



A new species of *Parapercis* (Teleostei: Pinguipedidae) from the Solomon Islands

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Abstract

A new species of pinguipedid fish, *Parapercis binotata*, is described from the Solomon Islands on the basis of six adult specimens, 46.5–56.5 mm SL. The new taxon belongs to the *Parapercis cylindrica* complex, which contains five other western Pacific Ocean species: *P. australis*, *P. cylindrica*, *P. haackei*, *P. lineopunctata*, and *P. snyderi*. It is most similar to *P. lineopunctata* from the East Indian Archipelago, but adult males are clearly distinguished by the presence of two short black bands, one on the cheek and another on the lower pectoral fin. Although lacking these markings, females differ from those of *P. lineopunctata* by the presence of a curved black band below the eye. The only known habitat of the new species consists of a nearly enclosed lagoon in 4–8 m depth. Analyses of the mtDNA “barcode” marker COI sequences for the *P. cylindrica* species complex show exceptionally deep divergences between most species, about 15–20% divergence between all but one pair of species, with *P. binotata* 14.52% different from its nearest relative, *P. lineopunctata*.

Key words: taxonomy, systematics, ichthyology, coral-reef fishes, Indo-Pacific Ocean, sandperch, DNA barcoding.

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Introduction

The Pinguipedid fishes of the genus *Parapercis* Bleeker (1863) are common inhabitants of sand and rubble bottoms throughout the tropical and temperate Indo-west Pacific region, as well as token representation in the eastern Atlantic Ocean (2 species) and eastern Pacific Ocean (1 species). The group was first reviewed by Cantwell (1964), who recognized 27 valid species from a total of approximately 80 nominal species. A second review by Randall (1984) increased the total to 40 valid species, including species that were described by Schultz (1966, 1968), McCosker (1971), Allen (1976), Kotthaus (1977), Fourmanoir & Rivaton (1979), and Gomon (1981). Numerous additional species have been described during the past few decades including those of Fourmanoir (1985), Anderson (1992), Randall & Francis (1993), Randall & McCosker (2002), Randall (1984, 2003, 2008), Johnson (2006), Randall & Yamakawa (2006), Imamura & Yoshino (2007), Randall *et al.* (2008), Ho & Shao (2010), Prokofiev (2010), Liao *et al.* (2011), Allen & Erdmann (2012), Sparks & Baldwin (2012), Ho *et al.* (2012, 2014), Ho & Johnson (2013), Chen *et al.* (2014), Johnson *et al.* (2014), and Ho (2015). Indeed, 32 new species have been described just since 2002, largely due to scuba exploration in moderate depths and demersal trawling activities in about 60-400 m. There are currently 81 species recognized as valid (Eschmeyer *et al.* 2017). The most species-rich region appears to be the northwestern Pacific Ocean (Taiwan to Japan) with about 35 species currently recorded, followed by Australia with 25 species. The largest number of coral-reef-associated species occurs in the East Indian region, which is inhabited by 17 species (Allen & Erdmann 2012).

The present paper describes a new *Parapercis* that was discovered in shallow depths by the authors while scuba diving at the Solomon Islands in October 2016. It was immediately recognized as an obvious close relative of *P. lineopunctata* Randall, 2003 which is widely distributed in the East Indian region. However, unlike that species, the new species exhibited diagnostic black bands on the cheek and pectoral fin. Subsequent mtDNA sequencing of the COI “barcode” marker shows a close relationship with *P. lineopunctata*.

Materials and Methods

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); body depth is measured at the origin of the pelvic fins and body width at the origin of the pectoral fins; head length (HL) is taken from the upper lip to the posterior end of the opercular membrane; snout length is measured from the tip of the upper lip to the nearest fleshy edge of the eye; eye diameter is the greatest fleshy diameter; upper-jaw length is taken from the tip of the upper lip to the fleshy posterior end of the maxilla; caudal-peduncle depth is the least depth, and caudal-peduncle length the horizontal distance between verticals at the base of the last anal-fin ray and caudal-fin base. Dorsal- and anal-fin spines and soft rays are measured from the point they exit from the contour of the body (not to their extreme bases for which x-rays or dissection would be needed); caudal and pectoral-fin lengths are the length of the longest ray; pelvic-fin length is measured from the base of the pelvic spine to the tip of the longest pelvic-fin soft ray. Counts of lateral-line scales are made to the base of the caudal fin and do not include two or three pored scales beyond the hypural flexure. Gill rakers are counted on the first gill arch, those on the upper limb listed first and separated from the lower-limb count with a plus sign; rudiments are included in the counts. In the description of dark color markings, bars are defined as oriented vertically, stripes are horizontal, and bands are oblique.

