 mm SL, male, Indonesia, Ende, south Flores, 08° 53.269' S, 121° 37.599' E, 3 m, field number MVE-15-039, Oct. 6, 2015, M.V. Erdmann.

Paratype. CAS 238222, 8.3 mm SL, male, collected with holotype, preserved in 95% ethanol, tissue EFL1, GenBank accession numbers KX432252 (COI) and KX432253 (*Ptr*).

Diagnosis. A species of *Eviota* with a cup-like urogenital papilla in males; cephalic sensory-canal pore system lacking only IT pore (pattern 2); some pectoral-fin rays branched; dorsal/anal fin-ray formula 9/8; dark spot over preural centrum; no wedge-shaped dark spot at caudal-fin base; no prominent dark distinct spots on pectoral-fin base; in life (Fig. 1), four obscure postanal subcutaneous bars, some broken, none completely vertical, first three extending dorsally just above lateral midline, last falling just short of lateral midline; two distinctive white (yellow in life) areas, one behind eye above operculum and second on upper two-thirds of pectoral-fin base; dorsal and anal fins black in preservative, caudal fin dusky (Fig. 2).



Figure 2. Eviota erdmanni, preserved holotype, CAS 238221, 11.8 mm SL, Ende, Flores, Indonesia (D.W. Greenfield).

Description. Dorsal-fin elements VI+I,9, first dorsal fin semi-triangular in shape, more rounded, 4th spine longest, none filamentous, all second dorsal-fin soft rays branched except first soft ray, last ray branched to base; anal-fin elements I,8, all soft rays branched, last ray branched to base; pectoral-fin rays 15, rays 9-13 branched, reaching posteriorly to below base of second soft dorsal-fin ray; fifth pelvic-fin ray absent, 5 branches on 4th ray, 3 segments between consecutive branches of 4th pelvic-fin ray, pelvic-fin membrane reduced and no basal membrane; 12 branched and 17 segmented caudal-fin rays; 23 (25) lateral scale rows; transverse scale rows 5 (6), area under first dorsal and back to third soft ray of second dorsal fin naked; scales on body finely ctenoid except on ventral surface of abdomen where cycloid, no scales on breast; genital papilla in male cup-shaped, with a pair of lateral folds and one posterior fold forming cup (as in Fig. 3); front of head rounded with an angle of about 60° from horizontal axis; mouth slanted obliquely upwards, forming an angle of about 60° to horizontal axis of body, lower jaw not projecting; maxilla extending posteriorly just past



Figure 3. Cup-like male genital papilla, illustrated by J. R. Schroeder, modified from Lachner & Karnella [1980], based on a 17.5 mm SL specimen of *Eviota saipanensis*.

posterior edge of pupil; anterior tubular nares of moderate length, extending past posterior margin of upper lip; gill opening extending forward to below posteroventral edge of operculum; only IT cephalic sensory-pore absent (pattern 2), cutaneous papillae not obvious on side of cheek.

Measurements: head length 30.5 (33.6); origin of first dorsal fin 36.4 (41.1), lying behind posterior margin of pectoral-fin base; origin of second dorsal fin 58.0 (55.4), slightly in advance of anal-fin origin; origin of anal fin 59.3 (64.4); caudal-peduncle length 22.0 (20.7); caudal-peduncle depth moderate 14.8 (14.9); body moderately deep, its depth 23.7 (23.5); eye diameter 9.7 (10.6); snout length 5.1 (6.2); pectoral-fin length 31.3; pelvic-fin length 28.0, reaching urogenital papilla.