Morphometric data presented as percentages of the standard length is included in Table 1. The range of counts and measurements for paratypes is indicated in parentheses, if different from the holotype. Randall (2003) was utilized for comparative morphometric and meristic data for *Parapercis lineopunctata*. Type specimens are deposited at the National Museum of Natural History, Washington, D.C. (USNM) and the Western Australian Museum, Perth (WAM).

A 652-bp segment (the “barcode” marker) was amplified from the 5' region of the mitochondrial cytochrome c oxidase (COI) gene using a variety of primers (Ivanova *et al.* 2007). DNA extractions were performed with the NucleoSpin96 (Machery-Nagel) kit according to manufacturer specifications under automation with a Biomek NX liquid-handling station (Beckman-Coulter) equipped with a filtration manifold. PCR amplifications were

performed in 12.5 μ l volume including 6.25 μ l of 10% trehalose, 2 μ l of ultra pure water, 1.25 μ l of 10 \times PCR buffer (10mM KCl, 10mM (NH₄)₂SO₄, 20mM Tris-HCl (pH8.8), 2mM MgSO₄, 0.1% Triton X-100), 0.625 μ l of MgCl₂ (50mM), 0.125 μ l of each primer (0.01mM), 0.0625 μ l of each dNTP (10mM), 0.0625 μ l of *Taq* DNA polymerase (New England Biolabs), and 2 μ l of template DNA. The PCR conditions consisted of 94°C for 2 min., 35 cycles of 94°C for 30 sec., 52°C for 40 sec., and 72°C for 1 min., with a final extension at 72°C for 10 min. Specimen information and barcode sequence data from this study were compiled using the Barcode of Life Data Systems (Ratnasingham & Hebert 2007, Ward *et al.* 2009). The sequence data is publicly accessible on BOLD and GenBank (accession numbers are listed in the tree). Sequence divergences were calculated using BOLD with the Kimura 2-parameter (K2P) model generating a mid-point rooted neighbor-joining (NJ) phenogram to provide a graphic representation of the species' sequence divergence.

Parapercis binotata, n. sp.

Solomons Sandperch

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Figures 1–2; Table 1.

Holotype. WAM P.34620–001, 56.5 mm SL, male, Lingatu Bay, 09° 07.852'S, 159° 10.547'E, Mbanika Island, Russell Group, Solomon Islands, 4–5 m, spear, M.V. Erdmann & G.R. Allen, 7 October 2016.

Paratypes. (collected with holotype) USNM 432535, 2 specimens, 51.5–53.2 mm SL; WAM P.34620–002, 3 specimens, 46.5–53.0 mm SL.

Diagnosis. Dorsal-fin rays V,21; anal-fin rays I,16–17; pectoral-fin rays 14–16; lateral-line scales 46–48; four, progressively larger, recurved canine teeth on each side at front of lower jaw; scales on body ctenoid except cycloid on prepelvic area; opercle and cheek covered with ctenoid scales; body depth 4.7–5.5 in SL; caudal fin truncate to slightly rounded; pelvic fins reaching beyond anal-fin origin; color of head and body generally white, 7–8 short brown bars on back, above lateral line and lower side with corresponding narrow yellow-orange to brown bars; adult with conspicuous black band on rear edge of cheek and short black band on lower pectoral-fin rays; females with curved black band under eye along lower edge of suborbital; found on sand substrates in depths of less than 10 m.



Figure 1. *Parapercis binotata*, preserved holotype, WAM P.34620–001, 56.5 mm SL, Mbanika Island, Russell Group, Solomon Islands (G.R. Allen).

Description. Dorsal-fin rays V,21; anal-fin rays I,16 (3 paratypes with 17); all dorsal- and anal-fin soft rays branched, last to base; pectoral-fin rays 15 (1 paratype with 14 and right side of another paratype with 16), branched except uppermost; pelvic-fin rays I,5; branched caudal-fin rays 13; upper procurrent caudal-fin rays 7 (6–8), posteriormost ray segmented; lower procurrent caudal-fin rays 6 (6–7), posteriormost ray segmented; lateral-line scales 48 (46–48, not including 2–4 smaller pored scales on base of caudal fin); scales above first lateral-line scale to origin of dorsal fin 5; scales below lateral line posteroventrally to origin of anal fin 12; median predorsal scales 5 (6 in one paratype); horizontal scale rows on cheek 5; circumpeduncular scales 20 (19 and 22 in each of 2 paratypes); gill rakers 3+10=13 (4+10=14 in 3 paratypes); pseudobranchial filaments 10 (8 and 10 in each of 2 paratypes and 9 in 2 paratypes); branchiostegal rays 6; vertebrae 30.

Body depth 5.1 (4.7–5.5) in SL; body nearly cylindrical anteriorly, width 1.2 (1.1–1.3) in depth, strongly compressed posteriorly; head length 3.3 (3.4–3.5) in SL; snout length 2.9 (3.0–3.1) in HL; eye diameter 3.9 (3.7–3.8) in HL; interorbital space slightly concave, least width 7.4 (7.0–9.8) in HL; caudal-peduncle depth 3.0 (2.9–3.2) in HL; caudal-peduncle length 3.6 (3.4–3.9) in HL.

Mouth large, maxilla reaching vertical through anterior third of eye, upper-jaw length 2.4 (2.5–2.6) in HL; mouth oblique, forming angle of about 20° to horizontal axis of body, lower jaw projecting; front of upper jaw with pair of recurved canine teeth on each side; band of villiform teeth in about 10–12 rows medial to canines at front of upper jaw, gradually narrowing posteriorly in jaw to 1–2 rows, teeth in outer row largest; front of lower jaw with four recurved canine teeth on each side, increasing in length posteriorly; second recurved canine about half as large as largest anterior canine, about halfway back in jaw; broad band of villiform teeth immediately behind anterior canines, narrowing to a single row of slender conical teeth along posterior half of jaw; dense band of small conical teeth on vomer in chevron-shaped patch; narrow band of small conical teeth on palatines; lips smooth, inner surface with large fleshy papillae; tongue more-or-less spatulate with broadly rounded tip, reaching forward to posterior vomerine teeth.

Gill membranes united, with a broad free fold across isthmus. Gill rakers short and spinous, longest about one-third length of longest gill filaments. Nostrils small, anterior in front of center of eye, halfway to groove at edge of upper lip, with tubular rim and pointed posterior flap, not reaching posterior nostril when laid back; posterior nostril dorsoposterior to anterior nostril, round aperture about twice as large as anterior nostril, and with slightly raised rim. Pores of cephalic sensory-canal system well developed on side of snout around perimeter of eye (including interorbital space), on occipital region, along margin of preoperculum, and on mandible. Opercle with a single sharp spine, slightly above level of ventral edge of pupil; upper edge of subopercle with strong spine, angling slightly upward, its tip slightly above level of lower edge of pectoral-fin base; preopercle broadly rounded, its free edge smooth, extending from behind lower third of eye to below middle of eye.

Scales finely ctenoid on body, except cycloid on prepelvic area; ctenoid scales on opercle and preopercle, those on cheek extending to posterior end of maxilla; no scales on dorsal, anal, or pelvic fins; caudal fin with small scales on inter-radial membranes, extending about three-fourths length of fin; base of pectoral fins covered with ctenoid scales; lateral line paralleling dorsal contour of body, broadly arched over pectoral fin, then gradually declining to straight mid-lateral portion on posterior part of body.

Origin of dorsal fin over fourth lateral-line scale, predorsal length 3.4 (3.3–3.4) in SL; first dorsal-fin spine 5.7 (4.4–5.9) in HL; longest (third) dorsal-fin spine 3.2 (2.7–3.0) in HL; fifth dorsal-fin spine 5.4 (4.0–5.7) in HL, membrane between tip of fifth dorsal-fin spine and first soft ray attached slightly above base of ray; middle dorsal-fin soft rays longest, 2.0 (1.8–1.9) in HL; origin of anal fin below base of fourth dorsal-fin soft ray, preanal length 2.1 (2.0–2.2) in SL; anal-fin spine 5.2 (7.7–5.5) in HL; middle anal-fin soft rays longest, 2.2 (2.2–2.4) in HL; caudal fin truncate to slightly rounded, 4.5 (4.1–4.5) in SL; pectoral fins broadly rounded when spread, ninth ray longest, 4.6 (4.3–4.6) in SL; origin of pelvic fins about level with dorsal-fin origin, prepelvic length 3.6 (3.6–3.9) in SL; pelvic spine slender, 4.5 (3.3–4.4) in HL; pelvic fins reaching base of fourth soft anal-fin ray, fourth soft pelvic-fin ray longest, 3.3 (3.1–3.2) in SL.