Color in preservative. (Fig. 2) Background color of head and body light tan. Body and head heavily peppered with dark brown chromatophores and ctenii of scales dark brown. A dark-brown to black, rounded internal spot on midline over preural centrum. Most definitive color consisting of two light spots, devoid of any dark pigment: one about size of eye behind eye above operculum; second on upper three-quarters of pectoral-fin base. Side of head heavily peppered with larger brown chromatophores, extending up behind eye to top of head and interorbital area where they are larger and more close set. Snout and jaws lighter with a few scattered dark chromatophores. Narial tubes light. Pupil of eye clear, iris black. Underside of head and prepelvic area heavily peppered with larger dark-brown to black chromatophores. Lower third of pectoral-fin base with scattered larger brown chromatophores. Dorsal and anal fins black. Caudal fin lighter with close-set dark marks on rays and distal third of fin dusky. Pectoral fin immaculate. Pelvic fin with light rays and dark membranes. Color of paratype fixed in 95% ethanol similar to that of holotype, except with a more dense peppering of dark melanophores over entire side of head and body, and scale margins with more prominent dark pigment.

Color when fresh. (Fig. 1) Background color of body and head pale pink. Side of head with several round to vertically elongate, bright reddish orange markings, approximately pupil diameter in size, along lower half of cheek and angle of jaw. Tip of snout, anterior interorbital region, and majority of upper and lower jaws bright reddish orange. Iris of eye bright reddish orange with 5 or 6 iridescent white spokes radiating outwards from pupil, pupil with reflective orange sheen when illuminated by camera strobe. Operculum with two irregular vertically elongate, reddish orange bars, posterior bar extends ventrally onto branchiostegal membrane. Nape with large, conspicuous, bright yellow, oval-shaped spot immediately above operculum, diameter of spot subequal to



E. minuta





Figure 4. Other species of *Eviota* with cup-like male genital papilla: *E. hinanoae*, Moorea, from Tornabene et al. (2013a); *E. minuta*, Philippines, S. Jewett from Greenfield & Jewett (2014b); upper *E. saipanensis*, Taiwan, from Fish Database of Taiwan; and lower *E. saipanensis*, Saipan, by D.W. Greenfield.

eye diameter. Pectoral-fin base with two conspicuous bright-yellow to orange blotches separated by an oblique iridescent white stripe peppered with melanophores, upper vellow blotch notably larger than lower orange blotch and extending onto base of pectoral-fin rays. Dorsal midline of body with approximately 14-15 small, dark-red spots beginning on nape and continuing posteriorly onto caudal peduncle, last spot centered over dark blackish blotch on preural centrum, most spots separated from one another by iridescent white spots or short bars. Side of body with four dark, reddish brown, obscure subcutaneous bars, first beginning at anal fin and last bar over posterior caudal peduncle, bars nearly vertical in orientation and extending from ventral midline (first two bars may extend ventrally onto base of anal-fin rays) to slightly above lateral midline, except for posteriormost bar which falls short of lateral midline. Scales over entire flank with dark red margins. Caudal peduncle with dark black, vertically elongate, internal blotch over preural centrum. Pectoral and pelvic fins translucent with light pink hue on rays and membranes. First dorsal fin with dark red pigment on rays and interadial membranes on lower half of fin, some rays with one or two small, iridescent bluish white spots, distal half of fin uniformly vellowish orange, entire first dorsal fin peppered with tiny dark melanophores. Second dorsal fin with yellowish orange membranes peppered with tiny dark melanophores and dark red rays, some rays with one or two small, iridescent bluish white spots, first white spot on rays positioned one-third up ray, second white spot (when present) positioned approximately two-thirds up ray. Caudal-fin rays and membrane uniformly washed with light pink coloration, some rays with indications of evenly-spaced, orange, reflective spots that are evident in camera strobe. Anal fin with dark reddish brown pigment over entire fin except for pale pinkish white distal margin, the base of some rays with dark red pigment extending down from subcutaneous bars on body.

Etymology. The specific epithet is a patronym, a noun in the Latin genitive case, in honor of Dr. Mark V. Erdmann, who has tirelessly photographed and collected numerous individuals of *Eviota*, many of which are new to science, including this species.

Distribution. Known only from the Savu Sea, at Ende, south Flores, Indonesia.

Comparisons. Only three other described species of *Eviota* are known to have a cup-shaped male urogenital papilla: E. hinanoae from the French Polynesia west to Ono-i-Lau, Fiji; E. minuta, known from the Philippine Islands; and E. saipanensis, known from the western Central Pacific (Fig. 4). Eviota minuta has a complete cephalic sensory-pore system (vs. IT missing in E. erdmanni), a dorsal/anal-fin formula of 8/8 (vs. 9/8), and distinct dark spots on the pectoral-fin base (vs. absent). Eviota erdmanni shares morphological and meristic characters with *E. hinanoae* and *E. saipanensis*, and the pattern of its postanal subcutaneous bars is similar to *E.* hinanoae, but it differs from both in its unique coloration of having large, distinct, white (yellow in life) spots on its head and pectoral-fin base. Of the 36 described species of Eviota with cephalic sensory-pore pattern 2 (lacking only IT), only 13 have branched pectoral-fin rays and a dorsal/anal fin-formula of 9/8 as does E. erdmanni. Excluding E. hinanoae and E. saipanensis, of the remaining 11 species, the following lack the large dark spot over the preural centrum that is present in *E. erdmanni*: *E. afelei*, *E. bimaculata*, *E. flavipinnata*, *E. punctulata*, and *E. rubrimaculata*. The following three species have dark spots on the pectoral-fin base (vs. absent in *E. erdmanni*): E. hoesei, E. japonica, and E. queenslandica. Eviota shibukawai has six dark spots on the postanal ventral part of the body whereas there are only 5 in *E. erdmanni*. Eviota prasina and *E. zonura* have 5 postanal subcutaneous bars and caudal spots above the midline, whereas there are only 4 bars and a centered caudal spot in E. erdmanni. None of these 13 species have a cup-shaped urogenital papilla or the distinct large white/yellow spots on the head and pectoral-fin base characteristic of *E. erdmanni*.

Discussion and Phylogeny. Several morphological characters were identified by Lachner & Karnella (1980) and Jewett & Lachner (1983) as being informative for diagnosing species of *Eviota*, including, but not limited to, sensory-pore patterns, pelvic-fin morphology, pectoral-fin-ray branching, fin-ray counts in the second dorsal and anal fins, and the shape of the male urogenital papilla. The extent to which these characters are useful for grouping species into phylogenetic clades is unknown for several characters and variable in others. For example, Tornabene *et al.* (2013) found that sensory-pore patterns were apparently highly homoplasious across the phylogeny, whereas the presence or absence of branched pectoral-fin rays corresponded perfectly to the two major clades of *Eviota*. In this regard, it is unclear whether a cup-like urogenital papilla has evolved a single time in *Eviota* and is thus useful for identifying a monophyletic species group, or whether it has independently evolved in several species/

clades. Our phylogeny (Fig. 5) shows a well-supported clade containing three species with cup-like papillae (*E. saipanensis*, *E. hinanoae*, and an undescribed species that is morphologically similar to *E. hinanoae* from Niue), which is resolved within the 'branched clade' that contains species of *Eviota* with branched pectoral-fin rays. It is probable that *E. erdmanni* belongs in the clade with these three species as well, although the exact position of *E. erdmanni* within the 'branched clade' of *Eviota* is unresolved on our tree. The other named species with a cup-like papilla, *E. minuta*, was not available for genetic analysis, but this species is superficially most similar to *E. lacrimosa* and *E. specca*— the former species lacking a cup-like papilla and the latter species being only known from a single sexually immature specimen (Greenfield & Jewett 2014a). The addition of these species and others within the 'branched clade' will help clarify the evolution of papilla morphology, but, given the current information available and the uncertainly regarding the position of *E. erdmanni*, it is most parsimonious to assume a single origin of the cup-like papilla. The functional significance of the various male papilla shapes in *Eviota* is not known.



Figure 5. Bayesian molecular phylogeny of the 'branched clade' of *Eviota*. Support values are Bayesian posterior probabilities. Clades with less than 0.5 support values are collapsed into polytomies.

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