Color adult male in life. (Figs. 2A & B) Head and body generally white, 7–8 short brown bars on back below dorsal fin and on lower side with corresponding narrow, yellow-orange to brown bars; brownish to orange patch frequently evident between spinous dorsal-fin base and anterior lateral line; dark brown band on each side of snout, joining at snout tip; conspicuous black band across middle of cheek and widely-scattered, small, black

TABLE 1

Proportional measurements of type specimens of *Parapercis binotata*, n. sp.
as percentages of the standard length

	holotype		paratypes			
	WAM P. 34620	WAM P. 34620	USNM 432535	WAM P. 34620	USNM 432535	WAM P. 34620
Standard length (mm)	56.5	55.4	53.2	53.0	51.5	46.5
Body depth (at pelvic-fin origin)	19.5	19.9	19.0	20.0	21.3	18.3
Body width	16.4	16.3	17.1	15.7	17.1	16.1
Head length	30.2	29.8	28.5	29.6	28.8	28.6
Snout length	10.4	9.9	9.3	9.5	9.4	9.7
Orbit diameter	7.8	7.8	7.7	8.3	7.5	7.7
Interorbital width	4.1	3.8	3.8	3.0	3.3	4.1
Upper-jaw length	12.3	11.7	11.4	11.7	11.7	11.0
Caudal-peduncle depth	10.1	9.7	9.2	9.6	9.8	9.1
Caudal-peduncle length	8.3	8.5	7.2	8.4	8.5	7.5
Predorsal-fin length	29.5	29.5	29.9	30.3	29.6	29.5
Preanal-fin length	47.1	48.5	48.0	46.5	47.8	49.1
Prepelvic-fin length	27.5	27.4	26.9	27.5	25.5	27.2
Dorsal-fin base	61.5	61.6	62.8	64.3	64.8	63.6
First dorsal-fin spine	5.3	5.9	5.8	5.0	6.4	6.5
Fourth dorsal-fin spine	9.6	10.3	10.7	9.9	10.7	10.1
Fifth dorsal-fin spine	5.6	5.9	7.1	5.2	6.3	5.6
Longest dorsal-fin ray	15.0	15.9	15.3	16.6	15.4	15.2
Anal-fin base	45.4	44.4	44.3	43.3	43.7	46.8
Anal-fin spine	5.8	5.4	6.0	5.7	5.3	6.0
Longest anal-fin ray	13.6	13.8	12.5	13.0	11.8	13.2
Caudal-fin length	22.4	24.3	22.8	24.4	22.8	22.3
Pectoral-fin length	21.7	22.3	23.4	23.4	23.3	21.9
Pelvic-fin length	6.6	9.5	9.4	8.4	9.2	7.3
Pelvic-fin spine	30.2	31.5	32.3	32.4	31.2	31.9

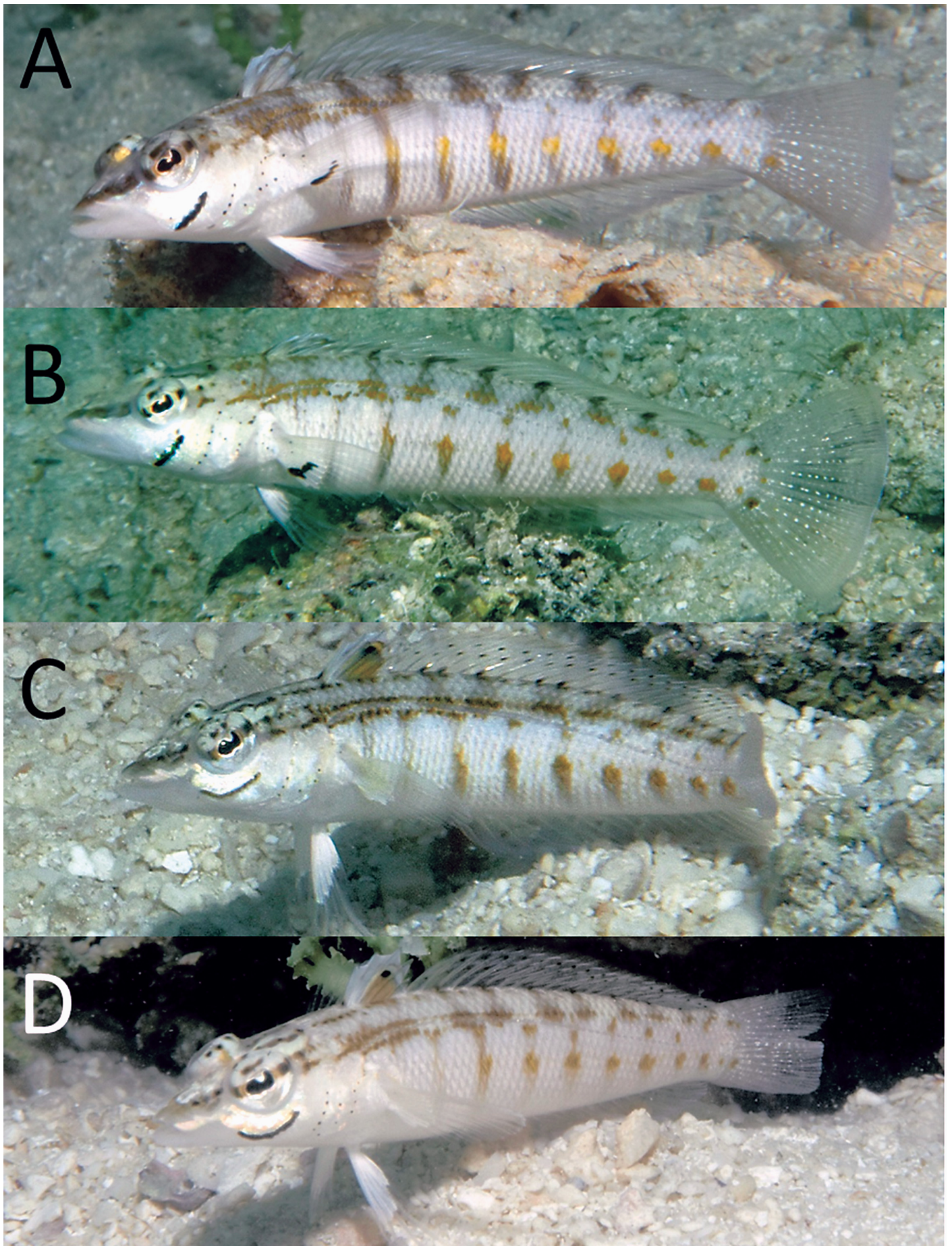


Figure 2. *Parapercis binotata*, underwater photographs at Mbanika Island, Russell Group, Solomon Islands. A & B: adult males, approximately 50–55 mm SL; C & D: females, approximately 35–40 mm SL (G.R. Allen).

spots along rear edge of cheek, on operculum, and on base of pectoral fin; pair of brown stripes on either side of dorsal mid-line of forehead, continuing along base of spinous dorsal fin; second pair of diffuse brown to orange stripes on each side of anterior portion of lateral line; spinous dorsal fin light brown with whitish outer edge; soft dorsal fin mainly translucent whitish, except faint brown stripe near base and relatively broad outer margin of same color, also row of small, dark-brown spots along base of fin, more or less connected to brown bars on back; anal fin translucent whitish; caudal fin translucent with 6–7 transverse bands of small white spots, also larger brown to orange spot on scaled portion of upper and lower base; pelvic fins white on basal one third and translucent on outer portion; pectoral fins translucent, with short black band across base of lower 5–6 rays; narrow yellowish rim around pupil; iris pale grey to whitish with large brown spots anteriorly and posteriorly and short brown stripe on upper portion.

Color of female in life. (Figs. 2C & D) Generally similar to male, but bars on upper body very diffuse with dominant marking in form of pair of brownish stripes straddling anterior half of lateral line, uppermost interrupted posteriorly, forming series of about 7 dash-like markings; female lacks black band across cheek, but instead has a conspicuous, curved, black band on lower edge of suborbital; spinous dorsal fin white marginally, but with yellowish brown central area and small blackish spot; soft dorsal fin translucent with double row of small brown spots on outer half and row of larger, diffuse, brown spots along base; remaining fins translucent except white basal portion of pelvic fins; pectoral fins plain without black band of male.

Color in alcohol. (Fig. 1) Head and body generally pale tan with similar dark markings described for live coloration above, except large dark-brown spot covering most of spinous dorsal fin, pair of dark-brown stripes straddling anterior half of lateral-line scales, black spot on upper and lower caudal-fin base, and small brown spots on caudal fin. Additionally, most scales on upper half of body with narrow to broad brownish margins, imparting an overall reticulated effect.

Etymology. The species is named *binotata* (Latin: two markings), with reference to the diagnostic dark bands on the cheek and pectoral fins of males. It is treated as a feminine singular compound adjective.

Distribution and habitat. The new species is known only from the Solomon Islands type locality. The relatively unusual habitat consisted of a nearly enclosed, narrow, dead-end lagoon (Fig. 3) with a gradually sloping, white sand bottom with scattered, mainly low-profile, coral formations. The fish was common at depths between about 4–8 m, generally occurring as solitary individuals.



Figure 3. Aerial view of type locality (arrow) of *Parapercis binotata* at Lingatu Bay, Mbanika Island, Russell Group, Solomon Islands (Google Earth).

Comparisons. The new species belongs to the *Parapercis cylindrica* species complex (Randall 2003), which contains the following five species from the western Pacific Ocean region: *P. australis* Randall, 2003; *P. cylindrica* (Bloch, 1792); *P. haackei* (Steindachner, 1884); *P. lineopunctata* Randall, 2003; and *P. snyderi* Jordan & Starks, 1905. The members of this complex have a prominent spine at the upper edge of the subopercle, 8 or 10 enlarged canine teeth in the outer row at the front of the lower jaw, palatine teeth present, ctenoid scales on the cheek, and 4–6 predorsal scales.

Our present investigation, including the genetic analysis (see below), indicates the new species is closely related to *P. lineopunctata* (Fig. 4), which was first described from the Philippines (type locality Bolinao, Luzon), Indonesia (Sumatra and Molucca Islands), Australia (Great Barrier Reef and Lord Howe Island), Coral Sea (Chesterfield Bank), and Papua New Guinea (Port Moresby vicinity and D'Entrecasteaux Islands). Our own surveys and underwater photographs further confirm the presence of *P. lineopunctata* throughout the East Indian region (Allen & Erdmann 2012). Although the two species have a similar appearance (compare Figs. 2 & 4), adult males of *P. binotata* are clearly distinguished by the presence of the conspicuous black bands on the cheek

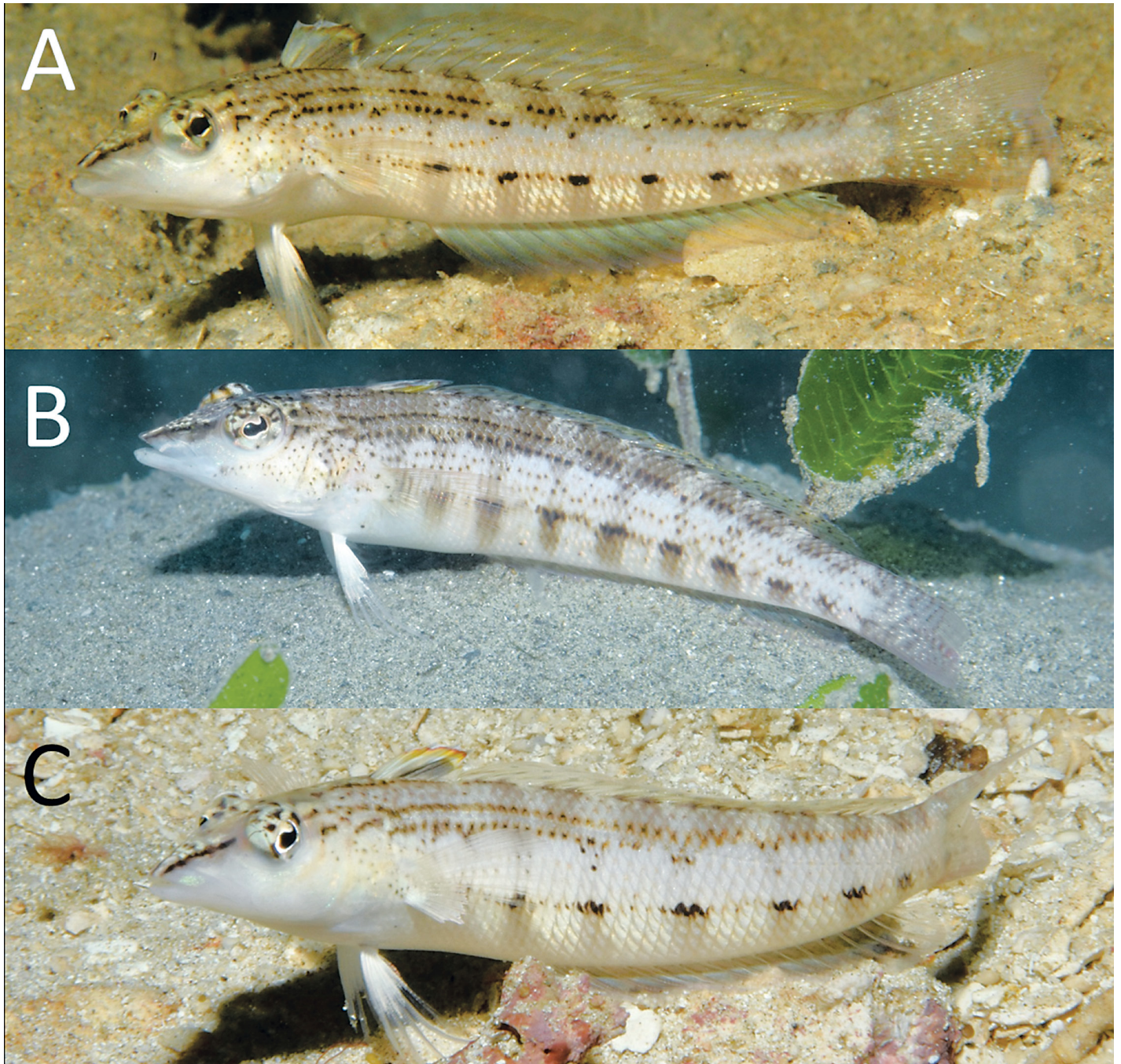


Figure 4. *Parapercis lineopunctata*, underwater photographs, approximately 55–65 mm SL: A) New Ireland, Papua New Guinea; B) Milne Bay, Papua New Guinea; C) Misool Island, Raja Ampat Islands, West Papua, Indonesia (G.R. Allen).

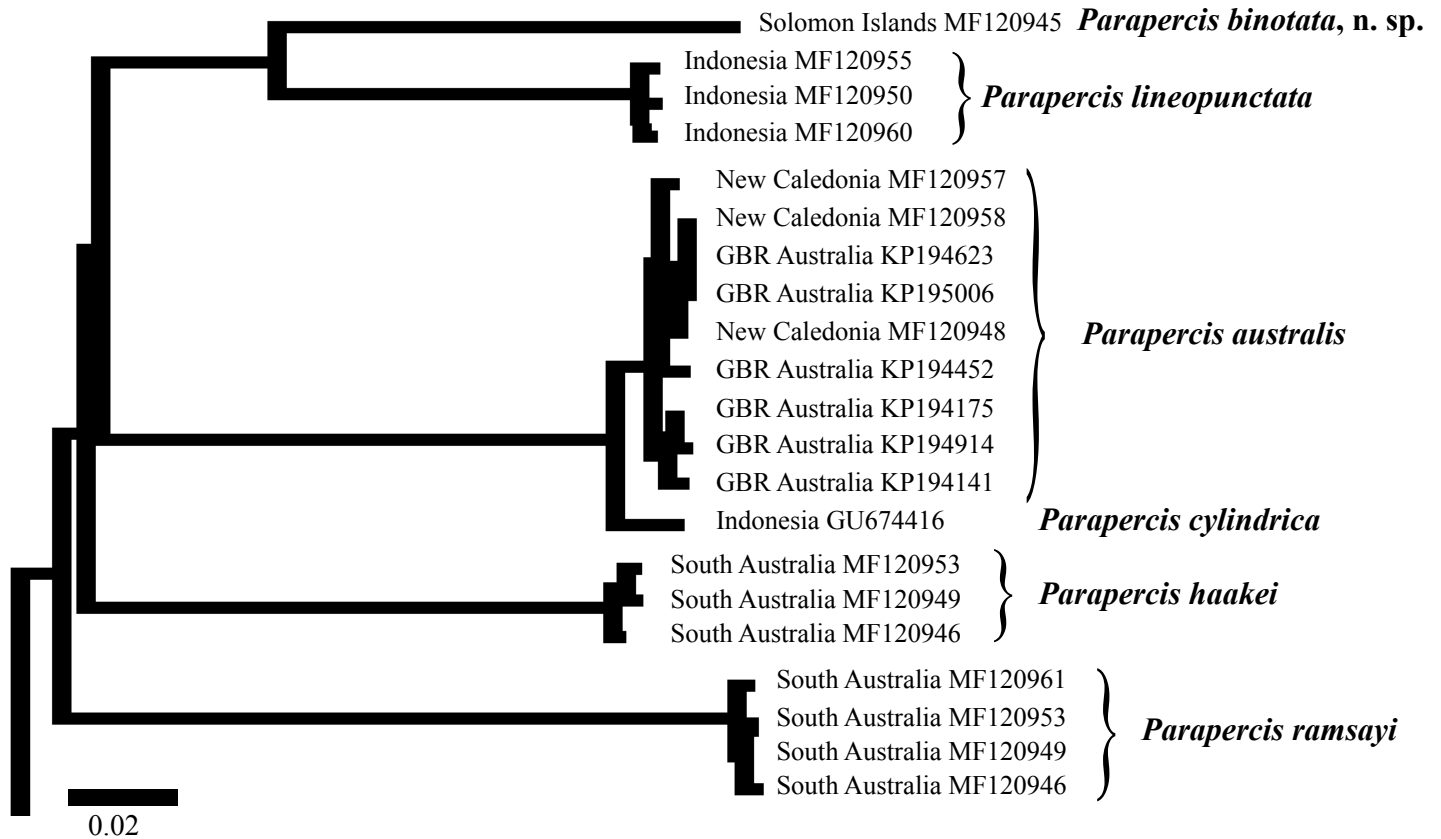


Figure 5. A portion of the neighbor-joining phenetic tree of the genus *Parapercis* based on mtDNA COI sequences, following the Kimura two-parameter model (K2P) generated by BOLD (Barcode of Life Database); <http://boldsystems.org/>. The scale bar at left represents a 2% sequence difference. Collection locations and GenBank accession numbers for all specimens are indicated.

and lower pectoral fin, not present on *P. lineopunctata*. Similarly, females and juveniles of *P. binotata* possess a diagnostic curved band below the eye, a feature that is invariably absent in *P. lineopunctata*. Another difference involves the markings on the lower side of the body, which in *P. lineopunctata* consists of a horizontal row of horizontally elongate, dark-brown markings, usually with a relatively broad, light-brown bar immediately below each one. In contrast, these markings are not apparent on *P. binotata*, which instead has a series of narrow, yellow-orange to brown bars. Moreover, the double row of black dots that straddles the lateral line on the anterior body of *P. lineopunctata* is poorly developed in adult males of *P. binotata*. In addition, *P. binotata* of both sexes generally lack the additional irregular rows of dotted lines on the body that are frequently present on *P. lineopunctata*. Although the two species share most meristic and morphometric features, the last dorsal-fin spine of *P. binotata* is generally longer (5.2–7.1% SL vs. 3.8–4.7% SL for *P. lineopunctata*). The new species apparently replaces *P. lineopunctata* at the Solomon Islands. The nearest known population of *P. lineopunctata* is near the eastern Papua New Guinea mainland in Milne Bay Province, which lies about 900–1000 km due west from the type locality of *P. binotata*.

Genetic analysis. The sequences of the mtDNA marker COI (the DNA “barcode”) for all but one of the *P. cylindrica* species complex (except *P. snyderi*) reveal deep divergences between species: ranging from a relatively small 2.03% divergence between *P. cylindrica* from Indonesia and *P. australis* from Australia and New Caledonia (minimum interspecific distance by K2P; 2.00% pairwise), up to 22.10% between *P. ramsayi* and *P. binotata* (minimum interspecific distance by K2P; 18.85% pairwise) (Fig. 5). Despite the similarity of the sibling species *P. lineopunctata* and *P. binotata*, the divergence between the two species is remarkably high, at 14.52% (minimum interspecific distance by K2P; 12.90% pairwise). This difference is well beyond the typical interspecific divergence in COI sequences for coral-reef fishes, which is usually around 2–5% (Ward *et al.* 2009, Victor 2015). Apparently, fishes of the genus *Parapercis* exhibit remarkably high interspecific divergences in mtDNA sequences. This

phenomenon is also characteristic of many closely related gobies and blennioids (e.g. Victor 2013, Tornabene *et al.* 2016). The origin of this apparently high rate of mutation is unclear and additional studies of nuclear genes and comparative studies across taxa would be required for an explanation of these findings.

Remarks. It is likely that many if not all *Parapercis* species are protogynous hermaphrodites, which was noted by Randall (1984). The six type specimens of *P. binotata* are all males. Although no females were collected, several smaller individuals, approximately 35–40 mm SL, were observed and photographed (Fig. 1C & D) at the type locality. Judging from their presence in the same area as males and general coloration (with the exception of the sexual dichromatic features noted above), we identify them as females of the new species.

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